ASSESSING THE ECOLOGICAL CONDITION OF NEBRASKA'S WETLAND RESOURCES AND AMPHIBIAN COMMUNITIES: AN INTENSIFICATION OF THE ENVIRONMENTAL PROTECTION AGENCY'S 2011 NATIONAL WETLAND CONDITION ASSESSMENT

by

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Wetlands provide valuable ecosystem services including flood control, nutrient retention, recreational opportunities, and wildlife habitat. Despite their importance, wetlands were historically displaced across the landscape in favor of alternative landuses. While general trends in wetland area have been tracked, the ecological condition of wetlands remains largely unknown. From 2011 – 2013, I conducted ecological assessments at 109 wetland sites in 11 wetland complexes across Nebraska. Using a novel standardized Floristic Quality Assessment Index score and additional vegetative metrics, I tested the efficacy of multiple landscape methods and the Nebraska Wetland Rapid Assessment Method for assessing the ecological condition of wetland sites in Nebraska.

The Rainwater Basins of central Nebraska represent a biologically and economically important region. Most of Nebraska's native anuran species have ranges that include the Rainwater Basins. From 2014 – 2016, volunteer roadside anuran call surveys were conducted at 124 wetland sites in the Eastern Rainwater Basins. I used occupancy modeling in conjunction with muli-model inference and model averaging to assess detection and occupancy of four species and a small, four species anuran community. Generally, detection was not affected by weather covariates, but varied with date and time of day and occupancy was most influenced by wetland type, with managed wetland more likely to be occupied than anthropogenic habitats.

The amphibian disease Chytridiomycosis is a potential cause of worldwide amphibian declines. I assessed the distribution of chytrid in Nebraska amphibian communities using the program MaxEnt. Results indicate that chytrid is widespread with the distribution best predicted by mean annual temperature and the type of aquatic habitat. Probability of chytrid presence peaked around 10.5 °C and was higher in lentic aquatic habitats.

Results of this research provide baseline data for Nebraska's wetlands and wetland reliant amphibian communities. Further, these results illustrate the need to consider multiple spatial scales and the importance of spatial context for ecosystem conservation planning and management. While plant communities thrive with minimal 100 m vegetative buffers, other taxa such as anurans and birds may respond to factors at much larger spatial scales and require broader planning and consideration of context, particularly in highly modified agricultural landscapes.

Dedication

I would like to dedicate this dissertation to my family. To my parents, David and Sandra Smeenk, who have supported me throughout my life and studies. Thank you for nurturing my curiosity for wildlife and nature. To my siblings, Bryan Smeenk and Elizabeth Borden, thank you for your life long love and support. To my wife, Grace Smeenk, thank you for being my rock. Without your love and support I never would have made it this far. And to my daughter, Charlotte and her future sibling, your daddy loves you. I hope that this work aids in promoting the conservation of our natural resources so that you can learn to love nature and wildlife as I did.

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CHAPTER 1

INTRODUCTION

The world's diverse ecosystems provide an estimated total $16 – 54 trillion in ecosystem services and natural capital per year, with approximately 40% of that value coming from wetland ecosystems (Costanza et al. 1997, Zedler 2003, de Groot et al. 2012). Functions provided by individual wetland ecosystems is partially dictated by position within the local and regional landscape (Mitsch and Gosselink 2000). For example, floodplain wetlands in riparian areas may provide flood control functions, but isolated playa wetlands likely provide minimal flood control benefits. Therefore, maintenance of diverse wetland ecosystems across the landscape is imperative for maintaining total wetland ecosystem function. The ability of wetlands to provide ecosystem services such as flood control, nutrient cycling, and recreational opportunities is largely predicated on the ecological condition of wetland ecosystems. The destruction, loss, and degradation of wetlands has led to an overall decrease in total wetland ecosystem function in many regions across the United States (Bedford and Preston 1988) despite the instated policy of no net loss (Turner et al. 2001, Moreno-Mateos et al. 2012).

National loss of wetlands has been tracked over time (Frayer et al. 1983, Dahl and Johnson 1991, Dahl 2000, Dahl 2005, and Dahl 2011). Since the mid-1800's, nearly 53% of wetlands across the United States have been destroyed (Dahl 1990). Recent trends indicate an increase in total wetland area, although most of the gains are in open water habitats (Dahl 2011). Similar to national trends, Nebraska has lost nearly 35% of its wetland resources (Dahl 1990, LaGrange 2005). Most losses may be attributed to both agricultural and urban development, particularly in areas like the Rainwater Basins and along the Missouri River floodplain (LaGrange 2005, Tang et al. 2018). Additionally, only 3% of Nebraska's wetland resources are owned and managed by state and federal agencies or conservation organizations. Despite significant efforts to monitor and track changes in wetland area, similar efforts to track the ecological condition of wetlands have lagged behind.

The Environmental Protection Agency's 2011 National Wetland Condition Assessment (NWCA) represents the first national effort to assess the ecological condition of wetlands at a national scale. Through this effort, the EPA advocates assessment of wetland condition at three levels: intensive site assessment, rapid assessment, and landscape assessment (Wardrop et al. 2007, EPA 2016). Level 3 intensive site assessments involve site visits in which data are collected in and immediately surrounding wetland sites. Often these efforts include and assessment of vegetative communities using standardized methodologies (Bourdaghs et al. 2006, Wardrop et al. 2007). Level 2 wetland rapid assessments involve the measurement of multiple on-site metrics, but assessments take less than four hours to complete (Fennessy et al. 2007). Such rapid assessment methods have been successfully developed and implemented in multiple states (Mack 2001, Fennessy et al. 2007, Stein et al. 2009). Level 1 landscape assessments use remote sensing and on-site calibration to assess wetland condition as it relates to surrounding landscape condition including methods such as the Landscape Development Intensity Index (Brown and Vivas 2005) and the NatureServe Landscape Condition Model (Hak and Comer 2016). Funding for this research was provided in conjunction with funding for the NWCA in an effort to assess additional wetland sites across Nebraska.

In this study, I conducted ecological assessments at 109 wetland sites associated with 11 important complexes across Nebraska from 2011 – 2014. At each site, assessed condition at three levels using multiple methodologies. As no methodologies existed in Nebraska for Level 1 and Level 2 assessments, multiple Level 1 landscape assessment techniques and Level 2 rapid assessment were developed and tested as portion of this project. Ecological condition using Level 3 assessment data, primarily that of vegetative communities, was used to test the efficacy of Level 1 and Level 2 ecological assessment methods.

For Level 3 ecological assessments, I primarily focused on vegetative communities present at sites. In chapter 2, I describe the vegetative communities at sites and within complexes using multiple vegetative community metrics described by Bourdaghs et al. (2006) and Andreas et al. (2004). These metrics can be used to compare vegetative communities within wetland complexes and provide a baseline for which to compare future wetland vegetation community studies. Vegetative community data can then be used to calculate floristic quality assessment index (FQAI) scores for individual sites. In chapter 3, I use the vegetative community data to calculate FQAI scores using multiple methodologies. I further describe a method to standardize FQAI scores using diagnostic species lists from "reference standard" wetland sites. As sufficient data from "reference standard" wetland communities is often sparse but vegetative community composition is often known, this method provides and opportunity for inferring departure from “reference standard” condition. Additionally, it provides the ability to compare condition among wetland complexes, among states, within regions, or even nationwide.

FQAI scores are generally accepted as good indicators of the ecological condition of wetlands (Cohen et al. 2004, Bourdaghs et al 2006, Miller and Wardrop 2006). I used FQAI scores calculated in chapter 3 to assess the efficacy of Level 2 and Level 1 assessment methods. In chapter 4, I describe the development, implementation, and validation of the Nebraska Wetland Assessment Method (NeWRAM). I validate NeWRAM for responsiveness, range and representativeness, and redundancy in relation the FQAI scores. I conclude with recommendations on how NeWRAM can be refined and further tested to improve the assessed relationship between FQAI scores and NeWRAM scores.

Land use in the surrounding landscape has direct and indirect impacts on the ecological condition of wetlands and the taxa that occupy wetlands (Houlahan et al. 2006, Houlahan and Findlay 2004). Multiple methods have been developed to assess wetland condition using land use including (from simple to complex) natural buffer condition, proportion of surrounding landscape in particular land uses, the Landscape Development Intensity Index (LDI; Brown and Vivas 2005), and the NatureServe Landscape Condition Model (Comer and Hak 2017). In chapter 5, I used simple correlation and multi-model inference to test for relationships between multiple vegetation metrics and multiple measures of landscape condition at multiple spatial scales. Results provide insight into minimum buffer width for the maintenance of vegetative communities.

Amphibians are sensitive to environmental degradation at multiple spatial scales due to their biphasic life cycle. The Rainwater Basin region of Nebraska offers a unique opportunity to assess impacts of landscape change on anuran communities due to the extensive loss of wetlands and extensive agricultural development. Additionally, this region holds a relatively high diversity of anurans in the state, with eight species present. To assess local and landscape effects on anuran communities, I coordinated volunteer roadside anuaran call surveys at 124 wetland sites distributed across the Rainwater Basins from 2014 - 2016. In each year, sites were visited approximately 4 times over a four-week period in May and June. In chapter 6, I use occupancy modeling and multi-model inference to analyze the roadside call survey data to assess factors that influence both the detection and occupancy of four anuran species and a small, four-species community. Abiotic factors found to affect detection can help to inform on the efficacy of volunteer based roadside surveys for detecting species. Landscape and local factors found to influence anuran occupancy of wetland sites can help to inform future management, conservation efforts, and land acquisition in the region.

Concern over worldwide amphibian declines began after the First World Congress of Herpetology in the early 1990's (Collins and Storfer 2003). Enigmatic declines were soon attributed to an emerging fungal pathogen, *Batrachochytrium dendrobatidis* (*Bd*) and the associated disease Chytridiomycosis (Skerratt et al. 2007). This concern led to a significant expansion in amphibian disease monitoring efforts around the world. In chapter 7, I conducted the first widespread survey for the *Bd* fungus in anuran communities in Nebraska. I assessed phenological, environmental, climate, and landscape factors that may affect the detection and distribution of *Bd*. The predicted distribution based on climate and landscape factors was assessed using the program

MaxEnt. Results provide the first assessment of factors influencing *Bd* detection and distribution in Nebraska.

Overall, this research provides an extensive analysis of methods for assessing the ecological condition of wetlands and taxa occupying these sites in Nebraska. Results can inform natural resource managers on the factors that most influence wetland condition, allowing for better future conservation planning and management efforts. Additionally, it lays the groundwork against which to base future monitoring efforts and track change in wetland condition, plant communities, amphibian communities in the Rainwater Basins, and the distribution of an amphibian disease. Further, it shows that management at a single spatial scale will be unlikely to adequately conserve habitat for all taxa, indicating that site-based management may be insufficient to effectively maintain ecological condition of wetland sites and taxa diversity.

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CHAPTER 2

ASSESSING AND COMPARING NEBRASKA'S WETLAND VEGETATIVE COMMUNITIES

INTRODUCTION

Plants associated with wetlands are adapted to unique conditions, including anoxia and frequent inundation by water (Keddy 2010). Wetland plant communities are highly variable in species composition, species richness, and productivity across wetland types. This variability among wetlands is influenced by abiotic factors such as hydrological regime, geomorphology, fertility and associated eutrophication, and environmental stress and disturbance (Batzer and Sharitz 2006, Keddy 2010). For example, plant communities distribute across gradients in response to stress, nutrients, and disturbance where low diversity, tolerant plant communities occur in areas of high nutrient loads and disturbance, relative to high diversity, sensitive plant communities that occur in areas of low nutrients loads and disturbance (Batzer and Sharitz 2006). Additionally, wetland vegetative community metrics have been shown to be good indicators of surrounding land use and human disturbance (Lopez and Fennessy 2002, Cohen et al. 2004, Bourdaghs et al. 2006, Miller and Wardrop 2006). These relationships result in plant community metrics that vary within and among different plant communities and represent accepted methodologies for measuring the ecological condition of wetland communities.

Intensive site assessments of the ecological condition of wetlands serve two main purposes. First, they provide quantitative and qualitative inference into the quality and condition of wetlands. Second, intensive assessments can be used to calibrate and refine additional ecological assessment methods (Wardrop et al. 2007). I conducted intensive site assessments at 109 wetland sites located in 11 wetland complexes. All sites within each compex represented a single wetland vegetative community and wetland type and consisted of up to nine randomly selectd wetlands and one "reference standard" site. I compared measures of condition to reference standard wetland condition within each wetland complex (Brinson and Rheinhardt 1996). Doing so allows measurement of the departure of wetlands from reference standard quality and condition (Wardrop et al. 2007). I calculated a suite of vegetative community metrics for each of the 109 sites in 11 wetland complexes across Nebraska that were visited during the growing seasons of 2011 – 2013. I compared vegetative community metrics within and among complexes when applicable. These comparisons allow for me to draw conclusions about the condition of wetland sites across Nebraska and provide baseline data for the development, testing, and refinement of additional wetland assessment methods.

METHODS

Study area

Nebraska encompasses and area of approximately 77,400 square miles of which nearly 1.9 million acres or 3.9% is wetland resources (LaGrange 2005). Only 50,000 acres of wetlands occur on conserved or managed lands owned by federal, state, or other conservation organizations (LaGrange 2005). The remaining wetlands occur mainly in the 45.6 million acres of agricultural farm and ranch lands. This has led to a landscape in which many wetlands are spatially and potentially functionally isolated.

The Nebraska Natural Heritage Program has recognized 40 areas in the state that are considered Biologically Unique Landscapes (BULs) (Schneider et al. 2011). These areas were identified to provide a habitat-based approach for prioritizing conservation and management decisions. The BULs are considered areas in Nebraska where a majority of biological diversity can be conserved. Many of Nebraska's wetland complexes coincide with one or more of these BULs.

Wetland complexes and natural communities

I conducted ecological assessments of wetlands in 11 wetland complexes spatially distributed across Nebraska (Figure 2.1). Each complex represents a biologically unique and, in some cases, economically important region in Nebraska. All complexes included opportunities to sample wetlands on both public and private lands. Within each wetland complex, I selected a single natural community within which to conduct ecological assessments (Rolfsmeier and Steinauer 2010) (Table 2.1). For mapping and site selection, each natural community was cross references with one or more Cowardin classes and soil mapping units (Table 2.2). The selection of specific natural communities within each complex served two purposes. First, it allowed for a research focus in natural communities of particular interest due to factors such as rarity on the landscape or known ecological importance. Second, it served to limit the scope of ecological assessments to single natural community and thus allow for within complex comparisons of vegetative communities and ecological quality of wetland sites.

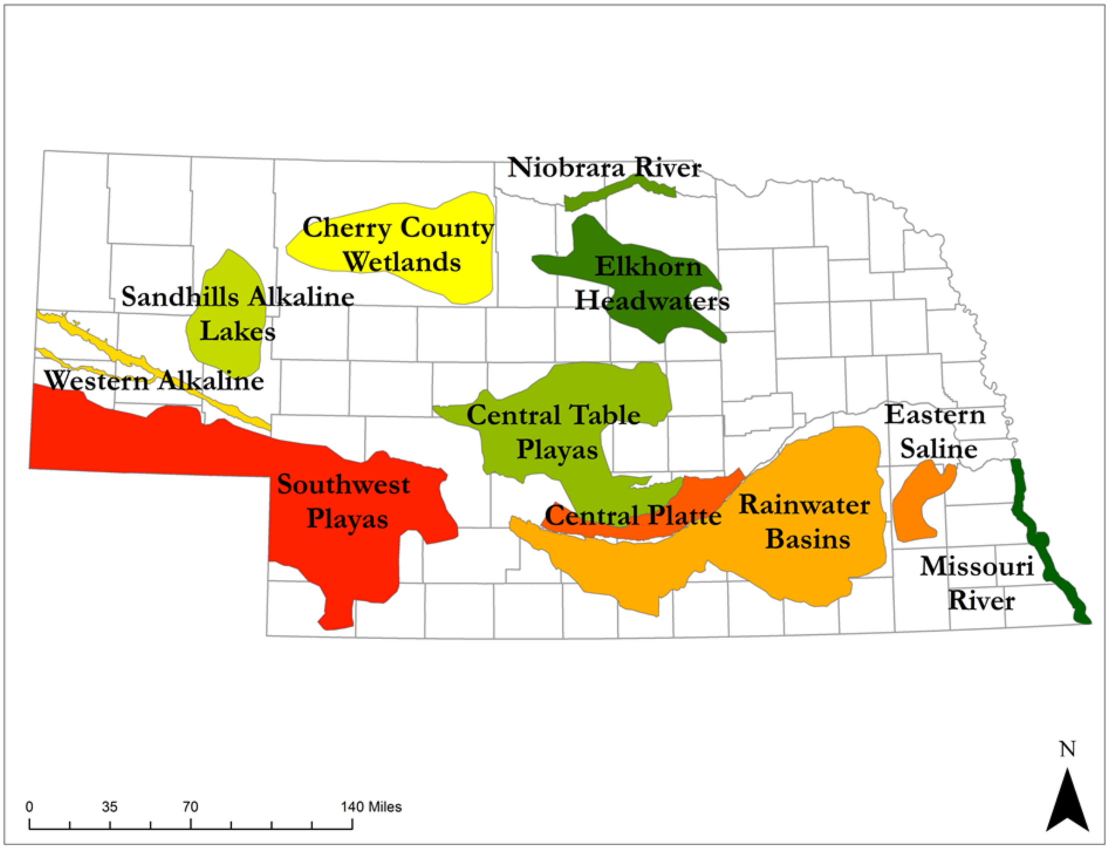

Figure 2.1 The wetland complexes within which ecological assessments of wetlands were conducted from 2011 – 2013.

Table 2.1 Natural communities associated with each wetland complex surveyed from 2011 – 2013. Natural community names are from Rolfsmeier and Steinauer (2010).

Wetland Complex	**Notation**	**Natural Community**
Central Platte	CP	Northern Cordgrass Wet Prairie
Central Table Playas	CTP	Wheatgrass Playa Grassland
Cherry County Wetlands	CCWM	Sandhills Wet Meadow
Elkhorn Headwaters	EHW	Sandhills Hardstem Bulrush Marsh
Missouri River	MR	Eastern Riparian Forest
Niobrara River	NR	Eastern/Northern Sedge Wet Meadow
Rainwater Basins	RWB	Cattail Shallow Marsh
Saline Wetlands	SAL	Eastern Saline Meadow
Sandhills Alkaline Lakes	SALK	Western Alkaline Marsh
Southwest Playas	SWP	Playa Wetland
Western Alkaline	NPR	Western Alkaline Meadow

Table 2.2. Parameters used to define and describe the natural communities associated with each complex including the natural community name (Rolfsmeier and Steinaur 2010), Cowardin classification (Cowardin et al. 1979), and hydric soil type.

Wetland Complex	Biologically Unique Landscape	Natural Community	NWI Cowardin Class	Soil Type
Central Platte	Central Platte River	Northern Cordgrass Wet Prairie	PEMA, PEMC	Barney Complex
Central Table Playas	Central Loess Hills	Wheatgrass Playa Grassland	PEMA, PEMC	Massie silty clay loam
Cherry County Wetlands	Cherry County Wetlands	Sandhills Wet Meadow	PEMA, PEMC	Tryon fine sandy loam
Elkhorn Headwaters	Elkhorn Headwaters	Sandhills Hardstem Bulrush Marsh	PEAM, PEMC	Marlake fine sandt loam
Missouri River	Missouri River	Eastern Riparian Forest/Eastern Cottonwood-Dogwood Riparian Woodland	PFOA, PFOC, PSSA, PSSC	Albaton
Niobrara River	Niobrara River	Eastern Sedge Wet Meadow	PEMA, PEMC	Barney silt loam and Barney Boel
Rainwater Basins	Rainwater Basin East and West	Cattail Shallow Marsh	PEMF, PEMFd	Massie silty clay loam
Saline Wetlands	Saline Wetlands	Eastern Saline Meadow	PEMA, PEMC	Salmo silty clay loam
Sandhills Alkaline Lakes	Sandhills Alkaline Lakes	Western Alkaline Marsh	PEMA, PEMC	Hoffland fine sandy loam
Southwest Playas	Sandsage North and South	Playa Wetland	PEMA, PEMC	Lodgepole silt loam
Western Alkaline	North Platte River Wetlands	Western Alkaline Meadow	PEMA, PEMC	Janise loam

Central Platte (CP) – northern cordgrass wet prairie

The Central Platte River flows through the western Great Plains floodplain which includes natural communities ranging from riparian floodplain forests to marsh and wet meadows. All CP sites were located along the big bend portion of the Central Platte River near Grand Island, Nebraska incorporating all or part of Merrick, Hamilton, and Hall counties. Historically, the Central Platte River consisted of many shallow braided channels and was described as being a mile wide and a foot deep (LaGrange 2005). However, diversions of approximately 70% of the flow combined with agricultural conversion have resulted in riparian forest encroachment and a loss of nearly 73% of historic wet meadow acreage and a presumed decrease in overall wetland condition and function (LaGrange 2005). Most of the remaining wet meadow communities along the Big Bend of the Central Platte River are Northern Cordgrass Wet Prairies. This natural community is found in depressions along the floodplains and terraces of the Central Platte River and may consist of narrow bands or broad swaths of contiguous meadow (Rolfsmeier and Steinauer 2010). The soils tend to be poorly drained alluvial loam and sandy loam with the water table close to or at the soil surface and riverine hydrology. The vegetative community tends to be low to moderate diversity and dense but can be patchy or homogenous, depending upon management and historical land use. Species composition of the northern cordgrass wet prairie is dominated by prairie cordgrass (*Spartina pectinate*) and northern reedgrass (*Calamagrostis stricta*) with interspersed sedges (*Carex* spp.), spikerushes (*Eleocharis* spp.), and rushes (*Juncus* spp.) (Rolfsmeier and Steinauer 2010).

Central Table Playas (CTP) – wheatgrass playa grassland

Central Table Playa wetlands are located on the table lands in the central loess hills of central Nebraska with the majority of the CTP wetlands located in Custer County near the town of Arnold, Nebraska (LaGrange 2005). Hydrology is largely controlled by overland runoff and precipitation, resulting in temporarily and seasonally-flooded wetlands located in small, poorly drained depressions in poorly drained silty clay loam soils (LaGrange 2005, Rolfsmeier and Steinauer 2010). Wetland losses are unknown with major threats being agricultural concentration pits and drainage due to agricultural conversion. Many sites that are not drained are farmed when the conditions allow, resulting in severe sedimentation (LaGrange 2005, Cariveau et al. 2011, Smith et al. 2011). The wheatgrass playa grassland community is typically dominated by perennial herbaceous graminoid species and overall species diversity is low. Diagnostic species of the wheatgrass playa grassland plant community include buffalograss (*Buchloe dactyloides*) and western wheatgrass (*Pascopyrum smithii*) with other common species interspersed including ticklegrass (*Agrostis hyemalis*), bur ragweed (*Ambrosia grayi*), and foxtail barley (*Hordeum jubatum*).

Cherry County Wetlands (CCWM) – sandhills wet meadow

The Sandhills region of Northcentral Nebraska represents the largest contiguous tract of grassland in the United States and largest stabilized sand dune system in the Western Hemisphere (LaGrange 2005). Most Sandhills wetlands are freshwater and include wet meadows, marshes, and lakes. Sandhills wet meadows occur in sandy loam and sandy soils with high organic content located between the stabilized sand dunes common in the Sandhills (Rolfsmeier and Steinauer 2010). The wetland hydrology is largely groundwater and precipitation mediated due to the presence of the Ogallala Aquifer and the water table within one meter of the surface throughout the growing season (Rolfsmeier and Steinauer 2010). Estimates of wetland loss in the Sandhills range from 15 – 46% largely due to water-table declines and drainage through surface ditches to expand hay fields (LaGrange 2005). The vegetative community of Sandhills wet meadows is densely vegetated with high species diversity and are frequently dominated by northern reedgrass (*Calamagrostis stricta*), sedges (*Carex* spp.), and spikerushes (*Eleocharis* spp.) (Rolfsmeier and Steinauer 2010).

Elkhorn Headwaters (EHW) – sandhills hardstem bulrush marsh

The Elkhorn Headwaters are located along the eastern edge of the Sandhills region in northeastern Nebraska. All EHW sites were located in Rock and Holt Counties in the Elkhorn River headwater drainages. Although they may also be associated with lakes, Sandhills hardstem bulrush marshes in the Elkhorn Headwaters occur in small, groundwater fed depressions and are semi-permanently flooded (Rolfsmeier and Steinauer 2010). These wetland communities occur on deep, poorly drained, eolian sand soils with high organic peat and muck content (Rolfsmeier and Steinauer 2010). Similar to Sandhills wet meadows, the major threats to these wetlands are ground water depletion due to agricultural irrigation and drainage for the purpose of increasing hay production (LaGrange 2005). The vegetation of Sandhills hardstem bulrush marshes is primarily dominated by emergent macrophytes with interspersed areas of submerged aquatic vegetation (Rolfsmeier and Steinauer 2010). Although species composition is highly variable due to local hydrological and soil variation dominant emergent species include hardstem bulrush (*Schoenoplectus acutus*), common arrowhead (*Sagittaria latifolia*), and broadleaf cattail (*Typha latifolia*) with locally abundant duckweed (*Lemna* spp.), watermeal (*Wolffia* spp.), coontail (*Ceratophyllum demersum*), and pondweeds (*Potamogeton* spp.) (Rolfsmeier and Steinauer 2010).

Missouri River (MR) – eastern riparian forest

The Missouri River floodplain supports both riverine and marsh wetlands along the Nebraska state line from Boyd County in the north to Richardson County in the southeast. Historically, the Missouri River consisted of braided channels supporting a high diversity of fish, wildlife, and wetlands (LaGrange 2005). Between 1930 and 1970, the Missouri River was drastically altered through channelization (downstream from Sioux City) and the building of mainstem dams in the Dakotas and Montana (LaGrange 2005). All of the MR eastern riparian forest wetland sites that I surveyed were located south of Plattsmouth, Nebraska, where the Platte River joins the Missouri River, including locations in Cass, Otoe, and Nemaha Counties. It is estimated that 95% of Missouri River floodplain has been altered with threats including continued channelization, urban and agricultural development, and drainage and filling for agricultural production (LaGrange 2005). The eastern riparian forest is sparse to moderately open with tree canopy, sub canopy, shrub, vine, and herbaceous communities resulting in sites varying from low to relatively high species diversity (Rolfsmeier and Steinauer 2010). Diagnostic species of the eastern riparian forest community include silver maple (*Acer saccharinum*), roughleaf dogwood (*Cornus drummondii*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoids*), and American elm (*Ulmus americana*) (Rolfsmeier and Steinauer 2010).

Niobrara River (NR) – northern sedge wet meadow

The Niobrara River flows across northern Nebraska along the northern edge of the Sandhills, eventually joining the Missouri River upstream from Lewis and Clark Lake. The eastern sedge wet meadow community occurs along the floodplains of the Missouri River and its tributaries, sometimes in narrow bands interspersed with marshy, backwater channels (Rolfsmeier and Steinauer 2010). Eastern sedge wet meadows may be temporarily or seasonally flooded and occur on poorly drained alluvial silty and clay loam soils (Rolfsmeier and Steinauer 2010). All of the NR eastern sedge wet meadow sites that I surveyed were located along the Niobrara River in Rock, Holt, and Boyd Counties. Wetlands along the Niobrara River have not been highly altered by human activity, although many are hayed and actively grazed (LaGrange 2005). Perhaps the biggest threat to wetlands along the Niobrara River is invasion by purple loosestrife (*Lythrum salicaria*), which has little value to wildlife and is highly invasive (LaGrange 2005). Vegetative cover in eastern sedge wet meadows tends to be dense, but patchy and dominated by species such as fox sedge (*Carex vulpinoidea*), crested sedge (*C. cristatella*), wooly sedge (*C. pellita*), saw-beak sedge (*C. stipata*), and pale bulrush (*Scirpus pallidus*).

Rainwater Basins (RWB) – cattail shallow marsh

The Rainwater Basins (RWB) is a playa wetland complex that is named for the abundant wind formed, clay bottomed depressions that hold precipitation and over-land run-off (LaGrange 2005). The RWB are most noted for their importance to migrating waterfowl, especially during the spring migration, when an estimated 14 million waterfowl annually stop during migration (LaGrange 2005). It is estimated from soil survey maps that there was historically nearly 100,000 acres of wetland habitat present in the RWB; however, estimates from the early 1990's indicated a nearly 80% loss of wetland area and 90% loss of historic wetlands (Schildman et al. 1984, Raines et al. 1990, LaGrange 2005). Most losses can be directly attributed to draining and filling for agricultural development, although the digging of reuse pits, sedimentation, and pollution are also major threats (LaGrange 2005). Due to these historic losses, importance to wildlife, and continued threats, the U.S. Fish and Wildlife Service has declared the RWB an area of critical concern for wetland losses (Tiner 1984). Additionally, the state of Nebraska assigned the wetland complex a priority 1 ranking in the Nebraska Wetlands Priority Plan (Gersib 1991). All of the RWB cattail shallow marshes surveyed were located east of Hastings, Nebraska in Clay, Fillmore, York, and Seward Counties. Cattail shallow marshes are common in the RWB and occur in wind-formed alluvial or loess depressions underlain by an impervious clay pan (Rolfsmeier and Steinauer 2010). RWB cattail shallow marshes tend to be semi-permanently flooded with a vegetative community consisting mainly of emergent macrophytes, submerged aquatic vegetation, and floating vegetation (Rolfsmeier and Steinauer 2010). Common species of cattail shallow marshes include river bulrush (*Bolboshoenus fluviatilis*), broadleaf cattail (*Typha latifolia*), narrowleaf cattail (*T. angustifolia*), and slender bulrush (*Schoenoplectus heterochaetus*).

Saline Wetlands (SAL) – eastern saline meadow

The eastern saline wetlands are all located in and around Lincoln, Nebraska in Lancaster and Saunders Counties. All historic and remaining eastern saline wetlands occur in swales and depressions within the floodplains of Salt Creek and its tributaries

(LaGrange 2005). The hydrology of the eastern saline wetlands is mainly mediated through groundwater and overbank flooding (LaGrange 2005). The salinity in the wetlands occurs due to groundwater passing through underground rock formation that contain salt deposits (LaGrange 2005). The salinity of these wetlands results in a vegetation community dominated by halophytic plants with variations in plant community due to variations in local salinity. Eastern saline wetlands are used by over 230 bird species and are critically important for the state endangered and federally listed Salt Creek tiger beetle and state endangered saltwort (*Salicornia rubra*). Eastern saline wetlands and their associated plant communities are considered the most limited and endangered in Nebraska (Clausen et al. 1989). Although the historic extent of eastern saline wetlands is unknown, inventory and monitoring efforts have noted significant losses due to the expansion of the city of Lincoln, Nebraska and agricultural conversion (Gilbert and Stutheit 1994). Continued expansion of Lincoln, agricultural activities, and incision of Salt Creek and its tributaries continue to result in direct and indirect losses of eastern saline wetlands and their associated plant communities. Common and diagnostic species of the eastern saline meadow plant community include inland saltgrass (*Distichlis spicata*), seablite (*Suaeda calceoliformis*), plains bluegrass (*Poa arida*), Texas dropseed (*Sporobolus texanus*), and saltwort.

Sandhills Alkaline Lakes (SALK) – western alkaline marsh

The western alkaline marshes are abundant in portions of the western Sandhills in Garden, Morrill, and Sheridan Counties where interdunal basins and lakes are present with little to no surface water inflow or outflow (LaGrange 2005, Rolfsmeier and Steinauer 2010). Soils underlying the western alkaline lakes and marshes are poorly drained, strongly alkaline silty loams and sandy loams. Hydrology in these systems is influenced by precipitation, overland flow, and groundwater discharge with sites remaining inundated through most of the growing season (Rolfsmeier and Steinauer 2010). The western alkaline lakes have not been heavily impacted by drainage, grazing, and exotic species and remain fairly widespread in the western Sandhills (Rolfsmeier and Steinauer 2010). Many of these wetlands support unique bird communities resulting in wildlife watching opportunities. Western alkaline marsh plant communities tend to be somewhat sparse and low diversity, dominated by three-square bulrush (*Shcoenoplectus pungens*) and in some cases Nevada bulrush (*Amphiscripus nevadensis*) (Rolfsmeier and Steinauer 2010).

Southwest Playas (SWP) – playa wetland

The southwest playas occur in shallow, wind-formed, clay-lined depressions in southwestern Nebraska (LaGrange 2005, Rolfsmeier and Steinauer 2010). Hydrology of these wetlands is mediated by precipitation and surface runoff, resulting in temporary to seasonally flooded that usually dry out by mid to late summer (LaGrange 2005, Rolfsmeier and Steinauer 2010). Due to minimal rainfall, most southwest playas have not been drained and are annually farmed. Continued tillage and farming has resulted in increased sedimentation in some instances and the presence of concentration pits and roadside ditches have led to loss of some playa wetlands (LaGrange 2005, LaGrange et al. 2011). Furthermore, no southwest playa wetlands occur on protected lands (Rolfsmeier and Steinauer 2010). Little is known about the ecological importance of these wetlands, but it has been noted that they provide important habitat for both shorebirds and amphibians during the spring (LaGrange 2005, Cariveau et al. 2011). Due to the dynamic nature of these wetlands, vegetative communities may vary among sites and years. Diagnostic species of southwest playa wetlands include plains coreopsis (*Coreopsis tinctoria*) and barnyard grass (*Echinocloa muricata*) (Rolfsmeier and Steinauer 2010).

Western Alkaline (NPR) – western alkaline meadow

Western alkaline meadows occur in depressions along the floodplain of the North Platte River and along the upper reaches of Pumpkin Creek in northwestern Nebraska (LaGrange 2005). Hydrology of western alkaline meadows is a result of springs, runoff, and flooding and is largely influenced by local irrigation withdraws and seepage(LaGrange 2005). The high alkalinity is principally caused by high rates of evaporation resulting in the concentration of sodium carbonate and calcium carbonate (LaGrange 2005). Although wetlands in this complex have experienced fewer direct losses to urban and agricultural development, local irrigation withdraws from the North Platte River and Pumpkin Creek have resulted in partial or complete loss of wetland hydrology and subsequent shifts in wetland plant communities (LaGrange 2005). Diagnostic plant species of the western alkaline meadow include Nevada bulrush, inland saltgrass, saline saltbush (*Atriplex dioica*), alkali sacaton (*Sporobolus airoides*), and alkali arrowgrass (*Triglochin maritime*).

Site selection

Individual sites in each wetland complex were selected using a probability-based sample design (Stevens and Jensen 2007, Wardrop et al. 2007) in ArcGIS 10.3 (ESRI 20014). Because it is difficult to implement a probability-based sample of wetlands from one data frame (e.g. the National Wetland Inventory Maps (NWI) miss 50% of forested wetlands and up to 20% of other wetlands; Stevens and Jensen 2007, Wardrop et al. 2007), this design used multiple frames to define a "universe" of potential sample locations from which a simple random sample of wetlands is selected. I used three data frames in order to define the "universe" from which used simple random sampling to select sites that were surveyed. These data frames are: the National Wetlands Inventory (NWI), which uses the Cowardin wetland classification system to define wetland types (Cowardin et al. 1979); the Soil Survey Geographic (SSURGO) for Nebraska, which maps soil types throughout the state; and a wetland complex coverage, which depicts the boundaries for the wetland complexes that were surveyed. Wetland complexes included in the coverage map largely coincide with BUL's recognized by the Nebraska Natural Heritage Program as unique natural communities in the state, but some were modified to limit the spatial distribution of sample points.

I defined the "universe" of wetlands by merging these data frames to create a new data set that only included polygons where NWI wetlands, hydric soils, and the wetland complexes coincided. In order to reduce the inherent variation in site characteristics, only one wetland natural community type (Rolfsmeier and Steinauer 2010) was sampled in each complex. I spatially defined these natural communities based on soil types that typically coincide with each community type. Both the community types and coinciding soils are based on expert local knowledge (see Table 2.2 for descriptions of wetlands complexes, natural communities, Cowardin classification, and hydric soil types). For example, in the saline wetland complex, I defined the sample "universe" for eastern saline meadows by determining the intersection of NWI emergent wetlands and salmo silty clay loam soils within the saline wetland complex boundaries. I further constrained the “universe” of wetlands to wetlands larger than 500 m^2 because all five 10 m x 10 m vegetation plots must fit within the wetland without overlapping.

A simple random sample of nine wetlands was selected from this defined “universe” of wetlands. The simple random sample was limited to sites at least 280 m apart to avoid spatial overlap and hydrological connectivity among sites, as buffer zones around each point extended 140 m in all directions. A single “reference standard” wetland was selected within each complex based on local knowledge and previous studies (Brinson and Rheinhardt 1996). The “reference standard” wetland is a site that is considered to be representative of the best ecological condition known to exist. It also provides a site to which all other sample locations in a complex can be compared. I also selected up to 21 extra sites that were surveyed if sample points are unsampleable due to permission being denied or wetlands occurring in areas that are inaccessible due to logistical or physical constraints (Stevens and Jensen 2007, Wardrop et al. 2007).

Site and vegetation sample plot set-up

In general, I followed sample plot set-up as described by the 2011 NWCA field manual (USEPA 2011). For each wetland site, a random point was selected within the confines of the wetland boundary. A standard assessment area (AA) was a 0.5 ha area surrounding the point. It was established using 40 m transects in each of the cardinal directions (north, south, east, and west), thus creating a circle that is 80 m in diameter. The area within this circle is the AA. The entirety of the AA must fall within the boundaries of the wetland. For wetlands with an area that is less 0.5 ha, but greater than 0.1 ha, the wetland boundary demarcated the boundary of the AA.

I assessed a total of five 100 m^2 plots in each AA, extending in the cardinal directions from the point. One plot was located 2 m south of the central point with the remaining plots occurring 22 m, 20 m, 15 m, and 15 m (S, E, N, W respectively) from the central point (Figure 2.2). I collected vegetative data using a nested design in which characteristics will be collected at three spatial scales. Species diversity, relative abundance, and vegetative structure are assessed at the 100 m^2 scale and in two 10 m^2 and two 1 m^2 nested plots located in the NW and SE corners of the larger 100 m^2 plots.

Vegetation Sampling

With the help of an experienced botanist, I measured vegetative characteristics at each wetlands site focusing on species composition, relative abundance, and vegetative structure within the wetland AA. Within each vegetation plot, all vascular plant species were identified to the lowest possible taxonomic level. Absolute percent cover was estimated visually for each individual species. Summed absolute cover could exceed 100% due to canopies of different heights and species overlapping one another. If a plant species could not be identified in the field, a representative specimen was collected and identified in the lab. If a plant could not be identified to the species level, data were recorded but excluded from any further analysis. Prior to analysis nomenclature was standardized among years to match the 2011 Nebraska Natural Heritage Program state species list. Additionally, a site-specific relative cover value was calculated for each species using the following equation:

$$RC_{ij} = \frac{AC_{ij}}{\sum(AC_{ij})}$$

where:

RC_{ij} = relative cover of species *i* at site *j*

AC_{ij} = absolute cover of species *i* at site *j*.

Vegetative community metrics and calculations

Due to the relative ease of calculating multiple vegetation metrics from a single data set, vegetative community data is both robust and powerful. This plethora of metrics and indicators provide multiple useful measures of the ecological integrity of wetlands. Using the plant community richness and cover data, I calculated vegetative community metrics similar to those described in the Ohio Vegetation Index of Biotic Integrity manual (Table 2.3) (Mack 2004) and components of FQAI metrics (Swink and Wilhelm 1994, Taft et al. 1997, Rooney and Rogers 2002, Matthews et al. 2005, and Bourdaghs et al. 2006)

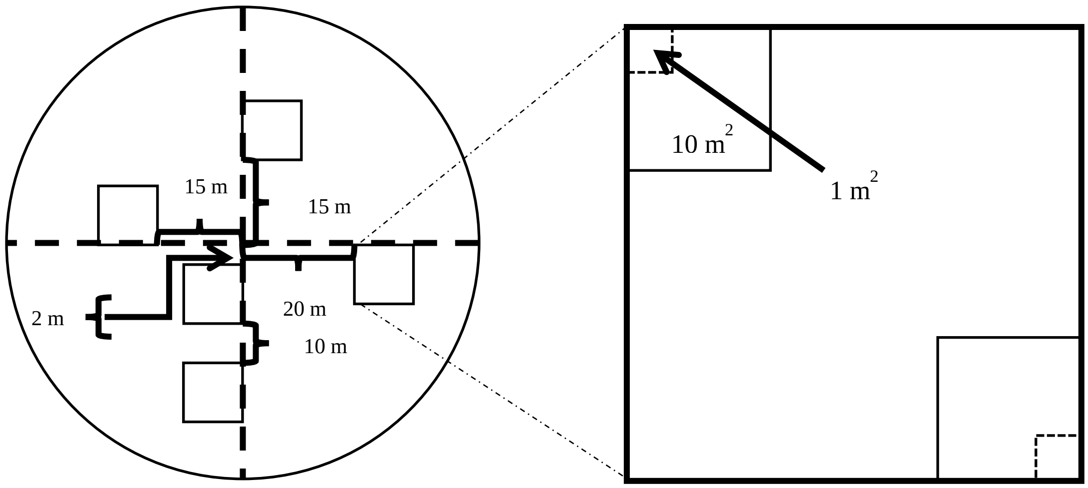

Figure 2.2 Vegetation species diversity, relative abundance, and vegetative structure were assessed in five vegetation plots consisting of a 100 m^2 and two 10 m^2 and two 1 m^2 nested plots located in the NW and SE corners of the larger 100 m^2 plot.

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Table 1.3 Descriptions of the metrics calculated based upon the vegetative community data for each site. The first six metrics represent various measures of plant community richness and cover. The final two metrics are similar to values calculated during wetland delineations based upon wetness descriptors and associated scores.

Metric	Notation	Description
Total species richness	tot	Total number of species (S_i)
Native species richness	nat	Total number of native species (S)
Proportion of native species	prop.nat	S / S_i
Relative cover of tolerant species	tol	Sum of the relative cover of plants with a coefficient of conservatism (C) ≤ 3
Relative cover of sensitive species	sens	Sum of the relative cover of plants with a coefficient of conservatism (C) ≥ 6
Carex species richness	car	Number of species in the genus *Carex*
Number of native genera	gen	Number of native genera with at least one species
Proportion of FAC of greater species	fac	Number of dominant (relative cover ≥ 20%) native species with a wetness designation of FAC or greater divided the total number of dominant native species (dominance test; USACE 2010)
Mean wetness	wet	The mean wetness value for all dominant plant species present calculated as the sum of the wetness scores divided by the total species richness (prevalence index; USACE 2010)

Reference Standard Wetlands

Reference standard wetlands are sites within a defined geographic region or ecological classification, such as wetland plant community type, and may include both high quality and low-quality wetland sites (Brinson and Rheinhardt 1996). The use of reference standard wetland sites provides for a baseline for comparison against which wetland condition at subsequent sites can be compared and the determination of relative quality determined. I performed full ecological condition assessments at one reference standard wetland site within each of the 11 wetland complexes. Each of the reference standard wetland sites were selected based upon the best professional judgement of managers and researchers who conduct work in and around each wetland complex. For my purposes, I selected sites assumed to exhibit the highest level of ecological condition and function.

RESULTS

I conducted vegetative community surveys at 109 sites located in 11 wetland complexes across Nebraska (see Figure 2.1 for map of complexes). I calculated vegetative community metrics for each site. Results for each complex are described separately with summaries provided in the tables below.

Central Platte (CP) – northern cordgrass wet prairie

I conducted vegetative community surveys at ten wetlands along the Central Platte River including nine randomly selected sites and one reference standard site (Figure 2.3). Although all of the sites surveyed fell on privately held lands, two sites (CPREF and CP4) were located on Mormon Island, which is owned and actively managed by the Whooping Crane Trust. Vegetative community metrics varied among sites within the Central Platte wetland complex, but native species richness ($\mu = 43.5$) and proportion of native species ($\mu = 0.84$) were consistently high at all sites (Table 2.3).

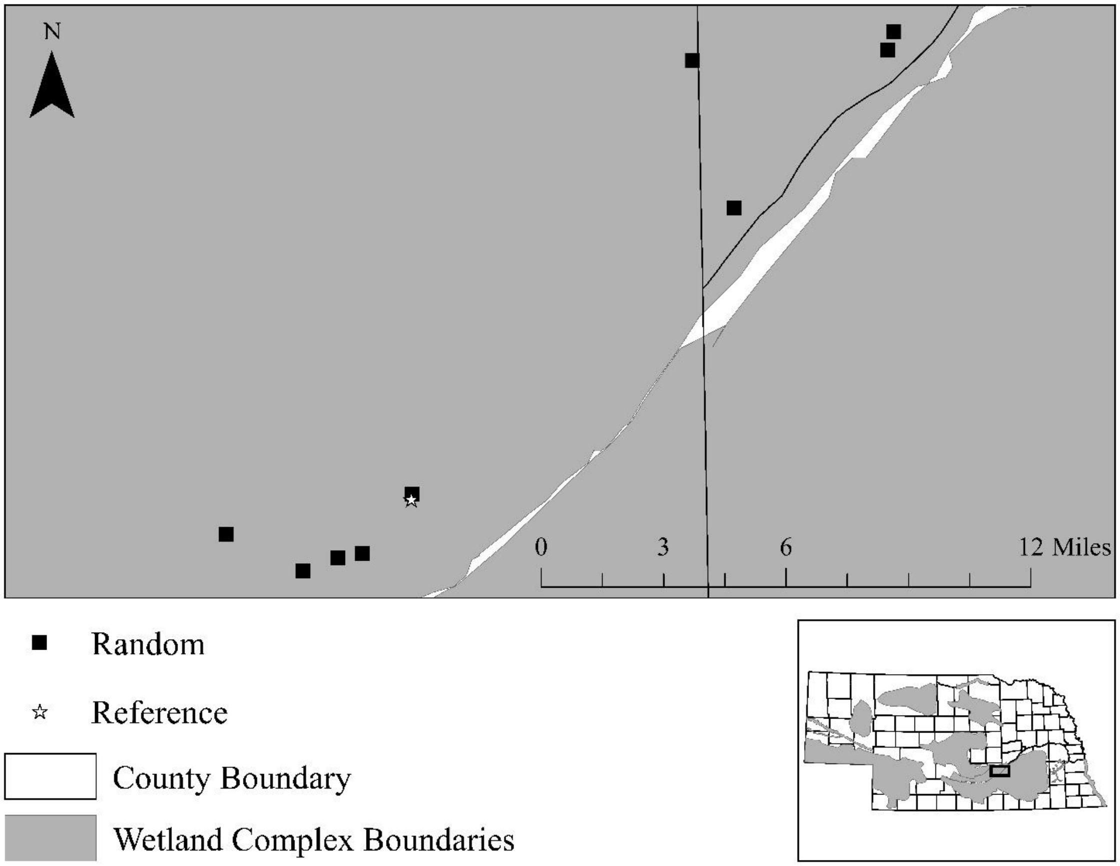

Figure 2.3. The locations of the nine randomly selected and one reference standard wetland site surveyed in the CP wetland complex.

Table 2.4. Results of vegetative community metric calculations for northern cordgrass wet prairie wetland sites in the CP wetland complex located along the Big Bend portion of the Central Platte River.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
CP1	50	39	0.78	2.11	1.06	2	35	0.41	3.74
CP2	49	38	0.78	10.62	6.60	6	30	0.79	2.59
CP3	42	34	0.81	7.95	8.37	8	23	0.76	2.69
CP4	65	60	0.92	5.56	48.68	7	43	0.88	2.14
CP5	50	46	0.92	3.03	0.91	3	20	0.96	1.58
CP6	43	39	0.91	1.99	19.99	8	28	0.92	1.86
CP7	51	36	0.71	26.03	0.88	4	31	0.92	2.39
CP8	43	35	0.81	19.39	7.66	7	24	0.86	2.37
CP9	64	52	0.81	7.52	12.01	6	40	0.94	1.97
CPREF	61	56	0.92	5.46	12.62	8	41	0.88	2.21
Complex mean	51.80	43.50	0.84	8.97	11.88	5.90	31.50		

Central Table Playas (CTP) – wheatgrass playa grassland

I conducted vegetative community surveys at nine CTP wetlands in the central loess hills. Like most of Nebraska, most CTP wetlands fall on privately owned lands making it potentially difficult to gain access to wetland sites. Due to these issues, I was only able to gain access to nine CTP wetland sites including eight randomly selected and one reference standard wetland site (Figure 2.4). Two of the CTP wetland sites (CTP3 and CTP4) were farmed prior to vegetative community surveys, resulting in no wetland vegetation being present (Table 2.5). When wetland vegetation was present, due to lack of recent tillage and/or weed control, sites had relatively low species richness and were dominated by tolerant plant species (Table 2.5).

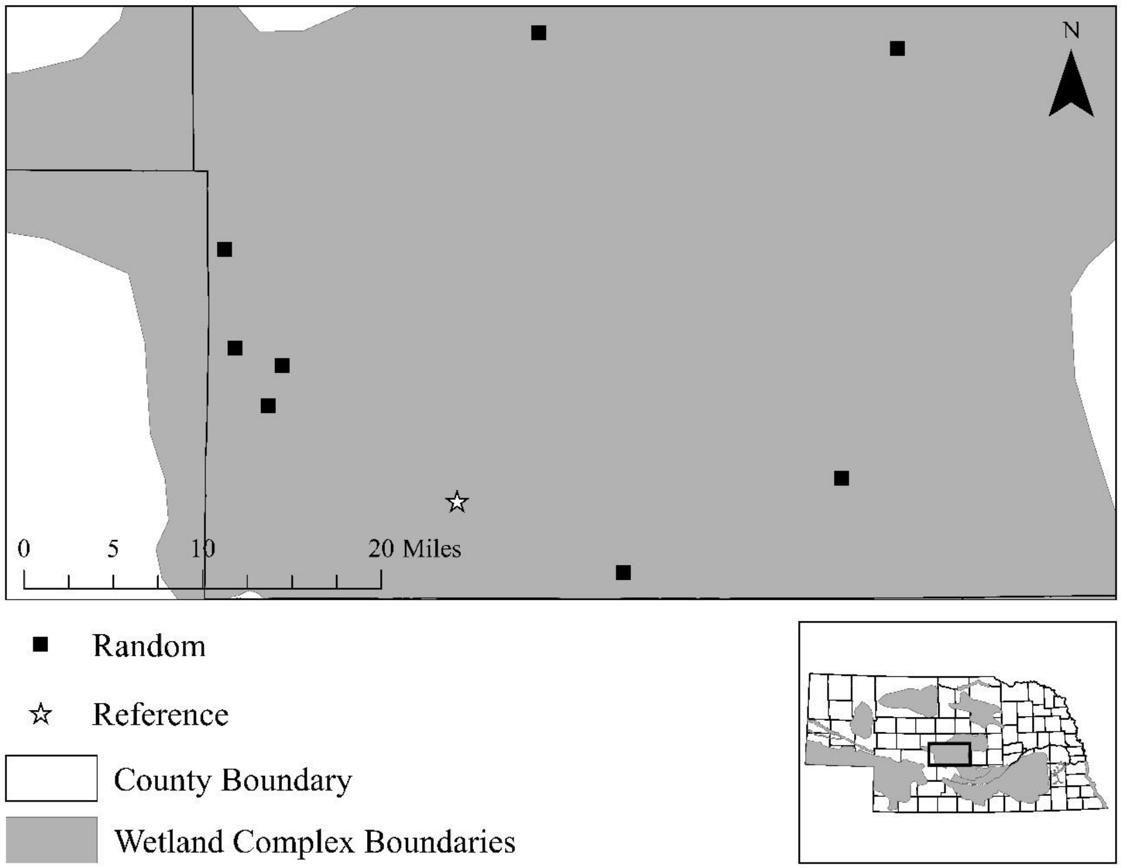

Figure 2.4. The locations of the eight randomly selected and one reference standard wetland site surveyed in the CTP wetland complex.

Table 2.5. Results of vegetative community metric calculations for northern cordgrass wet prairie wetland sites in the CTP wetland complex located in the central loess hills of central Nebraska.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
CTP1	27	21	0.78	95.91	0.00	1	18	0.76	2.70
CTP2	4	1	0.25	0.00	0.00	0	1	1.00	2.50
CTP3	0	0	0.00	0.00	0.00	0	0	0.00	5.00
CTP4	0	0	0.00	0.00	0.00	0	0	0.00	5.00
CTP5	16	13	0.81	95.15	0.00	2	12	0.62	2.81
CTP6	14	12	0.86	90.67	0.00	0	12	0.75	2.43
CTP7	4	1	0.25	12.73	0.00	0	1	1.00	2.75
CTP8	10	7	0.70	90.53	0.00	0	7	0.71	2.40
CTPREF	16	10	0.63	11.20	0.00	1	10	0.60	3.00
Complex mean	10.11	7.22	0.47	44.02	0.00	0.44	6.78		

Cherry County Wetland (CCWM) – sandhills wet meadow

I conducted vegetative community surveys at ten Sandhills wet meadow sites in the Sandhills of Cherry County in north central Nebraska (Figure 2.5). Of the ten wetland sites surveyed, seven occurred on public property including six sites located on the Valentine National Wildlife Refuge and one site on the Samuel McKelvie National Forest. All sites had a high native species richness (μ = 36.3) and high proportion of native species (μ = 0.90) as well as high relative cover of sensitive plant species (Table 2.6).

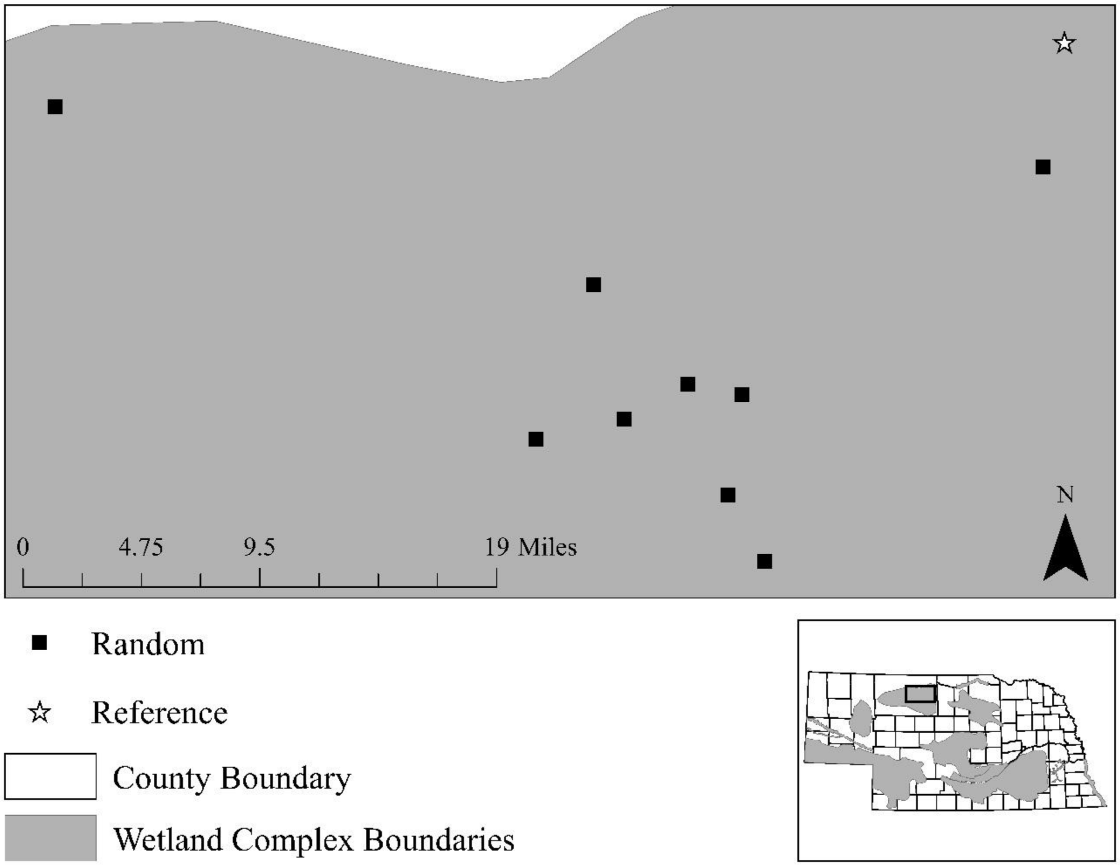

Figure 2.5. The locations of the nine randomly selected and one reference standard wetland site surveyed in the CCWM wetland complex.

Table 2.6. Results of vegetative community metric calculations for northern cordgrass wet prairie wetland sites in the CCWM wetland complex located in Cherry County and the Sandhills region of northcentral Nebraska.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
CCWM1	43	39	0.91	8.27	23.74	4	30	0.67	2.60
CCWM2	33	28	0.85	3.12	30.10	9	15	1.00	1.79
CCWM3	44	41	0.93	23.38	22.74	7	28	0.85	2.05
CCWM4	35	32	0.91	11.23	26.24	7	21	0.88	2.37
CCWM5	38	34	0.89	19.6	21.60	9	19	0.94	1.63
CCWM6	46	42	0.91	3.06	35.51	13	23	0.81	2.22
CCWM7	51	46	0.90	18.88	12.04	13	27	0.87	1.98
CCWM8	44	42	0.95	6.45	14.92	6	25	0.86	2.07
CCWM9	35	27	0.77	1.72	34.08	7	18	0.89	2.26
CCWMREF	35	32	0.91	2.3	29.57	10	19	0.94	2.03
Complex mean	40.40	36.30	0.90	9.80	25.05	8.50	22.50		

Elkhorn Headwaters (EHW) – Sandhills hardstem bulrush marsh

I performed vegetative community surveys at ten EHW wetland sites in the eastern Sandhills region of Nebraska (Figure 2.6). All nine randomly selected sites were located on private lands; however, the reference standard site was located on Yellowthroat Wildlife Management Area in Rock County, Nebraska. EHW sites showed moderate native species richness ($\mu = 24.4$) with a high proportion of native species ($\mu = 0.87$) and moderate relative cover of sensitive plant species ($\mu = 21.97$) (Table 2.7).

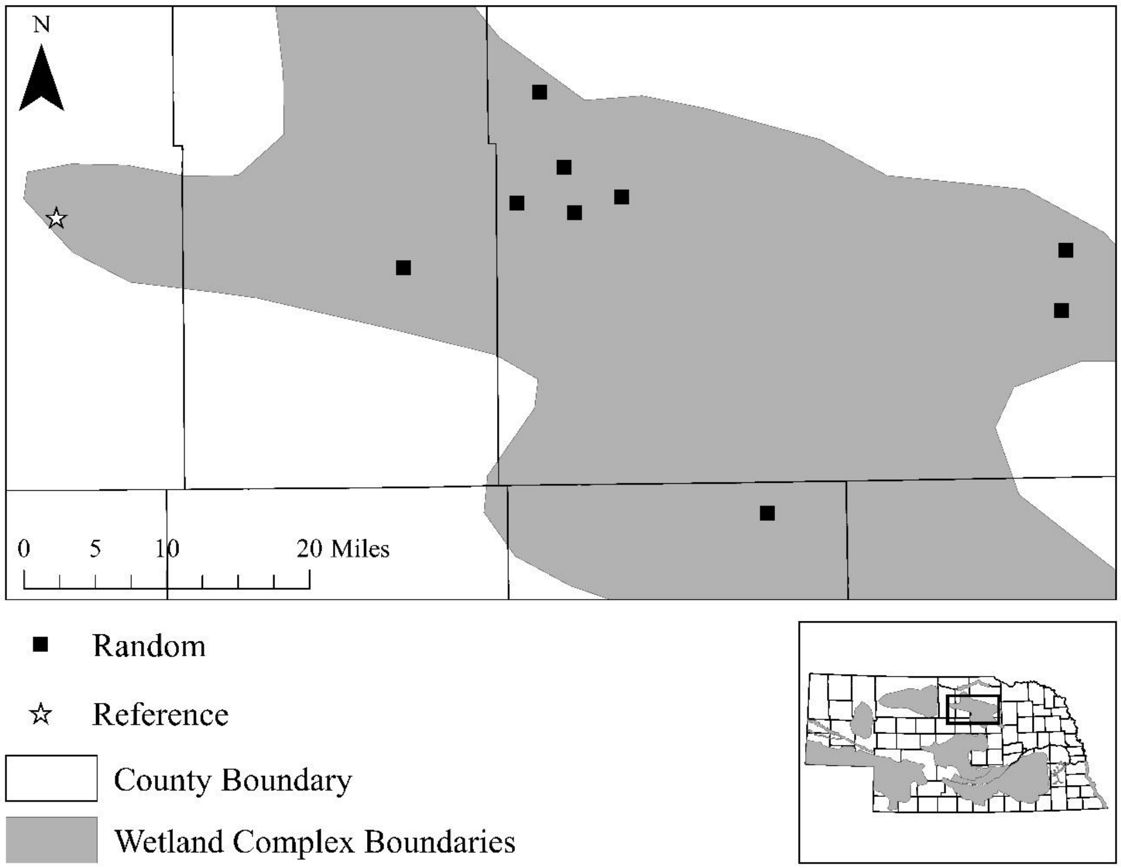

Figure 2.6. The locations of the nine randomly selected and one reference standard wetland site surveyed in the EHW wetland complex.

Table 2.7. Results of vegetative community metric calculations Sandhills hardstem bulrush marsh wetland sites in the EHW wetland complex located in the eastern Sandhills region of Nebraska.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
EHW1	19	18	0.95	25.23	4.94	2	14	1.00	1.11
EHW2	32	28	0.88	13.99	53.87	2	23	0.96	1.41
EHW3	58	43	0.74	0.18	22.59	3	33	0.98	1.76
EHW4	30	27	0.90	22.31	25.64	3	21	1.00	1.20
EHW5	14	12	0.86	0.02	19.49	1	10	1.00	1.21
EHW6	16	15	0.94	0.61	23.72	2	11	1.00	1.19
EHW7	24	22	0.92	5.68	15.18	3	18	1.00	1.13
EHW8	42	37	0.88	0.34	1.24	3	29	0.92	1.79
EHW9	22	19	0.86	30.02	44.80	1	17	1.00	1.14
EHWREF	31	23	0.74	4.02	8.23	2	18	0.96	1.81
Complex mean	28.80	24.40	0.87	10.24	21.97	2.20	19.40		

Missouri River (MR) – eastern riparian forest

I conducted vegetative community surveys at ten MR eastern riparian forest wetland sites located south of Plattsmouth, Nebraska (Figure 2.7). Five of the randomly selected sites were located on public properties managed by the Nebraska Game and Parks Commission, while the remaining sites, including the reference standard site were located on private properties in the Missouri River floodplain. In general, MR sites had low to moderate native species richness ($\mu = 24.3$) with vegetative communities dominated by tolerant species ($\mu = 49.95$) (Table 2.8).

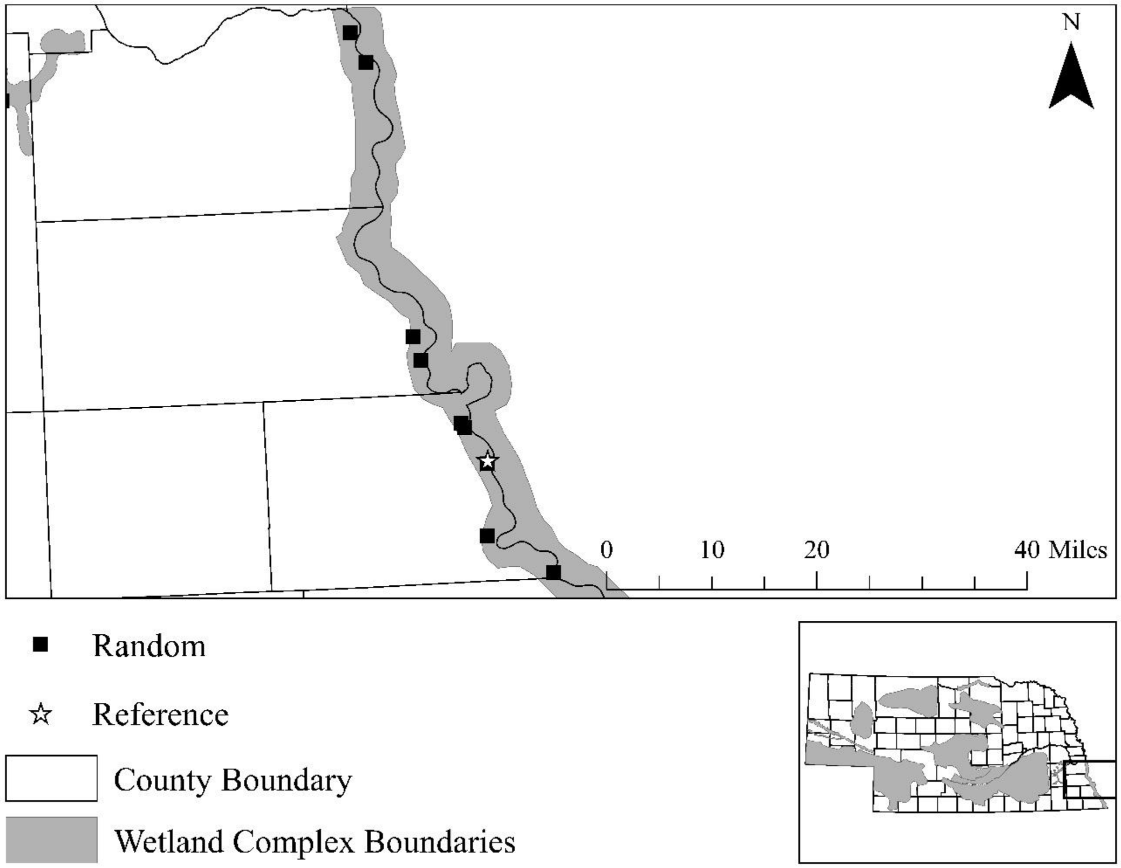

Figure 2.7. The locations of the nine randomly selected and one reference standard wetland site surveyed in the MR wetland complex.

Table 2.8. Results of vegetative community metric calculations for eastern riparian forest wetland sites in the MR wetland complex located in the Missouri River floodplain between Cass County and Nemaha County.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
MR1	46	36	0.78	46.38	0.86	1	33	0.58	3.16
MR2	71	58	0.82	26.01	2.87	3	42	0.67	3.03
MR3	14	5	0.36	45.27	0.00	0	5	0.60	2.93
MR4	30	22	0.73	82.62	1.34	1	18	0.73	2.62
MR5	35	23	0.66	46.86	2.51	0	22	0.74	2.77
MR6	24	17	0.71	51.63	0.49	1	16	0.65	2.92
MR7	23	14	0.61	80.06	0.00	0	14	0.79	2.70
MR8	27	18	0.67	37.10	0.00	0	18	0.67	3.15
MR9	21	11	0.52	16.45	0.00	0	11	0.64	3.29
MRREF	48	39	0.81	67.14	2.86	1	35	0.77	2.75
Complex mean	33.90	24.30	0.67	49.95	1.09	0.70	21.40		

Niobrara River (NR) – northern sedge wet meadow

I surveyed ten eastern sedge wet meadow wetland sites located in Niobrara River floodplain in Rock, Holt, and Boyd Counties in northern Nebraska (Figure 2.8). Because little work has been conducted within this wetland complex, no reference standard site was selected for sampling and I instead sampled ten randomly selected sites. Two randomly selected NR wetland sites were located on public lands, while the remaining eight randomly selected sites were located and private property including one site on lands actively managed by the Nebraska Audubon Society. NR wetland site native species richness was moderately high ($\mu = 34.0$) with approximately equal relative cover of both tolerant and sensitive plant species ($\mu = 11.46$ and $\mu = 15.2$ respectively) (Table 2.9).

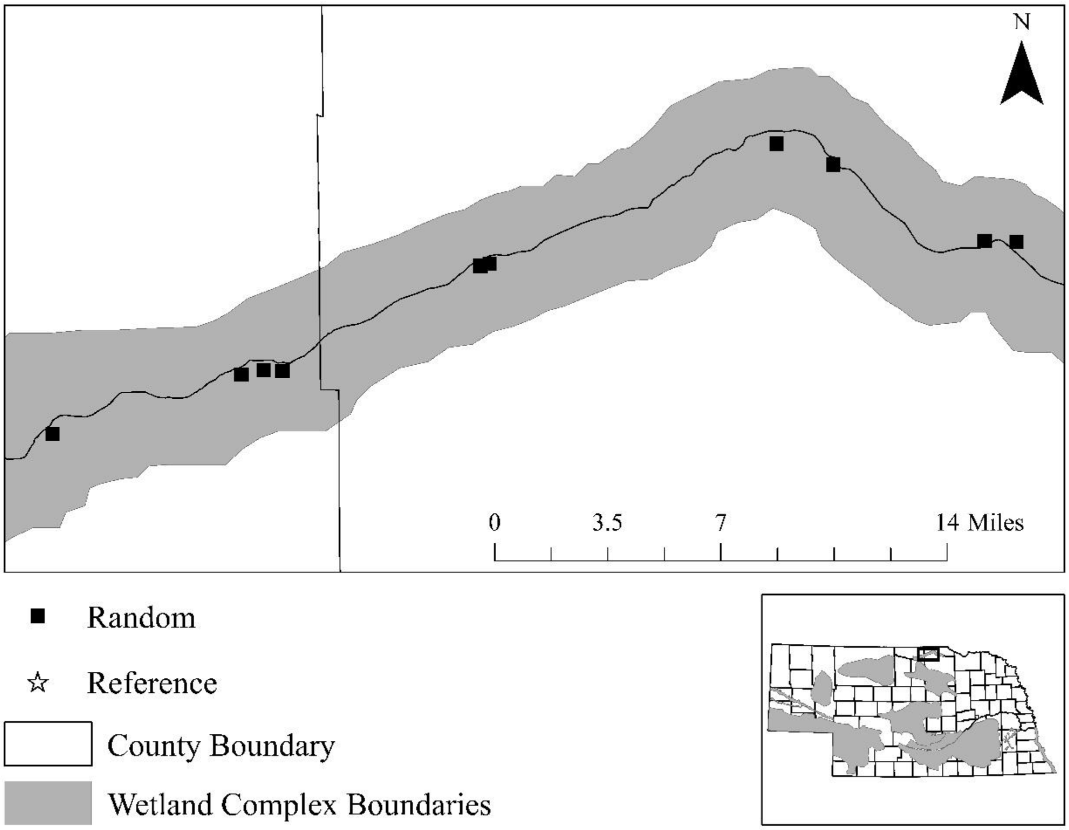

Figure 2.8. The locations of the nine randomly selected and one reference standard wetland site surveyed in the NR wetland complex. No reference standard site was selected for this complex due to lack of knowledge in regards to wetland condition in the complex.

Table 2.9. Results of vegetative community metric calculations for eastern sedge wet meadow wetland sites in the NR wetland complex located in the Niobrara River floodplain in Rock, Holt, and Boyd Counties.

Site	**tot**	**nat**	**prop.nat**	**tol**	**sens**	**car**	**gen**	**fac**	**wet**
NR1	38	34	0.89	3.10	6.64	2	25	0.71	2.33
NR2	38	32	0.84	6.49	23.03	5	23	0.81	2.61
NR3	55	47	0.85	12.39	15.46	7	34	0.91	2.07
NR4	32	28	0.88	35.88	29.02	4	24	0.82	2.28
NR5	34	23	0.68	8.40	1.50	4	19	0.83	2.71
NR6	70	57	0.81	16.43	17.63	5	45	0.74	2.70
NR7	45	39	0.87	7.50	16.23	5	30	0.82	2.31
NR8	40	33	0.83	9.80	13.33	7	22	0.91	2.18
NR9	23	10	0.43	1.67	0.00	4	7	0.90	2.74
NR10	43	37	0.86	12.89	29.13	5	29	0.84	2.02
Complex mean	41.80	34.00	0.79	11.46	15.20	4.80	25.80		

Rainwater Basins (RWB) – cattail shallow marsh

I conducted vegetative community surveys ten cattail shallow marsh wetland sites in the RWB complex located in southcentral Nebraska (Figure 2.9). Because many wetlands of this type are deep and frequently flooded and thus difficult to farm and drain, seven of the randomly selected wetland sites as well as the reference standard wetland site were located on public lands including Wildlife Management and Waterfowl Production Areas managed by the Nebraska Game and Parks Commission and US Fish and Wildlife Service respectively. Native species richness was low RWB sites ($\mu = 13.1$) but proportion of native species was high ($\mu = 0.88$) (Table 2.10).

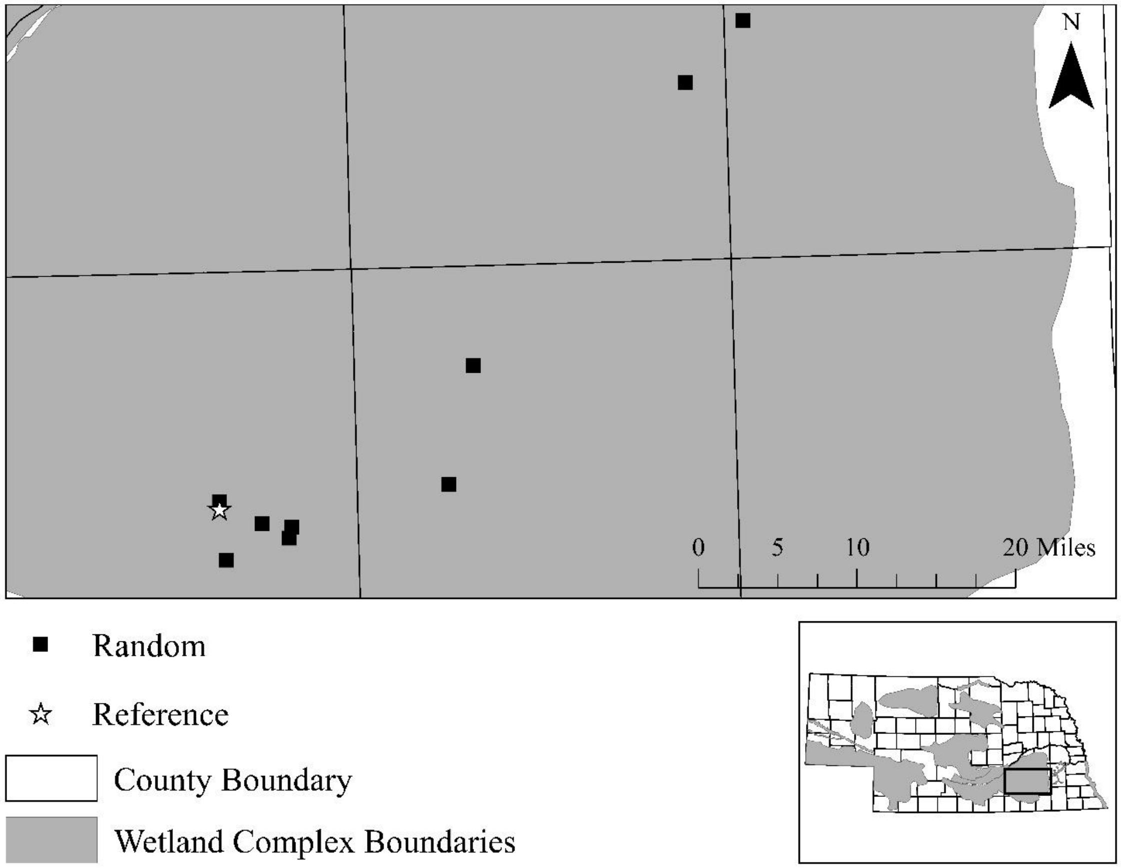

Figure 2.9. The locations of the nine randomly selected and one reference standard wetland site surveyed in the RWB wetland complex.

Table 2.10. Results of vegetative community metric calculations for cattail shallow marsh wetland sites in the RWB wetland complex located in Clay, Fillmore, York, and Seward Counties in central Nebraska.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
RWB1	21	18	0.86	25.34	33.17	0	15	1.00	1.14
RWB2	3	3	1.00	99.72	0.00	0	3	1.00	1.33
RWB3	11	11	1.00	69.07	2.48	0	10	1.00	1.09
RWB4	6	6	1.00	65.26	1.10	0	6	1.00	1.17
RWB5	5	5	1.00	85.64	0.00	0	5	1.00	1.20
RWB6	19	17	0.89	66.34	1.48	0	14	1.00	1.16
RWB7	18	13	0.72	79.78	0.00	0	11	0.85	1.78
RWB8	8	5	0.63	35.15	0.00	0	5	1.00	1.25
RWB9	52	43	0.83	41.70	1.28	0	33	0.88	1.92
RWBREF	11	10	0.91	45.44	4.38	0	10	1.00	1.09
Complex mean	15.40	13.10	0.88	61.34	4.39	0.00	11.20		

Saline Wetland (SAL) – eastern saline meadow

I conducted vegetative community surveys at ten eastern saline meadow wetland sites in the SAL wetland complex located in an around Lincoln, Nebraska (Figure 2.10). Five of the saline meadow wetland sites were located on public properties including the reference standard site, while the remaining five sites were located on private properties north of Lincoln. Native species richness was relatively low at all SAL wetland sites (μ = 16.7) but the proportion of native species at sites was high (μ = 0.83) (Table 2.11). I detected the state endangered saltwort (*Salicornia rubra*) at only two SAL wetland sites (SAL4 and SALREF).

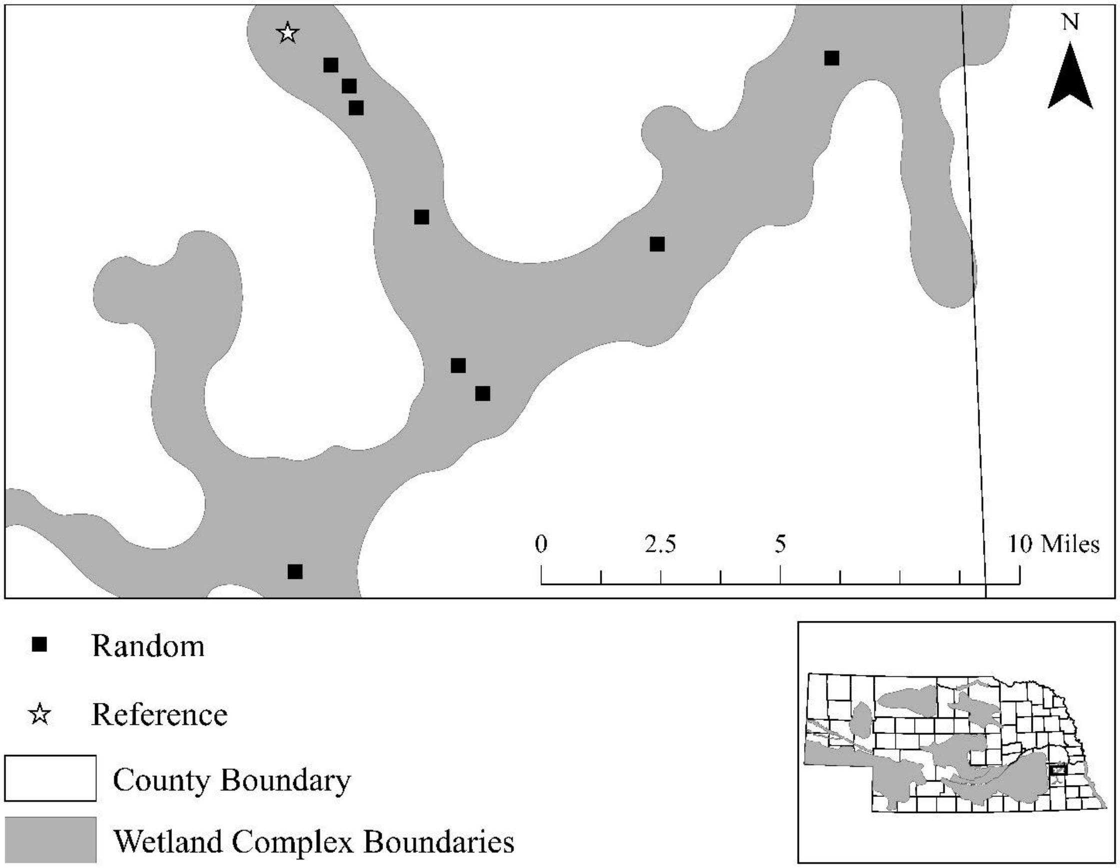

Figure 2.10. The locations of the nine randomly selected and one reference standard wetland site surveyed in the SAL wetland complex.

Table 2.11. Results of vegetative community metric calculations for eastern saline meadow wetland sites in the SAL wetland complex located Lancaster County in and around Lincoln, Nebraska.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
SAL1	34	27	0.79	53.91	4.63	4	22	0.74	2.65
SAL2	30	26	0.87	14.76	15.68	1	25	0.81	2.10
SAL3	32	26	0.81	42.93	0.53	5	20	0.77	2.31
SAL4	10	9	0.90	52.44	12.28	0	9	1.00	1.90
SAL5	9	7	0.78	2.89	0.00	0	7	0.86	2.11
SAL6	26	23	0.88	20.39	0.19	0	22	0.65	2.46
SAL7	9	8	0.89	55.28	42.89	0	8	0.88	1.56
SAL8	24	18	0.75	90.93	3.40	1	16	0.78	2.29
SAL9	21	16	0.76	1.95	0.58	1	16	0.75	2.52
SALREF	8	7	0.88	84.31	0.60	0	6	1.00	1.50
Complex mean	20.30	16.70	0.83	41.98	8.08	1.20	15.10		

Sandhills Alkaline Lakes (SALK) – western alkaline marsh

I conducted vegetative community surveys at ten sandhills alkaline lake wetland sites in the SALK wetland complex in the western Sandhills of Garden, Morrill, and Sheridan Counties (Figure 2.11). All ten wetlands sites were located on private property. Native species diversity was low at most sites ($\mu = 17.2$) and the relative cover of tolerant species was low ($\mu = 8.43$; Table 2.12). In addition, the proportion of native species was high ($\mu = 0.83$) including three sites with proportions of native species greater than 0.9 (Table 2.12).

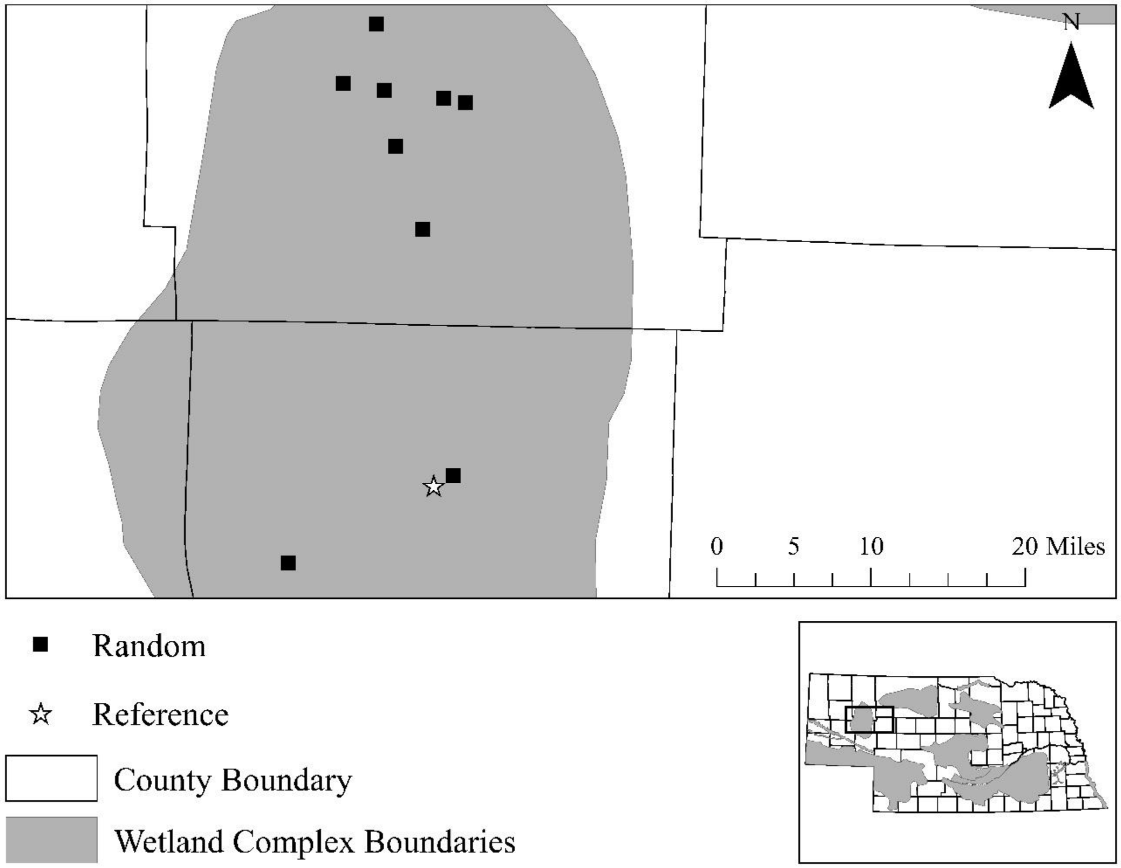

Figure 2.11. The locations of the nine randomly selected and one reference standard wetland site surveyed in the SALK wetland complex.

Table 2.12. Results of vegetative community metric calculations for western alkaline marsh wetland sites in the SALK wetland complex located in the western Sandhills of Garden, Morrill, and Sheridan Counties.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
SALK1	23	14	0.61	0.82	15.79	5.00	9.00	0.86	2.65
SALK2	10	9	0.90	4.43	13.62	2.00	7.00	1.00	1.20
SALK3	18	12	0.67	1.16	11.35	4.00	8.00	0.92	2.11
SALK4	29	28	0.97	7.07	15.82	0.00	23.00	0.82	2.24
SALK5	13	11	0.85	23.17	7.03	1.00	11.00	0.91	1.85
SALK6	42	36	0.86	19.12	7.95	1.00	29.00	0.64	2.88
SALK7	16	12	0.75	2.84	2.42	4.00	9.00	1.00	1.88
SALK8	30	25	0.83	2.39	21.72	3.00	17.00	1.00	1.77
SALK9	15	13	0.87	20.33	0.00	0.00	12.00	0.85	2.07
SALKREF	12	12	1.00	2.95	11.14	2.00	10.00	1.00	1.50
Complex mean	20.80	17.20	0.83	8.43	10.68	2.20	13.50		

Southwest Playas (SWP) – playa wetland

I conducted vegetative community surveys at ten playa wetlands in the SWP complex in the southern panhandle of western Nebraska (Figure 2.12). Six of the SWP wetland sites were in active row crops and had no native vegetation present. All of the ten sites were privately owned. Total species diversity and native species diversity were low at all sites ($\mu = 4.6$ and $\mu = 3.6$ respectively) and when vegetation was present, most communities were dominated by native species (> 0.65) (Table 2.13). No sensitive species were present at any site.

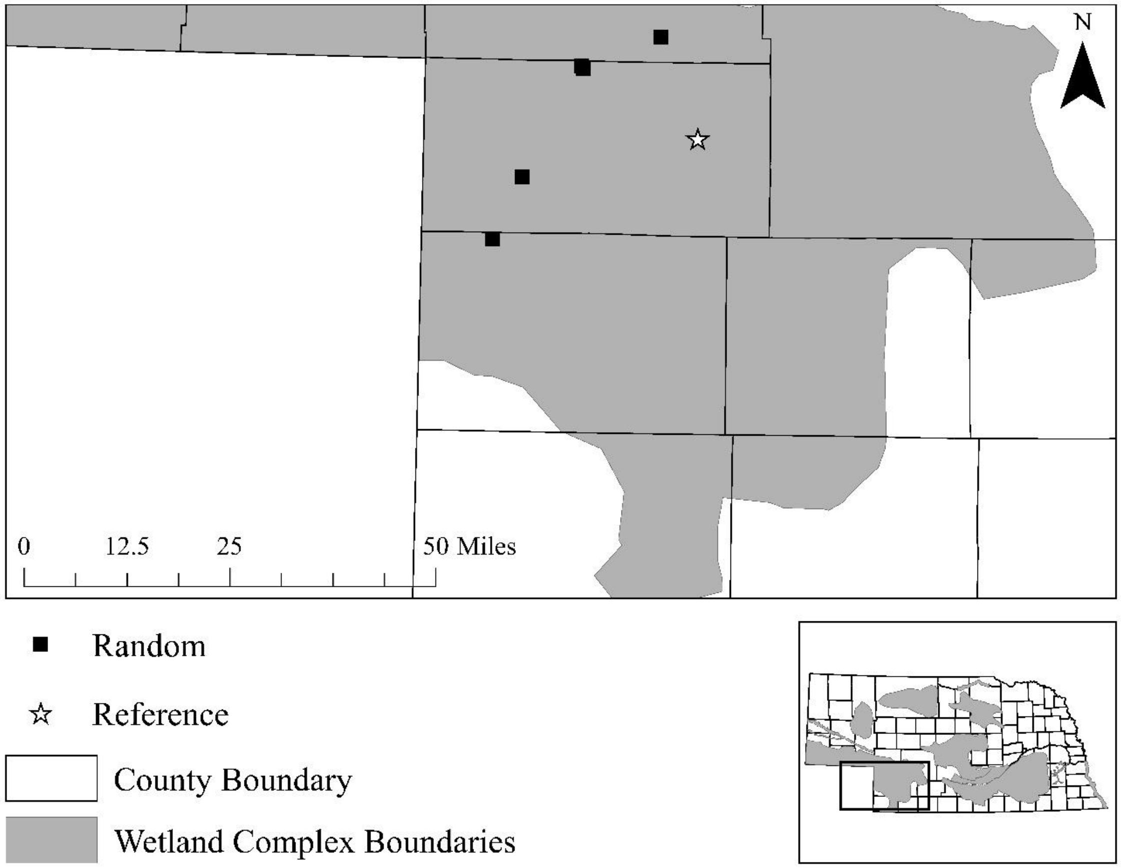

Figure 2.12. The locations of the nine randomly selected and one reference standard wetland site surveyed in the SWP wetland complex.

Table 2.13. Results of vegetative community metric calculations for southwest playa wetland sites in the SWP wetland complex located in the panhandle of southwestern Nebraska.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
SWP1	19	13	0.68	62.09	0.00	0	11	0.92	2.11
SWP2	0	0	0.00	0.00	0.00	0	0	0.00	5.00
SWP3	5	2	0.40	25.50	0.00	0	2	1.00	3.20
SWP4	8	8	1.00	2.38	0.00	0	5	0.75	1.75
SWP5	0	0	0.00	0.00	0.00	0	0	0.00	5.00
SWP6	0	0	0.00	0.00	0.00	0	0	0.00	5.00
SWP7	0	0	0.00	0.00	0.00	0	0	0.00	5.00
SWP8	0	0	0.00	0.00	0.00	0	0	0.00	5.00
SWP9	0	0	0.00	0.00	0.00	0	0	0.00	5.00
SWPREF	14	13	0.93	7.31	0.00	0	10	0.85	2.07
Complex mean	4.60	3.60	0.30	9.73	0.00	0.00	2.80		

Western Alkaline (NPR) – western alkaline meadow

I conducted vegetative community surveys at nine randomly selected and one reference standard wetland site in the NPR wetland complex in western Nebraska along the North Platte River and Pumpkin Creek (Figure 2.13). Three of the randomly selected sites and the reference standard site were located on public lands, while the remaining sites were located on private properties. Native species diversity was relatively low (μ = 15.5) in addition to the proportion of native species (μ = 0.66) (Table 2.14). Furthermore, tolerant species cover was nearly 50%.

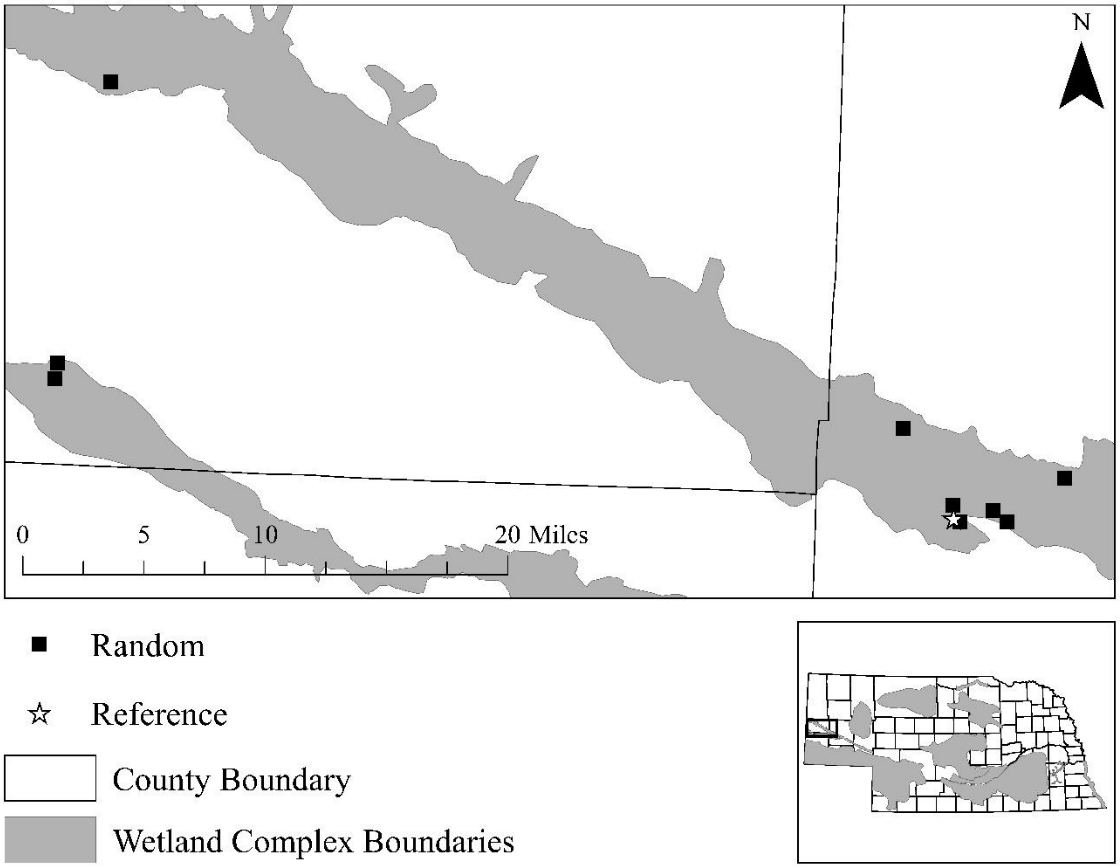

Figure 2.13. The locations of the nine randomly selected and one reference standard wetland site surveyed in the NPR wetland complex.

Table 2.14. Results of vegetative community metric calculations for western alkaline meadow wetland sites in the NPR wetland complex located along the North Platte River and Pumpkin Creek in the Nebraska panhandle.

Site	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
NPR1	28	14	0.50	24.02	1.53	2	12	1.00	2.68
NPR2	15	8	0.53	73.55	0.00	1	8	0.88	2.93
NPR3	20	13	0.65	40.37	1.95	1	13	0.85	2.65
NPR4	34	23	0.68	43.01	2.13	1	21	0.70	3.24
NPR5	26	17	0.65	30.45	0.66	2	15	0.76	3.12
NPR6	27	16	0.59	47.79	0.00	1	15	0.63	3.48
NPR7	22	16	0.73	30.60	26.32	2	14	0.88	2.27
NPR8	12	11	0.92	70.24	0.00	0	10	0.64	3.08
NPR9	29	22	0.76	72.43	0.22	1	22	0.64	3.48
NPRREF	27	15	0.56	52.43	8.21	1	15	0.87	3.04
Complex mean	24.00	15.50	0.66	48.49	4.10	1.20	14.50		

Site Comparisons

Vegetative community metrics were variable within and among complexes although some generalizations may be inferred (Table 2.15). As expected, there was a wide variation in measures of species and genera richness, with all three being greater in wet meadow and similar wetland communities and lowest in playa wetland communities. Overall, the proportion of native species was relatively high, but somewhat lower in the three playa wetland communities (RWB, CTP, and SWP) and in the NPR wetland community. Cover of both tolerant and sensitive species was variable within and among wetland communities, but generally higher in wet meadow plant communities. The fac and wet metrics taken together are a measure of wetland plant community presence and dominance at a site. Generally, fac was high and wet was low as expected, but this trend did not hold true for two of the playa wetland communities (CTP and SWP) and the MR wetland community.

Table 2.15. Summary and comparison of vegetative community metrics for each of the 11 wetland complexes surveyed across Nebraska. Standard error is reported in parenthesis.

Complex	tot	nat	prop.nat	tol	sens	car	gen	fac	wet
CP	51.80 (± 2.74)	43.50 (± 2.97)	0.84 (± 0.02)	8.97 (± 2.50)	11.88 (± 4.52)	5.90 (± 0.69)	31.5 (± 2.54)	0.83 (± 0.05)	2.35 (± 0.19)
CTP	10.11 (± 3.00)	7.22 (± 2.46)	0.47 (± 0.12)	44.02 (± 15.60)	0.00 (± 0.00)	0.44 (± 0.24)	6.78 (± 2.20)	0.60 (± 0.12)	3.18 (± 0.35)
CCWM	40.40 (± 1.90)	36.30 (± 2.07)	0.90 (± 0.02)	9.80 (± 2.56)	25.05 (± 2.42)	8.50 (± 0.92)	22.50 (± 1.55)	0.87 (± 0.03)	2.10 (± 0.09)
EHW	28.80 (± 4.21)	24.40 (± 3.06)	0.87 (± 0.02)	10.24 (± 3.70)	21.97 (± 5.29)	2.20 (± 0.25)	19.40 (± 2.33)	0.98 (± 0.01)	1.38 (± 0.09)
MR	33.90 (± 5.34)	24.30 (± 4.99)	0.67 (± 0.05)	49.95 (± 6.81)	1.09 (± 0.39)	0.70 (± 0.3)	21.40 (± 3.69)	0.68 (± 0.02)	2.93 (± 0.07)
NR	41.80 (± 4.11)	34.00 (± 4.04)	0.79 (± 0.04)	11.46 (± 3.06)	15.20 (± 3.25)	4.80 (± 0.47)	25.80 (± 3.14)	0.83 (± 0.02)	2.40 (± 0.09)
RWB	15.40 (± 4.51)	13.10 (± 3.70)	0.88 (± 0.04)	61.34 (± 7.55)	4.39 (± 3.23)	0.00 (± 0.00)	11.20 (± 2.73)	0.97 (± 0.02)	1.31 (± 0.09)
SAL	20.30 (± 3.30)	16.70 (± 2.68)	0.83 (± 0.02)	41.98 (± 9.97)	8.08 (± 4.24)	1.20 (± 0.57)	15.10 (± 2.25)	0.82 (± 0.04)	2.14 (± 0.12)
SALK	20.80 (± 3.21)	17.02 (± 2.88)	0.83 (± 0.04)	8.43 (± 2.79)	10.68 (± 2.07)	2.20 (± 0.55)	13.50 (± 2.30)	0.90 (± 0.04)	2.02 (± 0.16)
SWP	4.60 (± 2.20)	3.60 (± 1.75)	0.30 (± 0.13)	9.73 (± 6.34)	0.00 (± 0.00)	0.00 (± 0.00)	2.80 (± 1.38)	0.35 (± 0.14)	3.91 (± 0.46)
NPR	24.00 (± 2.13)	15.50 (± 1.44)	0.66 (± 0.04)	48.49 (± 5.80)	4.10 (± 2.59)	1.20 (± 0.2)	14.50 (± 1.38)	0.78 (± 0.04)	3.00 (± 0.12)

Discussion

Vegetative community metrics are commonly used to make inferences about the ecological condition of wetlands. For example, the Ohio Vegetative Index of Biotic Integrity uses multiple measures from vegetative community survey data to measure ecological condition of wetlands, but found measures to be variable among wetland types and regionally (Mack 2004). Vegetative community metrics were variable within and among wetland complexes in Nebraska (Table 2.15). Despite potential issues in making comparisons among wetland complexes, these results may inform on drivers of variation in wetland plant communities including hydrology, extreme weather events, tillage, and eutrophication. Additionally, some metrics may not be applicable to all vegetative communities studied.

Vegetative communities in Nebraska wetlands show natural variation in multiple vegetative community metrics (Table 2.15), including total species richness, native species richness, and number of native genera. A quick review of the abundant and diagnostic species lists for the communities assessed in this study, illustrates expected differences in species and genera richness (Rolfsmeier and Steinauer 2010). In general, one would expect higher species and genera richness in wet meadow communities, such as the CP, CCWM, and NR vegetative communities; in contrast, one expects lower diversity in playa wetlands such as the CTP, RWB, and SWP vegetative communities. These trends are consistent with results from wetland sites assessed during this study. One of the primary drivers of the presence and maintenance of wetlands in general, as well as the type of vegetative community present is hydrologic regime (Thiet 2002, Rolfsmeier and Steinauer 2010, Lou et al. 2016). In the case of RWB wetlands in this study, most are semi-permanent shallow water depressional wetlands, with water above the surface during most if not the entire growing season in most years. While some of this is natural, many of the wetlands in the RWB region are manually pumped to maintain water depth during the spring and fall. Although a similar depressional wetland, the EHW vegetative community had greater species richness than RWB wetlands. The increase in species richness likely relates to the more permanent hydrology of these wetlands due to groundwater presence and sandy soils, allowing for the growth of submerged aquatic and emergent species, whereas RWB wetlands tended to be dominated by only emergent species. Further, EHW wetlands tended to have greater cover of sensitive species, as submerged aquatic species are more sensitive to the permanence of water table height than emergent species.

In contrast to the depressional wetland communities with presence of semi-permanent above ground water, wet meadow communities seasonally maintain water above the soil surface due to an influx of groundwater as the water table rises. As the water table recedes during the drier summer months, water above the soil surface is no longer present except for the occasional slough or heavy rain event. These conditions are ideal for diverse graminoid dominated plant communities (Casanova and Brock 2000). The CP and CCWM, both wet meadow vegetative communities, had both the highest levels of species richness, genera richness, and *Carex* species richness (Table 2.15). Similar results were observed in floodplain wetlands of Northeast China in which wet meadow communities with lower water levels and shorter plant height had significantly higher diversity than marsh communities (Lou et al. 2016). Coastal Great Lakes wetlands with lower water levels and lower vegetation height showed increased diversity over dyked coastal wetlands (Thiet 2002). These trends are consistent with vegetative community results in both marsh and wet meadow communities of Nebraska during this study.

Natural and human induced extremes in hydrology can also have significant impacts on vegetative communities. Impacts as the result of change in hydrology can be observed in vegetative metrics such as cover of tolerant species (tol), proportion of FAC or greater species (fac), and mean wetness (wet). These metrics, however, must be interpreted relative to references standard condition. For example, RWB wetlands are simplistic communities generally dominated by tolerant species with some sensitive species interspersed. Therefore, the expected plant community will have high cover of tolerant species and moderate cover of sensitive species. Such interpretations vary by vegetative community type. Differences from reference standard condition are particularly apparent in the CTP, MR, SAL, and MPR vegetative communities due to hydrological alterations or severe natural variations in hydrology. In two instances, CTP and MR wetland sites, variation from reference standard likely relates to extremes in natural hydrology. During the year in which CTP wetland sites were surveyed, Central Nebraska was experiencing an historic drought. The drought in conjunction with grazing and other management activities at many sites led to a situation in which upland species were able to flourish, resulting in lower proportions of fac or greater species and values for mean wetness. Both are indicative of a wetland partially dominated by upland plant species. In contrast to drought conditions, during the year prior to surveys of MR wetland sites, the Missouri River flood plain experienced a 500-year flood event during which all of the wetland sites surveyed were under water for extended period of time.

This resulted in early successional, annual plant species dominating the plant communities at the surveyed sites. A reset of the system resulting in an early successional plant community, such as those observed, is not unexpected after such severe flooding event (Bendix and Hupp 2000). I suspect that over the following decade, surveyed wetland sites will continue through succession, returning to the expected riparian hardwood forest.

Human induced changes to hydrology also have impacts on wetland vegetative communities. Perhaps the best and largest example of this occurs in the Everglades of Southern Florida in which hydrology is now disconnected from natural wet and dry seasons, but rather human manipulated through a series of canals and dykes, leading to drastic shifts in vegetation communities (David 1996, Zweig and Kitchens 2008). A similar series of agricultural canals and heavy water withdraws for center pivot agriculture in the Nebraska panhandle on the North Platte River has lowered the water table and in some cases nearly drained tributaries to the river. In some instances, this has led to a decrease in the proportion of FAC or greater species and increase in the mean wetness score for wetlands, both of which are indicative of a wetland that is becoming drier thus allowing upland species to invade. The SAL wetlands near Lincoln, NE are a wetland system with a hydrology dependent upon both groundwater and overbank flooding of the nearby Salt Creek and its tributaries. During the 1800's and early- to mid-1900's portions of Salt Creek were channelized and including the placement of hardened banks (Farrar and Gersib 1991). This has resulted in three major changes in the Salt Creek watershed: increased downward incision of the creek bed, decreased overbank flooding, and lowering of the water table (Rus et al. 2003). This is important, as upwelling of the groundwater through salt-rich bedrock is the primary source of salts for the saline wetlands. Reduction in salts has led to subsequent reductions in salinity, thus allowing tolerant plants such as *Typha* spp. to invade and spread such as seen at SAL2, SAL5, SAL6, and SAL9 (Table 2.11).

Although some of the shifts in the SAL and other Nebraska wetland vegetative communities may be attributed to changes in hydrology, eutrophication may also lead to decreases in diversity, increases in tolerant species, and other shifts in vegetative community diversity and structure. In a meta-analysis of vegetative communities and nutrients, Bedford et al. (1999) concluded that: 1) Plant communities shift across nutrient gradients; 2) species richness declines as nutrients increase; and 3) rare and uncommon species richness declines as nutrients increase. Although they also found that nutrient thresholds beyond which shifts occur are not always well known. Anecdotally, some of the sites with lower richness in the CP, RWB, and SAL wetland vegetative communities occur in areas with adjacent land uses dominated by various types of nutrient intensive agriculture. Such a juxtaposition often results in increases in nutrients and culturally accelerated sediment, both of which can alter vegetation communities. Although I collected water samples at many sites for water quality analysis, these types of snapshot samples are not necessarily representative of water quality as they do not capture the variation present in each system due to factors such as time of year and recent rainfall. Therefore, I cannot positively conclude that eutrophication has resulted in changes in vegetative communities, but it is likely given prior knowledge of the studied wetland communities and on the ground observations. I suspect that differences in within wetland complex native species richness, proportion of native species, and cover of tolerant species are all partially driven by increased nutrients. This may be particularly true for sites now dominated by non-native species such as *Typha x Glauca* (Woo and Zedler 2002) and *Phalaris arundinacea* (Green and Galatowitsch 2002) and be more obvious in typically higher diversity wetland complexes such as CP and CCWM.

Some of the metrics calculated are not applicable to all vegetative communities surveyed during this study. For example, the metric "car" measures the number of *Carex* species detected during vegetative surveys at a site. Within a complex such as CP or CCWM, both of which are sedge meadow communities, one would expect a high diversity of *Carex* species within a site, with a dearth of such species indicating a shift in vegetative community away from reference standard. This metric, however, is not very useful for CTP and SWP sites where *Carex* species are anticipated to be scarce or absent. Similarly, while one might expect high species diversity in the aforementioned wet meadow communities, one would also expect low species diversity in a playa wetland.

Conclusions

Although these results are somewhat inconsistent with other efforts, such as the Ohio VIBI where researchers were able to use vegetative community metrics to identify the condition of sites (Mack 2004), they are not entirely surprising, particularly when considering the fact that most other methods were developed using far fewer wetland community types. For example, the Ohio VIBI was developed using only four wetland community types, largely based upon Cowardin Classifications, rather than specific vegetative communities (Mack 2004), while in other cases, efforts were focused on a single wetland community type such depressional marshes (Cohen et al. 2004), temperate prairie wetlands (Genet and Bourdaghs 2006), or depressional wetlands (Lopez and

Fennessy 2002). This suggests that efforts such as IBI development may only be effective for few or single categories of wetlands and may work best when applied at general classification levels such as HGM or Cowardin classifications. It should also be noted, however, that I only surveyed nine or ten sites of each vegetative community, so an increased sample size would increase my ability to infer differences among complexes.

I calculate and report many vegetative community metrics; however, most are not useful when comparing wetlands among complexes. Therefore, one should not use vegetative metrics to make comparisons among complexes, but instead focus vegetative community metric comparisons within a single complex. Rather, these data provide baseline measures against which to measure changes within sites and complexes and opportunities to see inconsistencies among sites and identify the need and opportunities for ongoing and future management efforts.

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CHAPTER 3

LEVEL 3 - ASSESSING THE ECOLOGICAL CONDITION OF NEBRASKA'S WETLANDS USING A STANDARDIZED FLORISITIC QUALITY ASSSESSMENT INDEX

INTRODUCTION

Many methods exist for the ecological assessment of aquatic ecosystems, although paradigms and methodologies have shifted over time. During the 1980's, the functional assessment approach was introduced for the evaluating the condition of wetlands (Adamus 1983, Adamus et al. 1987). The incorporation of hydrological, biogeochemical, plant community, and faunal community data led to the development and proliferation of the use of the Hydrogeomorphic (HGM) approach to assessing the ecological condition of wetlands (Brinson 1993, Brinson and Rheinhardt 1996). During the same period, biological assessment techniques (Indices of Biologic Integrity; IBI), using various biological organisms as indicators of ecological condition were developed and implemented in multiple other aquatic ecosystems including rivers and streams (Karr 1981, 1991, Miller et al. 1988), lakes (Minns et al. 1994), and estuaries (Deegan et al, 1997). Although initially IBI's focused on fish communities (Karr 1981, Miller et al. 1988), similar indices have since been developed for macroinvertebrates (Burton et al. 1999, Uzarski et al. 2004), periphyton (Hill et al. 2000, Griffith et al. 2005), and plant communities (Simon et al. 2001, Ferreira et al. 2005). Although plant community IBI's have been successfully applied in wetland ecosystems (Rothrock et al. 2007), such assessments involve the calculation and incorporation of multiple community metrics. As an alternative, Floristic Quality Assessment Indices (FQAI) offer a simpler approach to assessing the ecological condition of multiple ecosystems and involve the calculation of only a single index score (Wilhelm 1977, Swink and Wilhelm 1994).

The Floristic Quality Assessment Index (FQAI) score, has been used as a method to identify wetlands of high conservation value, monitor wetlands, restorations, and mitigation sites over time, assess anthropogenic impacts to a wetland, and measure the ecological condition of wetland areas (Bourdaghs et al. 2006, Matthews et al. 2009). FQAI was initially developed in Illinois as a uniform and repeatable method to assess the quality of natural areas based upon vegetative communities (Wilhelm 1977) and was refined and expanded conceptually and methodologically by Swink and Wilhelm (1994) and Taft et al. (1997). Since the 1990's, FQAI methods have been further refined and developed for use in 10 states and one Canadian province (Milburn et al. 2007). Additionally, FQAI has been shown to be a responsive and reliable indicator of the ecological condition of wetlands relative to disturbance and stressors (Lopez and Fennessy 2002, Cohen et al. 2004, Bourdaghs et al. 2006, Miller and Wardrop 2006).

The calculation of FQAI scores is based upon the concept of individual species conservatism to natural habitats, communities, and environmental conditions, or coefficients of conservatism (C). Coefficients of conservatism are values assigned to individual plant species on a statewide level based upon two basic ecological concepts: individual plant species differ in their tolerances to natural and anthropogenic disturbance and plants show different fidelity and specificity to habitat integrity and type (Swink and Wilhelm 1994, Taft et al. 1997). Essentially, C-values represent a relative rank based upon observed patterns of occurrence of plant species across a state (Taft et al. 1997). Although simple in concept, the application of Coefficients of Conservatism can become convoluted as assigned values may vary among wetland types, states, and regions. This relates the regional variation in abundance of particular habitats and the natural ranges of plant species leading to a situation in which a particular species may be deemed sensitive in one state and assigned a high C-value but abundant in an adjacent state and assigned a mid to low C-value. A potential source of bias exists in the assigning of C-values using best professional judgement due to the subjective nature of these value assignments leading to the validity of such values being questioned (Mushet et al. 2002, Matthews et al. 2015). In North Dakota, (Mushet et al. 2002) compared panel assigned C-values to data generated C-values derived from 204 wetlands of varying ecological condition. Although they found that on average, panel assigned values were higher than those derived from plant community data, the resulting calculations of both Mean C and FQAI were nearly identical, suggesting that panel assigned C-values are adequate for measuring floristic quality. Similarly, Matthews et al. (2015) compared the co-occurrence of plants with similar C-values across 388 forest and wetland sites in Illinois, leading them to conclude that subjectively assigned C-values carry substantial ecological information and are thus valid for floristic quality assessments.

Although relatively simple in concept, interpretation and comparison of FQAI among different wetland vegetative communities, states, and regions can be difficult if not impossible. In theory, one could expect to be able to compare condition of wetlands within a state; however, the implementation of such comparisons is murky due to inevitable variation in potential C-metric and FQAI scores. For example, a vegetative community that naturally has a simple vegetative community, such as a marsh that dominated by relatively tolerant species will likely score low, while a vegetative plant community like a wet meadow will likely score high. This, however, does not indicate that the marsh is of lower ecological quality than the wet meadow, rather it is an artifact community diversity and of other controlling factors such as hydrology, disturbance, and nutrient availability. Researchers have recognized these issues and attempted to control for them by modifying the original FQAI equation to account for such variability. Multiple iterations for calculating Floristic Quality Assessment Index scores have been proposed, with most new methods attempting to deal with the issue of score inflation due to increased species richness. In addition, modifications have been added to account for non-native species and species abundance within sites. Each method inevitably results in differing scores for the same site due to differences in calculations; therefore, consistency in method application is necessary in order to allow for comparison of scores.

I used four methods to calculate and compare the floristic quality of vegetative communities at 109 wetland sites in 11 wetland complexes across Nebraska. To deal with the variability of potential FQAI scores among wetland vegetation communities, I standardized Mean C scores using the mean and standard deviation from expected reference standard vegetation communities. Such standardization allows for the both the comparison of FQAI scores among wetland vegetation communities as well the categorization of the ecological condition of wetlands. The standardized FQAI method and condition categories were then subsequently used test the efficacy of Level 1 and Level 2 wetland condition assessment methodologies.

METHODS

Study area

Nebraska encompasses and area of approximately 77,400 square miles of which nearly 1.9 million acres or 3.9% is wetland resources (LaGrange 2005). Only 50,000 acres of wetlands occur on conserved or managed lands owned by federal, state, or other conservation organizations (LaGrange 2005). The remaining wetlands occur mainly in the 45.6 million acres of agricultural farm and ranch lands. This has led to a landscape in which many wetlands are spatially and potentially functionally isolated.

The Nebraska Natural Heritage Program has recognized 40 areas in the state that are considered Biologically Unique Landscapes (BULs) (Schneider et al. 2011). These areas were identified to provide a habitat-based approach for prioritizing conservation and management decisions. The BULs are considered areas in Nebraska where a majority of biological diversity can be conserved. Many of Nebraska's wetland complexes coincide with one or more of these BULs.

Wetland complexes and natural communities

I conducted ecological assessments of wetlands in 11 wetland complexes spatially distributed across Nebraska. Each complex represents a biologically unique and, in some cases, economically important region in Nebraska. All complexes included opportunities to sample wetlands on both public and private lands. Within each wetland complex, I selected a single natural community within which to conduct ecological assessments (Rolfsmeier and Steinauer 2010). For mapping and site selection, each natural community was cross references with one or more Cowardin classes and soil mapping units. The selection of specific natural communities within each complex served two purposes. First, it allowed for a research focus in natural communities of particular interest due to factors such as rarity on the landscape or known ecological importance. Second, it served to limit the scope of ecological assessments to single natural community and thus allow for within complex comparisons of vegetative communities and ecological quality of wetland sites.

Site selection

Individual sites in each wetland complex were selected using a probability-based sample design (Stevens and Jensen 2007, Wardrop et al. 2007) in ArcGIS 10.3 (ESRI 20014). Because it is difficult to implement a probability-based sample of wetlands from one data frame (e.g. the National Wetland Inventory Maps (NWI) miss 50% of forested wetlands and up to 20% of other wetlands; Stevens and Jensen 2007, Wardrop et al. 2007), this design used multiple frames to define a “universe” of potential sample locations from which a simple random sample of wetlands is selected. I used three data frames in order to define the “universe” from which used simple random sampling to select sites that were surveyed. These data frames are: the National Wetlands Inventory (NWI), which uses the Cowardin wetland classification system to define wetland types (Cowardin et al. 1979); the Soil Survey Geographic (SSURGO) for Nebraska, which maps soil types throughout the state; and a wetland complex coverage, which depicts the boundaries for the wetland complexes that were surveyed. Wetland complexes included in the coverage map largely coincide with BUL’s recognized by the Nebraska Natural Heritage Program as unique natural communities in the state, but some were modified to limit the spatial distribution of sample points.

I defined the “universe” of wetlands by merging these data frames to create a new data set that only included polygons where NWI wetlands, hydric soils, and the wetland complexes coincided. In order to reduce the inherent variation in site characteristics, only one wetland natural community type (Rolfsmeier and Steinauer 2010) was sampled in each complex. I spatially defined these natural communities based on soil types that typically coincide with each community type. Both the community types and coinciding soils are based on expert local knowledge (see Table 2.2 for descriptions of wetlands complexes, natural communities, Cowardin classification, and hydric soil types). For example, in the saline wetland complex, I defined the sample “universe” for eastern saline meadows by determining the intersection of NWI emergent wetlands and salmo silty clay loam soils within the saline wetland complex boundaries. I further constrained the “universe” of wetlands to wetlands larger than 500 m^2 because all five 10 m x 10 m vegetation plots must fit within the wetland without overlapping.

A simple random sample of nine wetlands was selected from this defined “universe” of wetlands. The simple random sample was limited to sites at least 280 m apart to avoid spatial overlap and hydrological connectivity among sites, as buffer zones around each point extended 140 m in all directions. A single “reference standard” wetland was selected within each complex based on local knowledge and previous studies (Brinson and Rheinhardt 1996). The “reference standard” wetland is a site that is considered to be representative of the best ecological condition known to exist. It also provides a site to which all other sample locations in a complex can be compared. I also selected up to 21 extra sites that were surveyed if sample points are unsampleable due to permission being denied or wetlands occurring in areas that are inaccessible due to logistical or physical constraints (Stevens and Jensen 2007, Wardrop et al. 2007).

Site and vegetation sample plot set-up

In general, I followed sample plot set-up as described by the 2011 NWCA field manual (USEPA 2011). For each wetland site, a random point was selected within the confines of the wetland boundary. A standard assessment area (AA) was a 0.5 ha area surrounding the point. It was established using 40 m transects in each of the cardinal directions (north, south, east, and west), thus creating a circle that is 80 m in diameter. The area within this circle is the AA. The entirety of the AA must fall within the boundaries of the wetland. For wetlands with an area that is less 0.5 ha, but greater than 0.1 ha, the wetland boundary demarcated the boundary of the AA.

I assessed a total of five 100 m^2 plots in each AA, extending in the cardinal directions from the point. One plot was located 2 m south of the central point with the remaining plots occurring 22 m, 20 m, 15 m, and 15 m (S, E, N, W respectively) from the central point. I collected vegetative data using a nested design in which characteristics will be collected at three spatial scales. Species diversity, relative abundance, and vegetative structure are assessed at the 100 m^2 scale and in two 10 m^2 and two 1 m^2 nested plots located in the NW and SE corners of the larger 100 m^2 plots.

Vegetation Sampling

With the help of an experienced botanist, I measured vegetative characteristics at each wetlands site focusing on species composition, relative abundance, and vegetative structure within the wetland AA. Within each vegetation plot, all vascular plant species were identified to the lowest possible taxonomic level. Absolute percent cover was estimated visually for each individual species. Summed absolute cover could exceed 100% due to canopies of different heights and species overlapping one another. If a plant species could not be identified in the field, a representative specimen was collected and identified in the lab. If a plant could not be identified to the species level, data were recorded but excluded from any further analysis. Prior to analysis nomenclature was standardized among years to match the 2011 Nebraska Natural Heritage Program state species list.

Assignment of C-values

C-values for each state are assigned by a panel of experts and range from 0 to 10. In Nebraska, C-values were developed and assigned in cooperation with the Nebraska Natural Heritage Program (NNHP 2011). Plant species assigned a C-value of 0 include non-native invasive species such as common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). Those species assigned C-values of 1 – 2 are widespread taxa that are typical of disturbed communities and are not typical of any particular community including broadleaf cattail (*Typha latifolia*) and foxtail barley (*Hordeum jubatum*). Plants with C-values of 3 – 5 have an intermediate range of ecological tolerances and typically represent stable phases of native vegetative communities and include species such as sedges (*Carex* spp.) and rushes (*Juncus* spp., *Bolboshoenus* spp., and *Schoenoplectus* spp.). Plants with relatively narrow ecological and disturbance tolerances that are representative of late successional communities are assigned C-values of 6 – 8, while plants with narrow ecological tolerances are assigned values of 9 -10. While not a consideration for the assignment of C-values, plants with values of 8 -10 tend to be rare and often state and federally protected species.

Floristic Quality Assessment Indices

I used both Coefficient of Conservatism (C) metrics and Floristic Quality Assessment Indices (FQAI) to measure the ecological condition of wetland sites based on vegetative community richness and cover data. Multiple methods exist for calculating both Mean C and FQAI scores and have been applied with varying degrees of success (Swink and Wilhelm 1994, Taft et al. 1997, Lopez et al. 2002, Rooney and Rogers 2002, Bourdaghs et al. 2006). Bourdaghs et al. (2006) tested the performance of Mean C and FQAI metrics in Great Lakes wetlands. They were unable to distinguish performance results that included or excluded non-native invasive species; however, it intuitively makes sense to incorporate non-native invasive species data into calculations due to their impact on plant communities (Bourdaghs et al. 2006). Similarly, performance results were indistinguishable between indices that were weighted and not weighted by plant species abundance, suggesting that weighting indices should be avoided due to the inclusion of additional data (Bourdaghs et al. 2006). I calculated all non-weighted and weighted mean C and FQAI scores incorporating non-native invasive species data (Table 3.1). Although I calculate and report weighted FQAI scores due to their usefulness for tracking condition at sites over time, they are excluded from further analysis.

Table 3.1. Coefficient of Conservatism and Floristic Quality Assessment Indices. In all instances, *C* = the Coefficient of Conservatism for species, *N* = the total number of species, and *w* = the relative cover of an individual plant species.

Category	**Index**	**Notation**	**Equation**
Coefficient of Conservatism	Mean Coefficient of Conservatism	Mean C or $\bar{C}$	$\bar{C} = \frac{\sum C}{N}$
	Mean Weighted Coefficient of Conservatism	$w\bar{C}$	$w\bar{C} = \frac{\sum wC}{N}$
Floristic Quality	Floristic Quality Assessment Index	FQAI	$FQAI = \bar{C} \times \sqrt{N}$
	Weighted Floristic Quality Assessment Index	*w*FQAI	$wFQAI = w\bar{C} \times \sqrt{N}$

Reference Standard Sites and Standardized Mean C

Ideally, I would have had the opportunity to assess multiple high-quality reference standard wetland sites within each wetland complex in order to measure the natural variability that exists within these sites; however, this was not logistically feasible due to time constraints and, in some cases, apparent lack of reference standard sites on the landscape. Additionally, previous vegetative community data is lacking in almost all wetland complexes that I surveyed.

I used plant community data cross referenced with soils and National Wetlands Inventory data during the site selection process. The plant communities selected were based upon natural community descriptions from Rolfsmeier and Steinauer (2010) (Table 2.1; Figure 2.1). Diagnostic and common species associated with each natural community are described by Rolfsmeier and Steinauer (2010) and subsequently compiled by the U.S. Army Corps of Engineers – Omaha District (2012). Using these plant community lists, I calculated a mean and standard deviation reference standard of mean coefficient of conservatism for each natural community. Due to the assumption that reference standard vegetative communities will vary, I randomly selected 100 subsets with replacement of 80% of the species list for each natural community (Efron and Tibshirami 1993, Sokal and Rohlf 1995, Hesterberg 2015). Since some natural communities had fewer potential species, 80% subsets ensured that all of the possible species were never selected. A mean C was calculated for each subset and an overall mean and standard deviation were calculated based on all 100 subsets. These calculations served two purposes. First, the variability in the Mean C provides a better representation of reference standard condition. Second, the mean and standard deviation allow for the standardization of mean C scores from field data, allowing for a more intuitive interpretation of wetland condition and the determination of condition categories (i.e. "good", "fair", "poor", etc.) based on standard deviations relative to reference standard condition. Additionally, one common criticism of both Mean C and FQAI scores is the inability to compare scores among multiple natural communities and states. Standardization of the scores relative to reference standard places all sites on the same scale, allowing for the direct comparison of scores among natural community types.

Standardization of Mean C scores

To accommodate for this lack of knowledge and data in regards to reference standard wetland condition, I used diagnostic and common species for each wetland natural community (Appendix A) to calculate an expected range of Mean C scores for reference standard wetlands within each wetland complex. Using these estimated scores, I can get a better idea of the ecological condition of wetlands in Nebraska relative to reference standard condition. Where overlap occurs between reference standard estimates and calculated values, I can be fairly certain that at least some of the sites surveyed are in reference standard condition. While these results allow us to infer the relative ecological condition of wetlands within complexes, it still does not provide a means for comparing the ecological condition of wetlands among complexes.

In order to accommodate for the inherent differences in plant communities and allow for direct comparison among wetland complexes, Mean C and FQAI scores can be standardized relative to reference standard condition. This is accomplished by recalculating each individual wetland condition score as a *z*-score using the mean and standard deviations of scores from reference standard wetland sites. For example, the standardized score for a marsh is calculated using the mean and standard deviation from reference standard marshes. The results of standardization places the condition of all wetlands on the same scale and allows for direct comparison among wetlands and complexes regardless of plant community or wetland. I calculated standardized Mean C scores for each wetland complex, but the method can also be applied to FQAI scores if the data are available. Additionally, the placement of scores on the same scale allows for the determination of consistent wetland condition categories, which are often used in mitigation determinations and regulatory assessments.

I standardized mean C scores by calculating a z-score for each site based upon the coinciding mean and standard deviation. I used the following equation to calculate z-scores for each site and standardize the data:

$$standardized\ \bar{C} = \frac{\bar{C_i} - \bar{C}_{ref}}{\sigma_{ref}}$$

Where, $\bar{C_i}$ is the mean C for site I, $\bar{C}_{ref}$ is the mean C calculated from the 100 subsets of the reference standard community plant, and σ_{ref} is the standard deviation of the mean C for the 100 subsets of the reference standard plant community.

I report both unstandardized and standardized Mean C, however, only standardized Mean C was used for analysis and comparisons. For the purposes of condition categorization, I assumed that any site with a score of within 1.96 standard deviations (95% confidence interval) of reference standard was a reference standard quality or “Excellent” condition site. Other definitions of categorical wetland condition are described in Table 3.2.

Table 3.2. Wetland condition categories and associated standardized Mean C score ranges. Any standardized scores with 1.96 standard deviations (95% confidence interval) were considered to be in "Excellent" or "Reference Standard" condition.

Wetland Condition Category	**Notation**	**Standardized Mean C Score Range**
Excellent (Reference Standard)	E	Mean C $\leq \lvert 1.96 \rvert$
Very Good	VG	$\lvert 1.96 \rvert <$ Mean C $\leq \lvert 3.96 \rvert$
Good	G	$\lvert 3.96 \rvert <$ Mean C $\leq \lvert 5.96 \rvert$
Fair	F	$\lvert 5.96 \rvert <$ Mean C $\leq \lvert 7.96 \rvert$
Poor	P	Mean C $> \lvert 7.96 \rvert$

Results

Central Platte (CP) – Northern Cordgrass Wet Prairie

I calculated coefficient of conservatism and FQAI metrics for 10 CP wetland sites. Similar to vegetative community metrics, Coefficient of Conservatism and FQA indices varied among sites (Table 3.3). The overall complex standardized Mean C was less than 5.96 standard deviations from the reference standard mean indicating that, in general, wetland sites are in "Good" or better condition. In fact, two sites are classified as "Excellent" condition, with two more being classified as "Very Good".

Central Table Playas (CTP) – Wheatgrass Playa Grassland

I calculated coefficient of conservatism and FQAI metrics for nine CTP wetland sites. Floristic Quality Assessment metric scores were generally low for CTP wetland sites. Five of the wetlands surveyed were classified as "Good" condition, while the remaining four sites were classified as "Fair" or "Poor" condition as is apparent from the complex mean standardized Mean C score of -6.81 (Table 3.4).

Cherry County Wetland (CCWM) – Sandhills Wet Meadow

I calculated coefficient of conservatism and FQAI metrics for 10 CCWM wetland sites. The mean standardized Mean C score for the CCWM complex was -1.47, indicating that most sites are in "Good" or better condition. Six CCWM wetland sites were classified as "Excellent" and another three classified as "Very Good" (Table 3.5).

Elkhorn Headwaters (EHW) – Sandhills Hardstem Bulrush Marsh

I calculated coefficient of conservatism and FQAI metrics for 10 EHW wetland sites. Despite high vegetative community metric measurements, EHW site condition varied from “Fair” to “Excellent”. Additionally, the perceived reference standard site was only classified as being in “Fair” condition (Table 3.6).

Missouri River (MR) – Eastern Riparian Forest

I calculated coefficient of conservatism and FQAI metrics for 10 MR wetland sites. All MR sites were categorized as “Fair” or “Poor” condition relative to reference standard condition with a mean standardized Mean C score of -18.37 (Table 3.7).

Niobrara River (NR) – Northern Sedge Wet Meadow

I calculated coefficient of conservatism and FQAI metrics for 10 NR wetland sites. Despite moderately high relative cover of invasive species, including pervasive cover of purple loosestrife (*Lythrum salicaria*) at half of the sites surveyed, all NR sites were classified as “Very Good” and “Excellent” condition (Table 3.8). Weighted mean C scores (wC), however, suggest that there may be much greater variation in wetland condition (Table 3.8).

Rainwater Basins (RWB) – Cattail Shallow Marsh

I calculated coefficient of conservatism and FQAI metrics for 10 RWB wetland sites. RWB sites tended to be dominated by tolerant plant species, which is reflected in both the Mean C and weighted mean C scores (Table 3.9). Despite dominance by tolerant species, many of the RWB sites, including the reference standard site, were categorized as “Excellent” condition with only two sites categorized as either “Fair” or “Poor” (Table 3.9).

Saline Wetland (SAL) – Eastern Saline Meadow

I calculated coefficient of conservatism and FQAI metrics for 10 SAL wetland sites. All SAL wetland sites were categorized as “Good” or better condition, including

SAL4 and SALREF where saltwort (*Salicornia rubra*) was detected (Table 3.10). An additional three sites were categorized as "Very Good" (Table 3.10).

Sandhills Alkaline Lakes (SALK) – Western Alkaline Marsh

I calculated coefficient of conservatism and FQAI metrics for 10 SALK wetland sites. All SALK wetland sites were classified as "Very Good" or "Excellent" (Table 3.11). Three wetland sites were classified as "Excellent", including the reference standard site (Table 3.11).

Southwest Playas (SWP) – Playa Wetland

I calculated coefficient of conservatism and FQAI metrics for 10 SWP wetland sites. Although most sites were in active crop rotation, three of the four with native plant communities were classified as "Good" or better, including the reference standard site (Table 3.112).

Western Alkaline (NPR) – Western Alkaline Meadow

I calculated coefficient of conservatism and FQAI metrics for 10 NPR wetland sites. All NPR wetland sites were classified as being in "Poor" condition relative to reference standard with a mean standardized mean of -12.73 (Table 3.13).

Table 3.3. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for northern cordgrass wet prairie wetland sites in the CP wetland complex located along the Big Bend portion of the Central Platte River.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
CP1	2.90	-7.21	1.30	20.51	9.18	F
CP2	2.92	-7.11	6.73	20.43	47.08	F
CP3	3.12	-6.06	6.25	20.21	40.50	F
CP4	4.20	-0.37	7.25	33.86	58.43	E
CP5	3.84	-2.26	8.75	27.15	61.86	VG
CP6	3.88	-2.03	10.52	25.47	68.97	VG
CP7	2.61	-8.75	6.11	18.62	43.63	P
CP8	3.21	-5.58	7.21	21.04	47.30	G
CP9	2.98	-6.77	5.87	23.88	46.92	F
CPREF	4.05	-1.16	7.25	31.63	56.61	E
Complex mean	3.37	-4.73	6.72	24.28	48.05	

Table 3.4. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for wheatgrass playa wetland sites in the CTP wetland complex located in the central loess hills of central Nebraska.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
CTP1	1.19	-5.50	4.00	6.16	20.76	G
CTP2	1.00	-6.24	0.54	2.00	1.09	F
CTP3	0.00	-10.24	0.00	0.00	0.00	P
CTP4	0.00	-10.24	0.00	0.00	0.00	P
CTP5	1.38	-4.74	3.16	5.50	12.65	G
CTP6	1.21	-5.38	7.89	4.54	29.52	G
CTP7	0.50	-8.24	6.36	1.00	12.73	P
CTP8	1.20	-5.44	21.37	3.79	67.57	G
CTPREF	1.25	-5.24	1.47	5.00	5.88	G
Complex mean	0.86	-6.81	4.98	3.11	16.69	

Table 3.5. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for Sandhills wet meadow wetland sites in Cherry County and the Sandhills region of northcentral Nebraska.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
CCWM1	3.79	-3.32	8.44	24.86	55.35	VG
CCWM2	4.06	-2.24	13.20	23.33	75.85	VG
CCWM3	4.23	-1.57	8.18	28.04	54.27	E
CCWM4	4.06	-2.25	11.44	24.00	67.68	VG
CCWM5	4.34	-1.11	9.26	26.77	57.09	E
CCWM6	4.24	-1.52	9.43	28.75	63.94	E
CCWM7	4.73	0.42	7.51	33.75	53.64	E
CCWM8	4.75	0.52	9.26	31.51	61.44	E
CCWM9	3.63	-3.97	11.80	21.47	69.83	G
CCWMREF	4.71	0.38	13.32	27.89	78.82	E
Complex mean	4.25	-1.47	10.19	27.04	63.79	

Table 3.6. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for Sandhills hardstem bulrush marsh sites in in the eastern Sandhills region of Nebraska.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
EHW1	5.16	0.90	23.40	22.48	102.01	E
EHW2	4.31	-2.77	16.50	24.40	93.32	VG
EHW3	3.57	-6.00	4.26	27.18	32.42	F
EHW4	4.60	-1.52	12.78	25.20	69.97	E
EHW5	3.93	-4.44	9.70	14.70	36.29	G
EHW6	4.31	-2.77	14.80	17.25	59.22	VG
EHW7	4.63	-1.41	15.92	22.66	78.00	E
EHW8	3.76	-5.17	9.28	24.38	60.12	G
EHW9	4.23	-3.14	15.12	19.83	70.92	VG
EHWREF	3.32	-7.08	4.49	18.50	24.98	F
Complex mean	4.18	-3.34	12.62	21.66	62.73	

Table 3.7. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for eastern riparian forest wetland sites located in the Missouri River floodplain between Cass County and Nemaha County, Nebraska.

Site	**Mean C**	**Standardized Mean C**	***w*C**	**FQAI**	***w*FQAI**	**Condition Category**
MR1	1.57	-15.25	1.62	10.62	11.01	P
MR2	2.31	-7.80	3.10	19.46	26.11	F
MR3	0.21	-28.76	6.64	0.80	24.86	P
MR4	1.80	-12.90	3.20	9.86	17.55	P
MR5	1.49	-16.04	4.01	8.79	23.72	P
MR6	0.92	-21.73	2.28	4.49	11.17	P
MR7	0.61	-24.81	3.44	2.92	16.51	P
MR8	1.15	-19.42	2.49	5.97	12.92	P
MR9	0.38	-27.09	0.80	1.75	3.65	P
MRREF	2.10	-9.86	2.56	14.58	17.77	P
Complex mean	1.25	-18.37	3.02	7.92	16.53	

Table 3.8. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for eastern sedge wet meadow wetland sites along the Niobrara River in northern Nebraska.

Site	**Mean C**	**Standardized Mean C**	***w*C**	**FQAI**	***w*FQAI**	**Condition Category**
NR1	3.74	0.21	6.68	23.04	41.16	E
NR2	3.95	0.80	11.35	24.33	70.00	E
NR3	3.62	-0.12	1.82	26.83	13.48	E
NR4	3.50	-0.44	12.55	19.80	70.99	E
NR5	2.62	-2.90	7.51	15.26	43.81	VG
NR6	3.40	-0.72	4.73	28.45	39.57	E
NR7	3.87	0.57	7.98	25.94	53.55	E
NR8	3.80	0.39	7.42	24.03	46.91	E
NR9	1.52	-5.94	3.76	7.30	18.03	G
NR10	3.98	0.88	6.73	26.08	44.11	E
Complex mean	3.40	-0.73	7.05	22.11	44.16	

Table 3.9. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for cattail shallow marsh wetland sites in the eastern RWB of central Nebraska.

Site	**Mean C**	**Standardized Mean C**	***w*C**	**FQAI**	***w*FQAI**	**Condition Category**
RWB1	3.71	0.10	23.66	17.02	108.44	E
RWB2	3.33	-1.49	73.60	5.77	127.48	E
RWB3	5.00	5.46	32.00	16.58	106.12	E
RWB4	4.50	3.38	55.06	11.02	134.86	E
RWB5	4.00	1.29	57.51	8.94	128.59	E
RWB6	2.95	-3.09	11.65	12.85	50.79	VG
RWB7	1.72	-8.20	13.41	7.31	56.91	P
RWB8	2.25	-6.00	32.08	6.36	90.73	F
RWB9	2.69	-4.16	6.04	19.41	43.59	G
RWBREF	4.00	1.29	26.77	13.27	88.80	E
Complex mean	3.42	-1.14	33.18	11.85	93.63	

Table 3.10. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for eastern saline meadow wetland sites in SAL wetland complex in and around Lincoln, Nebraska.

Site	**Mean C**	**Standardized Mean C**	***w*C**	**FQAI**	***w*FQAI**	**Condition Category**
SAL1	2.29	-5.26	6.07	13.38	35.40	G
SAL2	3.27	-3.10	7.53	17.89	41.23	VG
SAL3	2.94	-3.83	5.58	16.62	31.54	VG
SAL4	3.80	-1.91	37.19	12.02	117.61	E
SAL5	2.00	-5.91	1.60	6.00	4.80	G
SAL6	2.65	-4.46	1.76	13.53	8.96	G
SAL7	3.78	-1.96	57.29	11.33	171.87	E
SAL8	2.38	-5.08	3.70	11.64	18.14	G
SAL9	2.62	-4.54	0.77	12.00	3.53	G
SALREF	3.25	-3.13	32.19	9.19	91.06	VG
Complex mean	2.90	-3.92	15.37	12.36	52.41	

Table 3.11. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for western alkaline marsh wetland sites in the SALK wetland complex located in the western Sandhills region.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
SALK1	2.61	-3.62	13.70	12.51	65.69	VG
SALK2	3.40	-2.18	47.62	10.75	150.59	VG
SALK3	3.17	-2.61	19.52	13.44	82.81	VG
SALK4	4.62	0.04	16.70	24.88	89.94	E
SALK5	3.31	-2.35	27.62	11.93	99.58	VG
SALK6	3.05	-2.82	9.64	19.75	62.50	VG
SALK7	3.25	-2.45	22.44	13.00	89.75	VG
SALK8	4.00	-1.09	14.92	21.91	81.71	E
SALK9	2.53	-3.76	25.59	9.81	99.13	VG
SALKREF	4.83	0.42	38.92	16.74	134.83	E
Complex mean	3.48	-2.04	23.67	15.47	95.65	

Table 3.12. Results of Coefficient of Conservatism and Floristic Quality Assessment index calculations for southwestern playa wetland sites in the SWP wetland complex located in panhandle of southwestern Nebraska.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
SWP1	1.47	-4.79	2.84	6.42	12.37	G
SWP2	0.00	-11.81	0.00	0.00	0.00	P
SWP3	0.00	-11.81	0.00	0.00	0.00	P
SWP4	2.38	-0.50	49.03	6.72	138.69	E
SWP5	0.00	-11.81	0.00	0.00	0.00	P
SWP6	0.00	-11.81	0.00	0.00	0.00	P
SWP7	0.00	-11.81	0.00	0.00	0.00	P
SWP8	0.00	-11.81	0.00	0.00	0.00	P
SWP9	0.00	-11.81	0.00	0.00	0.00	P
SWPREF	1.86	-2.97	26.46	6.95	99.01	VG
Complex mean	0.57	-9.09	7.83	2.01	25.01	

Table 3.13. Results of Coefficient of Conservatism and Floristic Quality Assessment Index calculations for western alkaline meadow wetland sites in the NPR wetland complex located along the North Platte River and Pumpkin Creek in the Nebraska panhandle.

Site	Mean C	Standardized Mean C	*w*C	FQAI	*w*FQAI	Condition Category
NPR1	2.14	-12.47	6.83	11.34	36.13	P
NPR2	1.67	-14.54	20.03	6.45	77.59	P
NPR3	2.40	-11.35	10.70	10.73	47.83	P
NPR4	2.29	-11.81	9.16	13.38	53.39	P
NPR5	2.00	-13.09	9.55	10.20	48.71	P
NPR6	1.37	-15.82	10.81	7.12	56.15	P
NPR7	3.14	-8.15	18.91	14.71	88.72	P
NPR8	1.75	-14.17	22.36	6.06	77.45	P
NPR9	2.10	-12.64	10.18	11.33	54.81	P
NPRREF	1.96	-13.25	12.06	10.20	62.65	P
Complex mean	2.08	-12.73	13.06	10.15	60.34	

Comparison of Coefficient of Conservatism and FQAI metrics among complexes

Calculated coefficient of conservatism and FQAI metrics were variable within and among wetland complexes (Table 3.14; Figure 3.1). In general, wetland vegetative communities such as those in the CP, CCWM, EHW, NR, and SALK with higher species richness had higher Mean C, FQAI, and *w*FQAI scores. The observed difference in metrics, however, is not representative of the comparative condition of wetland sites or complexes when drawing comparisons among complexes. Metric score ranges and degree of variability were not even among differing calculation methods, even when comparing within coefficient of conservatism and FQAI metrics, respectively.

Table3.14. Summary and comparison of Coefficient of Conservatism and Floristic Quality Assessment Index for 109 wetland sites in 11 wetland complexes across Nebraska.

Complex	**Mean $\bar{C}$**	**Mean $w\bar{C}$**	**Mean FQAI**	**Mean *w*FQAI**
CP	3.37	6.72	24.28	48.05
CTP	0.86	4.98	3.11	16.96
CCWM	4.25	10.19	27.04	63.79
EHW	4.18	12.62	21.66	62.73
MR	1.25	3.02	7.92	16.53
NR	3.4	7.05	22.11	44.19
RWB	3.42	33.18	11.85	93.63
SAL	2.9	15.37	12.36	52.41
SALK	3.48	23.67	15.47	95.65
SWP	0.57	7.83	2.01	25.01
NPR	2.08	13.06	10.15	60.34

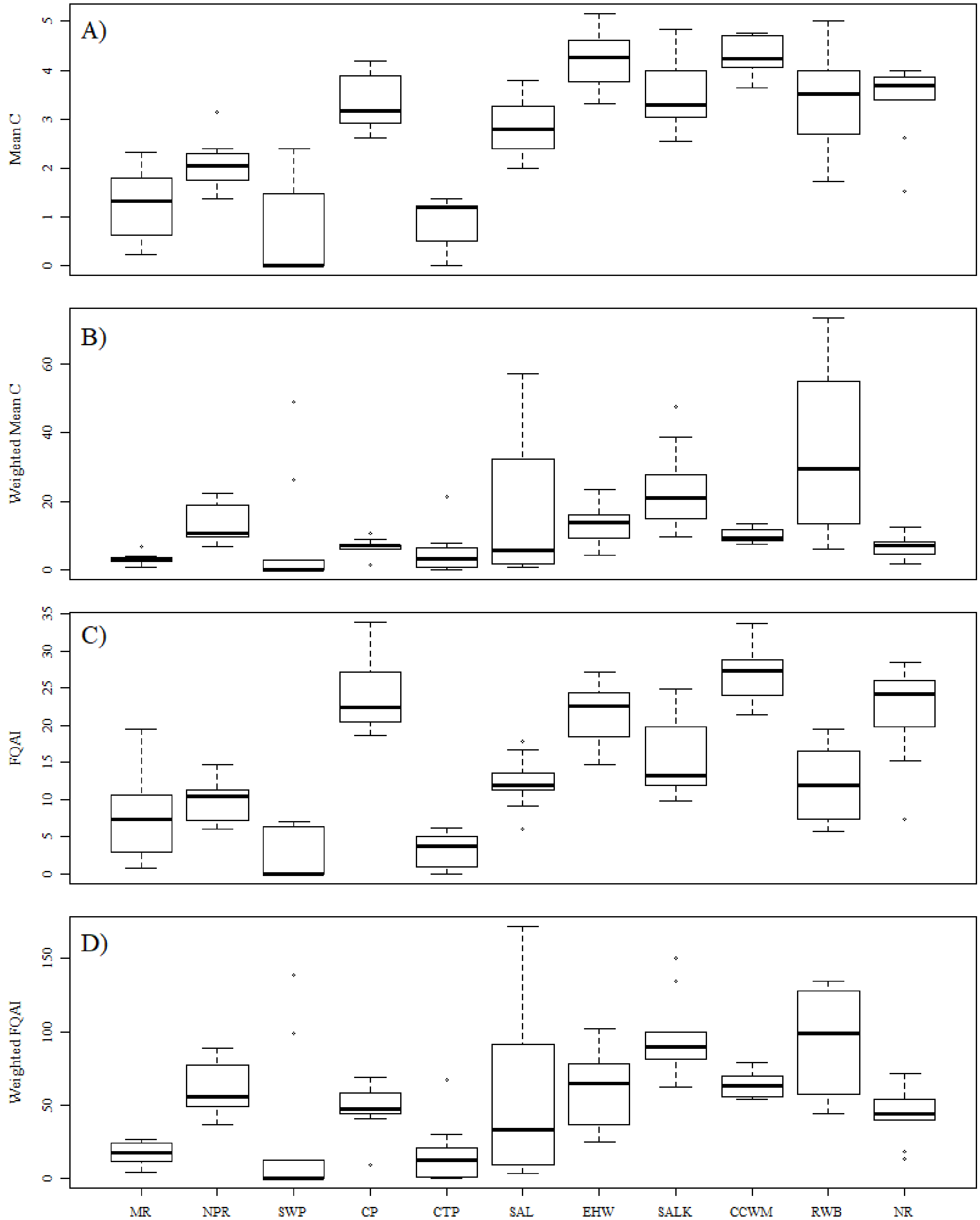

Figure 3.1. Comparison of Coefficient of Conservatism and Floristic Quality Assessment Index metrics among 11 wetland complexes in Nebraska. The dark bars indicate median score, boxes indicate interquartile range, and bars indicate 1.5 * the interquartile range. Points are indicative of potential outliers.

Standardized Mean C and Condition Categorization

Complex Mean C scores were variable among wetland complexes (Table 3.15). Estimated reference standard scores calculated from random subsets of representative vegetation data were similarly variable. These scores represent the estimated maximum Mean C score that a wetland site within a given complex could possibly attain. The same complexes with greater coefficient of conservatism and FQAI scores tended to have higher standardized Mean C scores and more wetland sites categorized as VG or E (Table 3.15; Figure 3.2). Reference standard sites in the CP, CCWM, NR, RWB, and SALK complexes were categorized as E, while those in the SAL and SWP complexes were categorized as VG.

Table 3.15. Comparison of complex mean coefficient of conservatism metrics among 11 wetland complexes in Nebraska. Overlap between Mean C and estimated reference standard $\overline{C}$ confidence intervals is indicative that some assessed sites are predicted to be in reference standard condition.

Complex	Mean C (± 95% CI)	Estimated Reference Standard $\overline{C}$ (± 95% CI)	Standardized Mean C (± 95% CI)	# of Sites Categorized as VG or E	Reference Standard Site Condition Category
CP	3.37 (± 0.35)	4.27 (± 0.37)	-4.73 (± 1.84)	4	E
CTP	0.86 (± 0.36)	2.56 (± 0.50)	-6.81 (± 1.43)	0	G
CCWM	4.25 (± 0.24)	4.62 (± 0.49)	-1.47 (± 0.97)	9	E
EHW	4.18 (± 0.34)	4.95 (± 0.46)	-3.34 (± 1.48)	6	F
MR	1.25 (± 0.45)	3.09 (± 0.20)	-18.37 (± 4.47)	0	P
NR	3.40 (± 0.48)	3.66 (± 0.71)	-0.73 (± 2.00)	9	E
RWB	3.42 (± 0.63)	3.69 (± 0.47)	-1.14 (± 2.64)	7	E
SAL	2.90 (± 0.38)	4.66 (± 0.89)	-3.92 (± 0.85)	5	VG
SALK	3.48 (± 0.48)	4.60 (± 1.08)	-2.04 (± 0.88)	10	E
SWP	0.57 (± 0.59)	2.48 (± 0.41)	-9.09 (± 2.78)	1	VG
NPR	2.08 (± 0.30)	5.01 (± 0.44)	-12.73 (± 1.29)	0	P

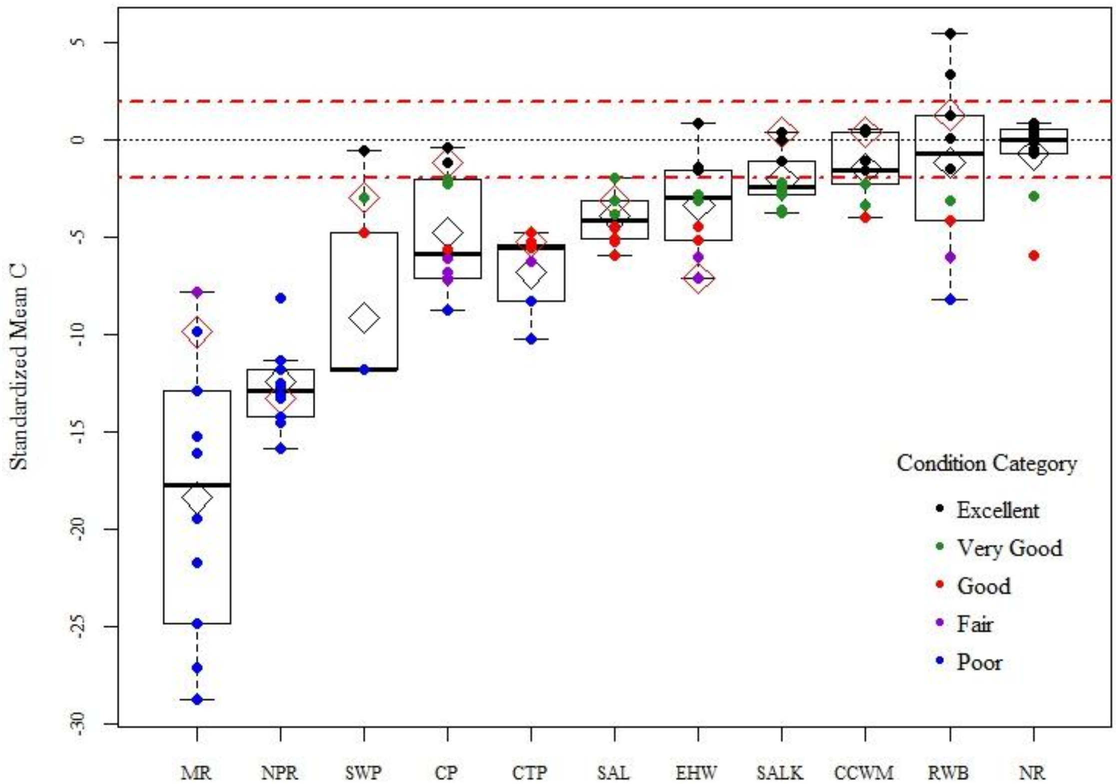

Figure 3.2. Results of standardized Mean C scores for the 11 wetland complexes sampled across Nebraska. Standardized Mean C scores provide an easy way to interpret measure of the ecological condition of wetlands based upon vegetative community surveys and estimates of reference standard wetland condition. The zero line indicates the estimated reference standard condition. Red lines on either side of zero indicate the 95% confidence intervals surrounding the estimated reference standard ("Excellent") condition, with points falling within these confidence intervals being considered reference standard. Subsequent condition categories occur at intervals of approximately 4, 6, 8, and 10 standard deviations ("Very Good", "Good", "Fair" and "Poor", respectively) from the estimated reference standard condition. Black open diamonds indicate complex means, while red open diamonds indicate the score from references standard sites.

DISCUSSION

Floristic Quality Assessment Indices and Standardization of Scores

Floristic Quality Assessment Indices (FQAIs) are widely accepted in the field of ecological assessment as effective measures of vegetative integrity (Taft et al. 1997). Variations of the FQAI methodology have been successfully applied to wetland systems as responsive and reliable indicators of the ecological condition of wetlands relative to anthropogenic disturbance and stressors (Lopez and Fennessy 2002, Cohen et al. 2004, Boudaghs et al. 2006, Miller and Wardrop 2006). Multiple equations exist for the calculation of FQAI scores including methodologies for scores both weighted and unweighted using the relative cover of species observed. However, Bourdaghs et al. (2006) determined that metric performance was not improved by incorporating relative cover of plants and should be avoided. Therefore, despite calculating and presenting weighted results, I only further compared unweighted calculations. I found both Mean C and FQAI (Figure 3.1) scores to be highly variable among complexes, but both showed similar variability and trends. While it may seem intuitive to infer that complexes with low Mean C and FQAI scores are inherently lower quality than those with high scores, this is not the case. In order to effectively assess the condition of sites, interpretations must be considered relative to reference standard.

Reference standard wetland sites provide a point of comparison against which to determine the condition of sites with comparable vegetative communities, HGM subclass, soil mapping unit, and NWI classification. I assessed vegetative communities at a single selected reference standard wetland site within each wetland complex. However, the selected reference standard site was not always representative of a high-quality wetland site and in some instances, scored lower relative to randomly selected sites within each complex (Figure 3.2). This is likely a result of a lack of on the ground knowledge within these complexes and typically very limited access to wetlands located on private properties, and in some case was likely due to most of the wetlands in the complex being in overall good condition. Furthermore, additional data from reference standard wetland sites is not available for most wetland complexes.

Inherently present in the calculation of Mean C and FQAI is the fact that wetland sites with naturally low diversity, simple communities, such as CTP and SWP, will typically have lower Mean C and FQAI scores than communities with naturally more diverse and sensitive communities, such as CCWM and CP (Figure 3.1). These results are not unique, with similar relationships being noted by Andreas et al. (2004) in Ohio, where wetland communities with high species richness and naturally high proportions of sensitive taxa score higher than those without. This trend is evident by the variable estimated range for Mean C scores among high species richness and low species richness wetland sites and complexes. This tight link between species richness measures and FQAI has been noted by Rooney and Rodgers (2002) and Andreas et al. (2004). To mitigate issues with the strong relationship between FQAI and richness, Rogers and Rooney (2002) suggest modifying FQAI to calculate a Mean C score rather than traditional FQAI. Even when applying suggested modifications of methods, disparities in Mean C scores among complexes still exist (Table 3.13; Table 3.14; Figure 3.1). This has led many to conclude that FQAI and Mean C scores should only be used for comparisons within the same wetland types due to insensitivity to natural differences among plant communities and leaves managers little ability to make comparisons among wetland and community types.

Coefficient of conservatism and FQAI metrics were variable within and among wetland complexes. Due to strong relationships between coefficient of conservatism and FQAI metrics and plant species richness at wetland sites and inherent differences among complexes due to variations in expected vegetative communities, differentiation of the ecological condition, particularly when attempting to make comparison among complexes, can be difficult if not impossible. Furthermore, all ecological condition determinations should be directly related to the condition of reference standard sites. Even when taking reference standard condition into consideration, the ability to draw comparisons of ecological condition among complexes is tenuous at best. By standardizing Mean C scores relative to the estimated reference standard Mean C score, one can minimize the relationship between Mean C and species richness, determine the condition category of each wetland site, and make direct comparisons among wetland complexes.

The Ecological Condition of Nebraska Wetlands

Overall, I estimated that nearly 50% (n = 52) of the wetlands surveyed in Nebraska are in “Very Good” or “Excellent” condition, while another 15% (n = 17) are considered to be in “Good” condition and the remaining 35% (n = 40) are in “Fair” or “Poor” condition (Figure 3.2). The majority of “Very Good” and “Excellent” wetlands were located in complexes associated with the Sandhills region in northcentral Nebraska including the NR, CCWM, SALK, and EHW wetland complexes. Wetlands categorized as “Good” condition were located in nearly all complexes across the state, although it should be noted all sites in the MR and NPR complexes were categorized as “Fair” or “Poor” and sites in the SALK complex were all categorized as “Very Good” or “Excellent”. Similarly, wetlands in “Fair” and “Poor” condition were distributed throughout Nebraska in seven of the wetland complexes. Many factors contribute to the ecological condition of wetlands, but most can be attributed to historic and present land use and management of both wetlands and the areas surrounding wetlands. The degree to which historic and present land use and management impact Nebraska’s wetland resources is regionally variable and is reflected by the variation in the ecological condition of wetlands among complexes.

The presence of “Good” or worse condition wetlands in many complexes can be attributed to either agricultural or urban conversion resulting in the direct loss or impairment of wetland communities in those regions. A primary example of the impacts of agriculture on the ecological condition of wetlands is apparent in the dominance of “Poor” condition wetland in the NPR complex. Over allocation of water from the North Platte River and Pumpkin Creek to agriculture has resulted in hydrological shift along the flood plains, leading to a direct loss of wetland function and shift from hydrophytic dominated to upland dominated plant communities. Although they occur in an agriculturally dominated landscape, CTP and SWP are traditionally tilled and planted to row crops such as corn, soy beans, and wheat only in dry years, meaning that evidence of wetland plant communities is absent; however, in wet years or years when fields are left fallow, the presence of wetland plant communities is evident. This results in fluctuating wetland condition both within and among years. Both CTP and SWP wetlands were surveyed during dry years meaning that many wetlands were tilled and condition estimates for those complexes are likely underestimates of the true condition of wetland sites in these complexes. In fact, when wetland vegetation was present, nearly all of the sites surveyed were found to be in “Good” or better condition. Similarly, vegetative community surveys in the MR complex occurred in 2012 following the historic Missouri River flood of 2011. The length of the flood resulted in death of many riparian trees and simplistic vegetative communities dominated by annual and invasive species that greatly differed from the expected vegetative communities. This leads to the conclusion that condition scores from the MR complex are not representative and likely an underestimate of the true condition of the riparian wetlands surveyed.

Active conservation programs are successfully managing, restoring, and protecting high quality wetlands in many complexes. Despite the dominance of intensive row crop agriculture and urban development in the landscape, many wetlands in the CP, SAL, and RWB complexes are in “Good” or better condition. This is in stark contrast to wetland condition in other complexes with agriculturally dominated landscapes, like the CTP, SWP, and NPR. Much of the reason for this disparity is the presence of active conservation, management, and stewardship programs in these wetland complexes. The Big Bend region of the Central Platte River is a primary stopover site for migrating Sandhill cranes and whooping cranes (Tacha et al. 1984, LaGrange 2005, Johnsgard 2012). Due to its importance for migratory wildlife, many conservation organizations and agencies have focused efforts on protecting and restoring habitat in the region (PRRIP 2006). Additionally, many private landowners practice lower impact agriculture, such as haying and grazing, within the wet meadows of the CP complex (pers. obs.). Similar to The Big Bend of the Central Platter River, the Rainwater Basins are of primary importance to millions of migratory waterfowl in the central flyway. The historic loss of more than 90% of the wetlands on the landscape and importance to waterfowl led to the inception of the interagency Rainwater Basin Joint Venture. Through this partnership, many of the remaining wetlands in the RWB complex have been protected and actively managed. The efficacy of such management is apparent, as many wetlands in the RWB complex are in “Excellent” or “Very Good” condition. Likewise, the Saline Wetland Conservation Partnership actively manages and acquires saline wetlands. Actions of the SWCP have led the protection and management of nearly 700 acres of saline wetlands around the Lincoln, Nebraska area. The presence of high quality wetlands in the CP, RWB, and SAL wetland complexes provides evidence that such programs are succeeding in maintaining high quality wetlands in the landscape.

With the exception of the SAL, all of the wetland complexes with “Very Good” and “Excellent” wetlands occur in complexes with low population density, a lack intensive agricultural land uses, and/or where focused management and conservation efforts are being implemented. In the Sandhills complexes (CCWM, SALK, and EHW), all three factors are present. The Sandhills region has a very low population density, which has resulted in very little historic loss of wetlands for urban conversion. Similar to much of the state, agriculture is of primary importance to the economics of the Sandhills region; however, in contrast to the prominent intensive row crop agriculture and feedlot operations in some areas, most landowners employ low intensity rotational grazing and haying on large ranches, resulting in minimal impact and grazing regimes mimicking those of large native grazers. These factors have resulted in minimal regional wetland loss and degradation. Additionally, present in the Sandhills region is a unique partnership among ranchers and conservation organizations, the Sandhills Task Force (STF), which works with private landowners through easements and agreements to protect the vast wetland resources of the region. The quality of ranch management is apparent based upon the ecological condition of the many wetlands in the CCWM, SALK, and EHW wetland complexes.

Conclusions

Overall, nearly 50% of wetlands surveyed in Nebraska are in “Very Good” or “Excellent” condition, with most of these high-quality wetland sites occurring in wetland complexes with active management and conservation through multiple interagency implementation plans and partnerships. It is clear from these results that where conservation and management programs have been implemented, wetlands condition and function are greater. Although management and conservation in these areas is of continued importance, it is clear that the restoration, conservation, and management of wetlands in some complexes is lagging behind. Wetland complexes such as NPR, SWP, and CTP offer opportunities for future management and conservation efforts. The success of interagency implementation plans and partnerships in areas such as the RWB, CP, SAL, and the Sandhills wetland complexes suggests that similar efforts may be successful in other regions and should be considered in the future.

Standardization and condition categories are useful in determining the efficacy of subsequent ecological assessment techniques, such as landscape methods (ex. landscape development intensity indices) or rapid assessment methods. Traditionally, such methods would be verified for single wetland types or HGM classes, such as depressional or forested wetlands (Lopez and Fennesy 2002, Cohen et al. 2004, Miller and Wardrop

2006), require the development of separate methodologies for each type or class, or inclusion of wetland type specific variables (Mack 2001). Standardization eliminates issues with varying coefficients of conservatism among states and regions (Milburn et al. 2007), allowing each state to independently determine C of C values based upon specific local habitat, distribution, and abundance variations and will allow for comparisons among states and regions. In addition, these results provide a means to move toward a national floristic quality assessment program and database, allowing for the tracking and comparison of the ecological condition of wetland and vegetative communities at a national level (Medley and Scozzafava 2009). In light of these results, federal and state agencies should consider the utility of standardizing ecological condition metrics relative to ecological condition reference standard sites. Implementation of simple standardization and consistent condition categorization would facilitate comparisons among wetland types and communities within states, regions, and even across the country, allowing local, state, regional, and federal agencies to better determine where to allocate funds.

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CHAPTER 4

DEVELOPMENT, FIELD TESTING, AND VALIDATION OF THE NEBRASKA WETLAND RAPID ASSESSMENT METHOD (NEWRAM V1.0)

INTRODUCTION

Wetlands are an increasingly threatened ecosystem due to anthropogenic activities resulting in both direct and indirect impacts on the ecosystem function and ecological condition (Brinson and Malvarez 2002, Kentula et al. 2004, Dahl 2011). From the 1780's to the 1980's, it is estimated that the conterminous United States lost approximately 53% of its total wetland area, with much of those losses occurring in the midwestern states (Dahl 1990). Since 1867, Nebraska has lost nearly 35% of its wetland resources, the equivalent of nearly one million acres (Dahl 1990). Similar to worldwide trends, most of these losses can be attributed to agricultural and urban development (LaGrange 2005). As of the 1980's, only 3% of remaining wetlands in Nebraska are owned by state, federal, or other conservation and management organizations (Dahl 1990). Trends in wetland quantity and distribution have been tracked regularly monitrored (see Frayer et al. 1983, Dahl and Johnson 1991, Dahl 2000, Dahl 2005, and Dahl 2011); however, these efforts do not inform on the ecological condition of the same wetlands.

Recent approaches to wetland condition assessment include the USEPA and others advocating the use of a three-leveled approach to wetland assessment based on 1) landscape data, 2) rapid assessment data, which combines landscape and on-site assessment approaches, and 3) intensive quantitative data collection (Mack 2006, Reiss and Brown 2007, Wardrop et al. 2007). Multiple methods can be applied to measure condition at each level including Landscape Development Intensity indices (LDI; Mack 2006, Brown and Vivas 2005) and watershed disturbance (Brooks et al. 2004) measured at larger spatial scales to assess landscape factors, rapid functional assessment and other rapid assessment methods including the national rapid assessment method (USA-RAM; USEPA 2011), and intensive quantitative methods such as indices of biotic integrity (ex. Floristic Quality Assessment Indices; Cohen et al. 2004, Lopez and Fennessy 2002).

Quantitative methods such as floristic quality assessment indices (FQAI) and landscape methods such as LDI may inform on the ecological condition of wetlands, but both have drawbacks and limitations. FQAI methodologies are labor and time intensive, potentially limiting the ability of individuals to monitor many wetland sites. Landscape methodologies, while fast, fail to provide a variety of quantitative data that may provide additional support in determining wetland condition. In comparison, rapid assessment methods require less time and expertise, yet provide a semi-quantitative ecological assessment (Fennessy et al. 2007). Due to their time efficiency and effectiveness, the use and development of rapid assessment techniques for wetlands has proliferated in recent years. By 2007, over 40 wetland rapid assessment methods existed for regulatory and land use planning in the United States (Fennessy et al. 2007).

For the 2011 National Wetland Condition Assessment, the US EPA developed the USA Rapid Assessment Method (USA-RAM). Along with the USA-RAM, additional rapid assessment methods have been utilized in the state of Nebraska, including functional assessments for multiple hydrogeomorphic (HGM) classes (NRCS HGM light models) and a full HGM functional assessment specifically for Rainwater Basin wetlands

(Stutheit et. al 2004). Multiple state and federal agencies use these varying methodologies to assess wetland condition for permitting and monitoring purposes. Unfortunately, due to the specificity of these methodologies in terms of HGM subclass and variations in their implementation and interpretation, comparison of wetland condition among wetland classes and among agencies is not possible. Therefore, the primary purpose for the development of the Nebraska Wetland Rapid Assessment Method (NeWRAM) was to provide a method to evaluate the functional and ecological condition of wetlands in Nebraska, regardless of wetland type or location. Additionally, NeWRAM represents a scientifically defensible, standardized, and cost-effective assessment method for state and federal agencies to measure the ecological integrity and stressors to wetlands in the state of Nebraska.

METHODS

Study area

Nebraska encompasses and area of approximately 77,400 square miles of which nearly 1.9 million acres or 3.9% is wetland resources (LaGrange 2005). Only 50,000 acres of wetlands occur on conserved or managed lands owned by federal, state, or other conservation organizations (LaGrange 2005). The remaining wetlands occur mainly in the 45.6 million acres of agricultural farm and ranch lands. This has led to a landscape in which many wetlands are spatially and potentially functionally isolated.

The Nebraska Natural Heritage Program has recognized 40 areas in the state that are considered Biologically Unique Landscapes (BULs) (Schneider et al. 2011). These areas were identified to provide a habitat-based approach for prioritizing conservation and management decisions. The BULs are considered areas in Nebraska where a majority of biological diversity can be conserved. Many of Nebraska's wetland complexes coincide with one or more of these BULs.

Wetland complexes and natural communities

I conducted ecological assessments of wetlands in 11 wetland complexes spatially distributed across Nebraska. Each complex represents a biologically unique and, in some cases, economically important region in Nebraska. All complexes included opportunities to sample wetlands on both public and private lands. Within each wetland complex, I selected a single natural community within which to conduct ecological assessments (Rolfsmeier and Steinauer 2010). For mapping and site selection, each natural community was cross references with one or more Cowardin classes and soil mapping units. The selection of specific natural communities within each complex served two purposes. First, it allowed for a research focus in natural communities of particular interest due to factors such as rarity on the landscape or known ecological importance. Second, it served to limit the scope of ecological assessments to single natural community and thus allow for within complex comparisons of vegetative communities and ecological quality of wetland sites.

Site selection

Individual sites in each wetland complex were selected using a probability-based sample design (Stevens and Jensen 2007, Wardrop et al. 2007) in ArcGIS 10.3 (ESRI 20014). Because it is difficult to implement a probability-based sample of wetlands from one data frame (e.g. the National Wetland Inventory Maps (NWI) miss 50% of forested wetlands and up to 20% of other wetlands; Stevens and Jensen 2007, Wardrop et al. 2007), this design used multiple frames to define a "universe" of potential sample locations from which a simple random sample of wetlands is selected. I used three data frames in order to define the “universe” from which used simple random sampling to select sites that were surveyed. These data frames are: the National Wetlands Inventory (NWI), which uses the Cowardin wetland classification system to define wetland types (Cowardin et al. 1979); the Soil Survey Geographic (SSURGO) for Nebraska, which maps soil types throughout the state; and a wetland complex coverage, which depicts the boundaries for the wetland complexes that were surveyed. Wetland complexes included in the coverage map largely coincide with BUL’s recognized by the Nebraska Natural Heritage Program as unique natural communities in the state, but some were modified to limit the spatial distribution of sample points.

I defined the “universe” of wetlands by merging these data frames to create a new data set that only included polygons where NWI wetlands, hydric soils, and the wetland complexes coincided. In order to reduce the inherent variation in site characteristics, only one wetland natural community type (Rolfsmeier and Steinauer 2010) was sampled in each complex. I spatially defined these natural communities based on soil types that typically coincide with each community type. Both the community types and coinciding soils are based on expert local knowledge (see Table 2.2 for descriptions of wetlands complexes, natural communities, Cowardin classification, and hydric soil types). For example, in the saline wetland complex, I defined the sample “universe” for eastern saline meadows by determining the intersection of NWI emergent wetlands and salmo silty clay loam soils within the saline wetland complex boundaries. I further constrained the “universe” of wetlands to wetlands larger than 500 m^2 because all five 10 m x 10 m vegetation plots must fit within the wetland without overlapping.

A simple random sample of nine wetlands was selected from this defined "universe" of wetlands. The simple random sample was limited to sites at least 280 m apart to avoid spatial overlap and hydrological connectivity among sites, as buffer zones around each point extended 140 m in all directions. A single "reference standard" wetland was selected within each complex based on local knowledge and previous studies (Brinson and Rheinhardt 1996). The "reference standard" wetland is a site that is considered to be representative of the best ecological condition known to exist. It also provides a site to which all other sample locations in a complex can be compared. I also selected up to 21 extra sites that were surveyed if sample points are unsampleable due to permission being denied or wetlands occurring in areas that are inaccessible due to logistical or physical constraints (Stevens and Jensen 2007, Wardrop et al. 2007).

Method Development

Development of the NeWRAM included a review of nationwide functional and rapid assessment methods with emphasis placed on methodologies already implemented in Nebraska and within the Great Plains region. Due to acceptance and application in Nebraska, specific portions of both the HGM Light and the Rainwater Basin HGM functional assessment protocols were modified for inclusion within the NeWRAM procedure. The interagency and interdisciplinary team was also used to provide input into the NeWRAM development. The approaches used in the NeWRAM are meant to quantify functional and ecological condition and include specific methods to assess watershed condition, wetland hydrology and stressors, buffer condition, and the vegetative community. Although initially developed for implementation in accordance with the assessment areas defined by the NWCA methodologies (i.e. 40 m radius circle surrounding a randomly selected point within a wetland), the AA can be modified according to agency or project specific requirements, although caution should be employed when interpreting comparisons of wetlands with differing AA set-ups. For the complete method description and forms, see Appendix B.

Purpose

Currently, multiple methodologies exist for rapidly assessing wetland condition in Nebraska including the HGM Light and Rainwater Basin HGM functional assessment methods. However, no single methodology is available that can be applied to all wetland types and HGM classes in Nebraska. The primary purpose of the NeWRAM is to provide a rapid and effective method that assesses the ecological condition of all wetland community types and classes in Nebraska (Table 4.1). The secondary purpose is to explore relationships among stressors and potential remediating factors including buffers and management.

Table 4.1. Plant communities, Cowardin classes, HGM class, and location of Nebraska wetland types (Cowardin et al. 1979, Rolfsmeier and Steinauer 2010, LaGrange 2010).

Wetland communities of Nebraska			
Plant Community	*Cowardin Class*	*HGM Class*	*Location*
Eastern riparian forest	Palustrine forested, temporarily flooded	Riverine floodplain	Primarily river floodplains in the eastern fourth of the state
Eastern cottonwood-dogwood riparian woodland	Palustrine forested, temporarily flooded	Riverine floodplain	Primarily river floodplains in the eastern fourth of the state
Cottonwood-peachleaf willow riparian woodland	Palustrine forested, temporarily flooded	Riverine floodplain	Primarily river floodplains in the eastern fourth of the state
Cottonwood riparian woodland	Palustrine forested, temporarily flooded	Riverine floodplain	Primarily river floodplains in the eastern 2/3 of the state
Cottonwood-diamond willow woodland	Palustrine forested, temporarily flooded	Riverine floodplain	Primarily river floodplains and island along the Missouri, Middle Loup and Elkhorn Rivers
Freshwater seep	Palustrine emergent, saturated	Slope wetland	Occurs throughout the state
Riparian dogwood-false indigobush shrubland	Palustrine scrub-shrub, intermittently flooded	Riverine floodplain	Along rivers and streams iin the eastern half of the state, but scattered westward
Sandbar willow shrubland	Palustrine scrub-shrub temporarily and seasonally flooded	Riverine Channel	Primarily along rivers and larger steams throughout the state
Peachleaf willow woodland	Palustrine forested, temporarily flooded	Riverine floodplain	A single site in the Pine Ridge in Dawes County
Prairie fen	Palustrine emergent, saturated	Slope wetland	Only occurs in sandstone canyons and ravines in the Little Blue River drainage in Jefferson County
Sandhill fen	Palustrine emergent, saturated	Organic soil flat	Valleys and dunes in the Sandhills of Cherry, Grant, Boone, Garfield, and Wheeler counties

Wetland communities of Nebraska (cont.)

Plant Community	*Cowardin Class*	*HGM Class*	*Location*
Eastern cordgrass wet prairie	Palustrine, temporarily to seasonally flooded	Riverine floodplain	River valleys the tall-grass prairie region of eastern Nebraska
Eastern sedge wet meadow	Palustrine emergent, seasonally and semi-permanently flooded	Riverine floodplain	Eastern part of the state in the floodplain of the Missouri River and its tributaries
Northern cordgrass wet prairie	Palustrine emergent, temporarily flooded	Riverine floodplain	Extensive in permanent stream and river valleys from the Platte River valley northward
Sandhills wet meadow	Palustrine emergent, temporarily to seasonally flooded	Mineral soil flat	Occurs throughout the Sandhills and drainages of Sandhills rivers
Western sedge wet meadow	Palustrine emergent, temporarily to seasonally flooded	Riverine floodplain	Occurs in the Nebraska Panhandle
Western alkaline meadow	Palustrine emergent, temporarily flooded	Floodplain depression	Occurs in the North Platte River valley, its smaller tributary valleys, and in closed basins in the western Sandhills
Western subirrigated alkaline meadow	Palustrine emergent, temporarily flooded	Riverine floodplain	Extensive in the upper Niobrara River valley and patchy to locally common in the North Platte River valley
Reed marsh	Palustrine emergent, temporarily to seasonally flooded	Lacustrine fringe or Riverine floodplain	Occurs in the northern half of the state from the Platter River valley northward
Playa wetland	Palustrine emergent, temporarily flooded	Playa depression	Occurs throughout the state but is most common in south-central and southwestern Nebraska
Eastern bulrush deep marsh	Palustrine emergent, semi-permanently flooded	Depressional	Generally found along banks and in backwaters of rivers and large streams in the eastern half of the state
Spikerush vernal pool	Palustrine emergent, temporarily to seasonally flooded	Depressional	Occurs in northwestern and north-central Nebraska

Wetland communities of Nebraska (cont.)

Plant Community	*Cowardin Class*	*HGM Class*	*Location*
Cattail shallow marsh	Palustrine emergent, temporarily to seasonally flooded	Playa depression	Can occur virtually statewide but is most abundant in the eastern half of the state
Eastern saline marsh	Palustrine emergent, seasonally to semi-permanently flooded	Saline depression	Restricted to Lancaster and Saunders, primarily near Salt Creek, Little Salt Creek and Rock Creek
Western alkaline marsh	Palustrine emergent, seasonally to semi-permanently flooded	Sandhills alkaline marsh	Most abundant in the western Sandhills in Garden, Morrill, and Sheridan counties
Eastern pondweed aquatic wetland	Palustrine aquatic bed, permanently and semi-permanently flooded	Floodplain depression	Floodplains, lakes, ponds, and impoundments in the southern half and eastern quarter of the state
American lotus aquatic wetland	Palustrine aquatic bed, permanently and semi-permanently flooded	Lacustrine	Occurs as a semi-natural community in artificial ponds in Lancaster and Platte counties and elsewhere
Northern pondweed aquatic wetland	Palustrine aquatic bed, permanently and semi-permanently flooded	Floodplain depression	Occurs in lakes and backwaters from the Platte River valley northward
Water-lily aquatic wetland	Palustrine aquatic bed, permanently and semi-permanently flooded	Lacustrine	Confined to lakes and ponds in the Sandhills
Saline/Alkaline aquatic wetland	Palustrine aquatic bed, permanently and semi-permanently flooded	Saline/Alkaline depression	Natural communities occur in the western Sandhills, with semi-natural communities in Lancaster county
Sandbar/mudflat	Riverine unconsolidated bottom, temporarily to seasonally flooded	Riverine channel	Occurs within the channel of larger streams and rivers throughout the state

Implementation

NeWRAM is designed to assess the overall ecological condition of all wetland types in Nebraska. The NeWRAM procedure is designed for implementation by individuals with varying levels of experience and expertise. Users do not need to be a certified professional wetland scientists, but should have basic knowledge of the factors used to identify wetlands and common anthropogenic stressors. For example, although users should be able to identify common and dominant hydric vegetation, he/she does not need to be a trained botanist. In general, if a user is trained in wetland delineation, he/she will possess the requisite skills to implement NeWRAM. In total, NeWRAM should take two people no more than a half-day in the field and no more than an additional half-day of preparation, GIS-based data collection, and analysis to calculate a condition score.

Descriptions of NeWRAM variables

The purpose of developing NeWRAM was to design an effective and rapid method for the ecological assessment of all wetlands in Nebraska. The use of a single method to assess all wetland sites simplifies the training required and implementation of NeWRAM for the rapid assessment of wetlands in Nebraska. In order to measure wetland condition, I assessed six metrics that directly influence or measure the ecological condition of wetlands including: 1) watershed land cover, 2) buffer width and continuity, 3) buffer condition, 4) vegetative composition, 5) stressors to wetland hydrology, and 6) wetland land use. Selection of assessment metrics was based upon knowledge of local and general wetland ecology and extensive review of other Nebraska and regional assessment methodologies. The general assumption was that individual assessment metrics can be used to measure one or more aspects of wetland condition and function. I used Level-3 ecological data collected at wetland sites for method validation and to test the ability of individual metric and composite condition scores to measure the ecological condition of wetland sites in Nebraska.

V_1 – watershed land cover

Most wetlands in Nebraska occur in a highly modified landscape dominated by agricultural and residential uses. Changes from natural land covers (e.g. grassland, wetland, forest, etc.) to human modified land covers (e.g. row crop agriculture, roads, cities, etc.) degrades watersheds and leads to decreases in wetland quality and function (Table 4.2). Using the previously defined watershed boundaries, determine % of each land cover class within the watershed. Each land cover category has an associated rank (Table 4.2) (Brown and Vivas 2005, Mack 2006). A rank of 1 indicates the highest severity of impact on the watershed and a rank of 10 indicates the least potential impact. Intermediate ranks represent varying relative impacts of anthropogenic land cover classes. I calculated the weighted average for watershed land cover as follows:

$$Weighted\ average\ score = \frac{\sum(LC_i \times r_i)}{10}$$

where:

LC_i = The proportion of the watershed of land cover class i

r_i = The associated rank of land cover class i.

As such, a weighted average score of 10 will result in a V_1 score of 1.0. In all cases, the resulting V_1 score should be rounded to the nearest 0.01.

Table 4.2. Land cover categories and their associated ranks. Ranks represent the varying impacts of anthropogenic land covers between urban development and natural habitats. Land cover classes are based on the LANDFIRE existing vegetation type raster data set developed by the USGS (2013). For these analyses, existing landcovers were reclassified into 12 broad land use classes. Ranks are adapted and inverted from the Landscape Development Intensity Index coefficients developed by Brown and Vivas (2005) and Mack (2006).

Land Cover Classes	**FL and OH LDI coefficients**	**NE r_i coefficients**
Natural	1.00	10.00
Water	1.00	10.00
Tree Farm	1.58	8.42
Pasture	3.41	6.59
Orchard/Vineyard	3.68	6.32
Natural, Managed	4.54	3.08
Row Crops	6.92	3.00
Mines	8.32	1.68
Roads	8.05	1.95
Developed, Low Intensity	7.47	2.53
Developed, Medium Intensity	7.55	2.45
Developed, High Intensity	9.42	0.58

*****V_2 *– modifications to watershed/source area hydrology*

Watershed-level hydrological stressors are human-made surface alterations located within the watershed boundaries of a wetland. These alterations degrade and alter the hydrological function of wetlands located within the watershed. Potential surface alterations include dams, diversions, agricultural reuse pits, and ditches. Although subsurface stressors may also be present, only surface stressors can be assessed from digital imagery. Therefore, only surface alterations and subsurface alterations that are known to exist can be considered when determining watershed-level hydrological stressors.

For non-riverine wetlands, based on aerial imagery and local knowledge, determine the extent of hydrological modifications in the watershed. The condition index rating for V_2 in non-riverine wetlands was determine based on the cumulative extent of modifications in the watershed (Table 4.3). For riverine wetlands, the HUC-8 watershed within which the wetland falls was determined.

Although I recognize that source area hydrology is an important factor in the maintenance and wetland form and function, I have chosen to exclude this variable from current analyses and NeWRAM score calculations due to perceived difficulties in determining both watershed area and area impacted by the various hydrologic stressors.

Table 4.3. Condition rating index for V_2 based on the presence of man-mad surface alterations present within the watershed boundary. Adapted from the NRCS Nebraska Wetland Functional Assessment Protocol for slope wetlands (NRCS 2009).

V_2 Condition Index Rating	
1.0	No surface alterations, including inputs such as irrigation, are present within the watershed boundaries
0.75	Surface alterations occur within the watershed boundaries, which impact wetland hydrology. Less than 20% of the watershed is impacted.
0.5	Surface alterations occur within the watershed boundaries, which impact wetland hydrology. Greater than 20% and up to 50% of the watershed area is impacted.
0.25	Many surface alterations occur within the watershed boundaries, severely affecting wetland hydrology. Greater than 50% and up to 75% of the watershed area is impacted.
0.1	Many surface alterations occur within the watershed boundaries, severely affecting wetland hydrology. Greater than 75% and up to 95% of the watershed area is impacted.
0	More than 95% of the watershed area is impacted by surface alterations, resulting in severely altered wetland hydrology.

V_3 – buffer continuity and width

Vegetated buffers surrounding wetlands act to mitigate potential stressors associated with the surrounding landscape . This variable is composed of two components, the continuity and the average width of the vegetated buffer adjacent to the AA for a wetland site. Continuity is defined as the estimated percentage of the AA, which is bordered by at least 10 m of continuous buffer and a minimum width of 5 m. Buffer width is considered the total width of a buffer land class until a non-buffer land class interrupts it, or the outer edge of the BA is reached (Table 4.4). I estimated buffer width in 5 m increments for the four cardinal (N, S, E, W) and four ordinal directions (NE, SE, NW, SW) surrounding the wetland point. The maximum estimated buffer width is 100 m. I calculated average buffer width as follows:

$$Average\ buffer\ width = \frac{\sum Estimated\ buffer\ width}{8}$$

Aerial photography and field investigation were used to determine both buffer continuity and average buffer width. Buffer continuity and buffer width are both used to estimate the variable V_3 based on the relationships detailed in Table 4.5 (NRCS).

Table 4.4. List of buffer land classes adapted from USA-RAM manual (USEPA 2011), CRAM (CWMW 2013) and Colorado FACWet procedure (Johnson et al. 2013). The buffer does not cross non-buffer land classes.

Buffer land classes	**Non-buffer land classes**
• Natural upland, riparian, and wetland habitats • Range and pasture lands • Natural or wildland parks • Railroads with infrequent use • Swales and ditches • Vegetated levees • Unpaved bike, foot, and horse trails	• Commercial development • Intensive agriculture (row crops, orchards, vineyards) • Golf courses • Urban and recreational lawns • Any road • Lawns • Parking lots • Enclosed animal feeding operations • Residential areas • Sports fields • Urbanized parks

Table 4.5. Condition rating index for V_3 based on the continuity and average width of the buffer land classes surrounding the wetland AA. The point at which the two values of buffer continuity and average width intersect is the summary rating of the two components. The condition rating index score is determined from the summary rating.

	Summary rating for buffer continuity and average width							
	Continuity (%)	*100*	*80-99*	*60-79*	*40-59*	*20-39*	*5-20*	*<5*
Average buffer width (m)	100	1.0	0.9	0.7	0.5	0.3	0.15	0
	75-99	0.8	0.75	0.6	0.4	0.25	0.1	0
	50-74	0.6	0.5	0.5	0.3	0.2	0.1	0
	25-49	0.4	0.3	0.3	0.2	0.15	0.05	0
	10-24	0.2	0.2	0.15	0.1	0.1	0.05	0
	5-9	0.1	0.1	0.1	0.05	0.05	0.01	0
	<5	0	0	0	0	0	0	0

V_4 – buffer condition

The buffer condition is assessed based on the extent and quality of native vegetative cover, stress to the substrate, and evidence of human visitation or management. Common buffer disturbances and stressors are listed and described in Table 4.6. Buffer condition should only be assessed for the area already defined as buffer based on V_3. Buffer condition was assessed on site, based on the cover of native vegetation, absence of non-native and native invasive species, and the presence and severity of substrate disturbance and human use and/or management (Table 4.7). The condition index rating of V_4 was based upon the presence of disturbances or stressors and their perceived extent and severity (Table 4.8) (USEPA 2011).

Table 4.6. Common buffer area modifications or stressors in Nebraska wetlands and their descriptions.

Indicators of buffer area modifications and stressors	
Substrate	
Indicator/Stressor	*Description*
Off-road vehicles or heavy machinery use	The presence of substrate disturbance in the form of ruts, compaction, or other disturbance due to the use or parking of off-road vehicles or heavy machinery
Grazing by domesticated or feral animals	The presence of deep prevalent hoof prints, digging, or wallows
Filling, grading, or other deposition of sediment	Deposition of soil in a wetland in order to fill in or eliminate topography in the BA
Human use and/or management	
Indicator/Stressor	*Description*
Mowing/haying	Presence of mowing or haying in the BA
Chemical vegetation control	Presence of dead or dying native vegetation due to the targeted use of herbicides
Excessive grazing by domesticated or feral animals	Presence of vegetation grazed to an average height of ≤ 3"
Excessive wildlife herbivory	Presence of vegetation grazed to an average height of ≤ 3"
Presence of oil or gas wells	Oil or gas wells located in the BA
Presence of continually maintained utility corridors	Powerline or other utility corridors continually maintained for maintenance access

Table 4.7. Definitions for the perceived severity of BA modification or stressor and invasive plant species cover based on the extent of the negative impact of a given modification/stressor. Severity definitions are adapted based on the Michigan Rapid Assessment Method for Wetlands (MDNRE 2010) and USA-RAM (USEPA 2011).

Severity of buffer area (BA) modifications/stressors	
Severity	*Description*
Not present	Stressor is not presentin or adjacent to the wetland or AA
Not severe	Stressor is present but does not appear to negatively impact the condition of the wetland/AA.
Moderately severe	Stressor is present and effects <10% of the area of the wetland/AA
Severe	Stressor is present and effects ≥10% of the area of the wetland/AA
Severity of invasive plant species cover	
Severity	*Description*
Absent	Invasive plant species are absent from the buffer
Trace	Invasive plants species cumulative relative cover ≤ 5%
Moderate	Invasive plant species cumulative relative cover is 5 - 25%
Extensive	Invasive plant species cumulative relative cover is 26 - 75%
Dominant	Invasive plant species cumulative relative cover is > 75%

Table 4.8. Condition rating index for V_4 based on the condition of the buffer surrounding the AA. Buffer condition is assessed based on vegetative composition, substrate disturbance, and evidence of human visitation.

V_4 Condition Index Rating	
1.0	BA is dominated by native vegetation and modifications and stressors are absent
0.75	Trace cover of invasive plant species in the BA and modifications and stressors are absent or invasive plant species are absent and modifications or stressors are not severe
0.5	Moderate cover of invasive plant species in the BA or moderately severe stressors impact ≤10% of the total BA or trace cover of invasive species in the buffer and moderately severe and/or severe modifications stressors impact between 10 and 15% of the BA
0.25	Extensive cover of invasive species in the BA or Moderate cover of invasive plant species in the BA and moderately severe and/or severe modifications or stressors cumulatively impact between 16 and 25% of the BA
0.1	BA is dominated by invasive species or moderately severe and/or severe modifications and stressors cumulatively impact > 25% of the BA or cover of invasive species in the BA is extensive and moderately severe and/or severe modifications and stressors cumulatively impact between 16 and 25% of the BA
0	Buffer is absent.

V_5 – vegetative composition

V_{Native}

The vegetative composition of a wetland responds to both natural and anthropogenic stressors at multiple spatial scales and represents the floristic quality of a wetland site. Table 4.1 describes the wetland communities of Nebraska, dominant Cowardin and HGM classes of those wetland communities (Cowardin et al. 1979), and the locations of the wetland communities in Nebraska. This information was used to aid in determining which wetland community or communities are included within the AA. The diagnostic and dominant plant species for each of the wetland communities based on descriptions from Rolfsmeier and Steinauer (2010) were used in determining plant communities present in the AA.

This variable was measured based on the dominant vegetation of each plant community within a wetland AA, where a dominant species is defined as a plant species with a relative cover ≥ 15%. The condition index rating was determined based on the comparison of dominant plant species observed in the AA to the list of diagnostic and abundant species in Appendix A. Invasive species should not be used when determining the variable score even if they are listed as diagnostic species. There are two major assumptions associated with this variable. First, the dominant species within the wetland AA is representative of the native species richness and diversity. Second, the plant associations listed in Table 6 represent the "reference standard" for each wetland community; therefore, deviations from these plant associations are indicative of a decrease in the quality of the vegetative composition. Definitions and interpretations of this variable are adapted from the Regional Guidebook for Applying the

Hydrogeomorphic Approach to Assessing Wetland Functions of Rainwater Basin Depressional Wetlands in Nebraska (Stutheit et al. 2004) and the Nebraska Stream Condition Assessment Procedure (Gilbert et al. 2012). The V_5 index rating score was calculated as follows:

$$V_{Native} = \sum \left(\frac{((\#RSS_j + 0.5(\#NN_j))}{n_j} \times \%area_j\right)$$

where,

V_5 = Sum of the weighted scores for each plant community *j* in the wetland AA;

$\#RSS_j$ = Number of reference standard dominant species in plant community *j* from the plant community species lists in Appendix A;

$\#NN_j$ = Number of native dominant species in the plant community;

n_j = Total number of dominant plant species in plant community *j;*

$\%area_j$ = Relative area of plant community *j* in the wetland AA.

$V_{Invasive}$

$V_{Invasive}$ is a score modifier used in calculating the overall V_5 variable index score. This score modifier can be determined in one of two ways as follows:

$$V_{Invasive} = Total\ \%\ cover\ of\ native\ species$$

or

$$V_{Invasive} = 1 - Total\ \%\ cover\ of\ invasive\ species.$$

The final V_5 variable index score is then calculated as follows:

$$V_5 = V_{Native} \times V_{Invasive}.$$

This variable index score is measured on a continuous scale from 0 to 1 and final V_5 calculations should be rounded to the nearest .01.

V_6 – stressors to wetland hydrology

Hydrology is a driving factor in the establishment and maintenance of wetland communities and their associated functions. Modifications to these hydrological regimes can negatively impact the plant communities associated with wetlands and functions such as the biogeochemical cycles (e.g. nitrogen cycle) and the ability of wetlands to act as carbon sinks. Extreme hydrological modifications, such as drainage with agricultural tiles or ditches, may result in the complete loss of wetlands or shifts in wetland type and/or plant community. Although sedimentation may occur naturally, particularly in riverine floodplains, culturally accelerated sedimentation can result in altered hydrology or decreases in wetland size subsequently causing decreases of wetland quality and function. Stressors and alterations to the hydric soils may result in changes to drainage and productivity, thus causing a decrease in wetland quality and function. Sediment deposition and soil disturbance are assessed using a list of indicators for stress that cause or are indicative of substrate degradation or accelerated sedimentation. This variable determines the presence of alterations to the hydrology and resulting stress to wetland condition and function (see Table 4.9 for a list of hydrologic modifications/stressors) (USEPA 2011). After stressors/alterations are identified, they were evaluated to determine the extent of resulting negative impact in relation to the wetland area and associated hydrologic regime (Table 4.10).

The resulting condition index rating score is based on both the number of stressors or modification present and their perceived severity on the hydrologic condition of the wetland. In general, highly modified wetlands have higher numbers and greater severity of stressors or modifications (Table 4.11).

Table 4.9. Common hydrologic modifications or stressors in Nebraska wetlands and their descriptions.

V_6 Condition Index Rating	
Modification/Stressor	*Description*
Ditch	Man-made channel dug for the purpose of draining an area
Tile drain	A subsurface modification generally used to drain wetlands located in agricultural fields
Dike/levee/berm	A man-made embankment, generally found in river floodplains, built to prevent flooding
Dam	A man-made structure which inhibits the natural flow of water through rivers and streams
Fill	Soil added to a wetland in order to fill in and reduce the area of existing wetlands
Human-induced sedimentation or burial	Culturally accelerated sedimentation indicated by silt accumulation or debris lines on or around vegetation or the presence of sediment fans, deposits, or plumes
Road/railroad bed	Located in or adjacent to the wetland, and may result in the bisection of a wetland or flashy stormwater flows into the wetland
Artificial increases in hydrology	Human-mediated increases in hydrology. Examples include irrigation pumps or culverts or pipes, which increase the flow of water into the wetland/AA
Invasive species that alter hydrology	Presence of plant species such as russian olive and saltcedar in or along the margins of the wetland/AA
Dredging or excavation	The removal of sediment from the wetland with the purpose of increasing the volume of water that a wetland can hold or reducing the total wetland area. Examples include agriculture pits and cattle ponds.

Table 4.10. Definitions for the perceived severity of wetland stressors and modifications based on the extent of the negative impact of a given stressor. Severity definitions are adapted based on the Michigan Rapid Assessment Method for Wetlands (MDNRE 2010) and USA-RAM (USEPA 2011).

Severity of hydrologic modifications/stressors	
Severity	*Description*
Not present	Modification or stressor is not present in or adjacent to the wetland or AA
Not severe	Modification or stressor is present but does not appear to negatively impact the condition of the wetland/AA
Moderately severe	Modification or stressor is present and effects <10% of the area of the wetland/AA or has moderate impacts on wetland condition and function
Severe	Modification or stressor is present and effects ≥10% of the area of the wetland/AA or has severe impacts on wetland condition and function

Table 4.11. Condition index rating for V_6 based on the presence and severity of hydrologic modification or stressors. Modified and adapted from the Nebraska Wetland Functional Assessment Protocol (NRCS).

V_6 Condition Index Rating	
1.0	No hydrologic modifications or stressors are present in or adjacent to the wetland/AA.
0.75	Hydrologic modifications or stressors are present in or adjacent to the wetland/AA but do not appear to negatively impact the condition of the wetland/AA or Hydrologic modifications or stressors have occurred in the past but the wetland/AA appears to have recovered
0.5	Multiple moderately severe modifications or stressors are present in or adjacent to the wetland/AA and cumulatively impact ≤10% wetland/AA
0.25	Multiple moderately severe modifications or stressors are present in or adjacent to the wetland/AA and cumulatively impact >10% of the wetland/AA or one severe modification or stressor is present in or adjacent to the wetland/AA
0.1	Many severe modifications or stressors are present in or adjacent to the wetland/AA, resulting in a highly modified hydrologic regime or complete loss of wetland function
0.0	Wetland is no longer present due to conversion to an alternate land use

V_7 – wetland land use

Land use in and adjacent to the wetland/AA may have negative impacts on the condition and function of the wetland. Common stressors and indicators of stress in Nebraska wetlands can be found in Table 4.12 (Stutheit et al. 2004, USEPA 2011) . A stressor was only considered if it cumulatively impacted ≥ 1 m^2 of the wetland or AA. The severity of land use stressors is determined similarly to hydrologic modifications, based on the area of the wetland or AA that is affected (Table 4.13). A general knowledge of land ownership and management will help in assessing this variable as some stressors and indicators of stress may be the result of commonly implemented management methods used to maintain and restore wetlands. In these instances, indicators were considered "Not severe" and scored as such. For example, a wetland may be disked or grazed in order to control the spread of noxious or invasive plant species; in agricultural systems, however, the same methods result in direct stress to the soil and decrease in wetland condition.

The resulting condition index rating score is based on both the number of stressors or modification present and their perceived severity on the hydrologic condition of the wetland. In general, highly modified wetlands have higher numbers and greater severity of stressors or modifications (Table 4.14).

Table 4.12. Stressors and indicators of stress due to land use practices and changes in Nebraska wetlands.

Indicators of wetland land use stressors	
Indicator/Stressor	*Description*
Plowing or disking	The turning and loosening of soil with a series of disks or plow in or at the edge of the wetland/AA. In some instances, disking is used for management and restoration of wetlands.
Intensive grazing	Indicated by the prominence of deep hoof imprints and excessive grazing of vegetation (average height ≤ 3"). In some instances, intensive grazing may also be used to manage for aggressive or invasive plant species.
Off-road vehicle use	The presence of exposed soil or rutted substrate due to the use of off-road vehicles in or at the edge of the wetland/AA
Construction or farm vehicle use	The presence of exposed or rutted substrate due to the use of construction or farm equipment in or at the edge of the wetland/AA
Urban or agricultural conversion	Wetland conversion to an alternate land use. In some cases, these changes may results in the complete destruction or removal of a wetland.

Table 4.13. Definitions of the perceived severity of sedimentation and substrate disturbance based on the extent of the negative impact for a given stressor or indicator. Severity definitions are adapted based on the Michigan Rapid Assessment Method for Wetlands (MDNRE 2010) and USA-RAM (USEPA 2011).

Severity of indicators of wetland land use stressors	
Severity	*Description*
Not present	Indicator is not present in or adjacent to the wetland or AA
Not severe	Indicator is present but does not appear to negatively impact the condition of the wetland/AA or the indicator is a direct result of management or restoration efforts.
Moderately severe	Indicator is present and effects <10% of the area of the wetland/AA
Severe	Indicator is present and effects ≥10% of the area of the wetland/AA

Table 4.14. Condition index rating for V_7 based on the presence and severity of sedimentation or substrate stressor indicators. Modified and adapted from the Nebraska Wetland Functional Assessment Protocol (USDA).

V_7 Condition Index Rating	
1.0	No land use modifications or stressors are present in or adjacent to the wetland/AA.
0.75	Land use indicators or stressors are present in or adjacent to the wetland/AA but do not appear to negatively impact the condition of the wetland/AA or Land use indicators or stressors have occurred in the past but the wetland/AA appears to have recovered
0.5	Multiple moderately severe indicators or stressors are present in or adjacent to the wetland/AA and cumulatively impact ≤10% wetland/AA
0.25	Multiple moderately severe indicators or stressors are present in or adjacent to the wetland/AA and cumulatively impact >10% of the wetland/AA or one severe indicator or stressor is present in or adjacent to the wetland/AA
0.1	Many severe indicators or stressors are present in or adjacent to the wetland/AA, resulting in a highly modified hydrologic regime or complete loss of wetland function
0.0	Wetland is no longer present due to conversion to an alternate land use

Calculating the NeWRAM condition score

The final NeWRAM wetland condition score is calculated based upon seven condition variables as follows:

$$NeWRAM\ score = V_1 + (V_3 \times V_4) + V_5 + V_6 + V_7.$$

Most variable scores are summed in determining the final NeWRAM score. The exception is the product of V_3 and V_4, which represents the intereraction between the buffer extent and buffer condition. Due to difficulties in effectively and consistently determining wetland watershed area and proportion of this area impacted by hydrological alterations, V_2 was excluded from inclusion in the current version of NeWRAM. This allows for a score range between 0 and 5, where a score of 0 represents a low quality or non-wetland site and a value of 5 represents are perfect, unaltered wetland site. In practice, wetland sites with scores of 0 or 5 likely do not exist on the landscape due to historical landscape modifications, conversions, and past and present management practices so calculated scores for an existing wetland should actually range between approximately 0.10 and 4.99.

Field Testing

Following method development during the fall of 2012 and spring of 2013, NeWRAM v1.0 was field tested from June to August of 2013 at 40 wetland sites located in four wetland complexes, mostly in western Nebraska. Specifically, I field tested the method in the NR, NPR, SWP, and SALK wetland complexes (Figure 4.1). During 2013 field testing, I tracked the approximate time it took to complete NeWRAM. Times were approximated because data for USA-RAM and intensive assessment methods were concurrently collected. In order to ensure consistent application of the methodology and interpretation of severity and condition index ratings, all assessments and score calculations were conducted by me. Additionally, NeWRAM scores were calculated for the 69 other wetland sites visited during the 2011 and 2012 sampling seasons using previously collected data.

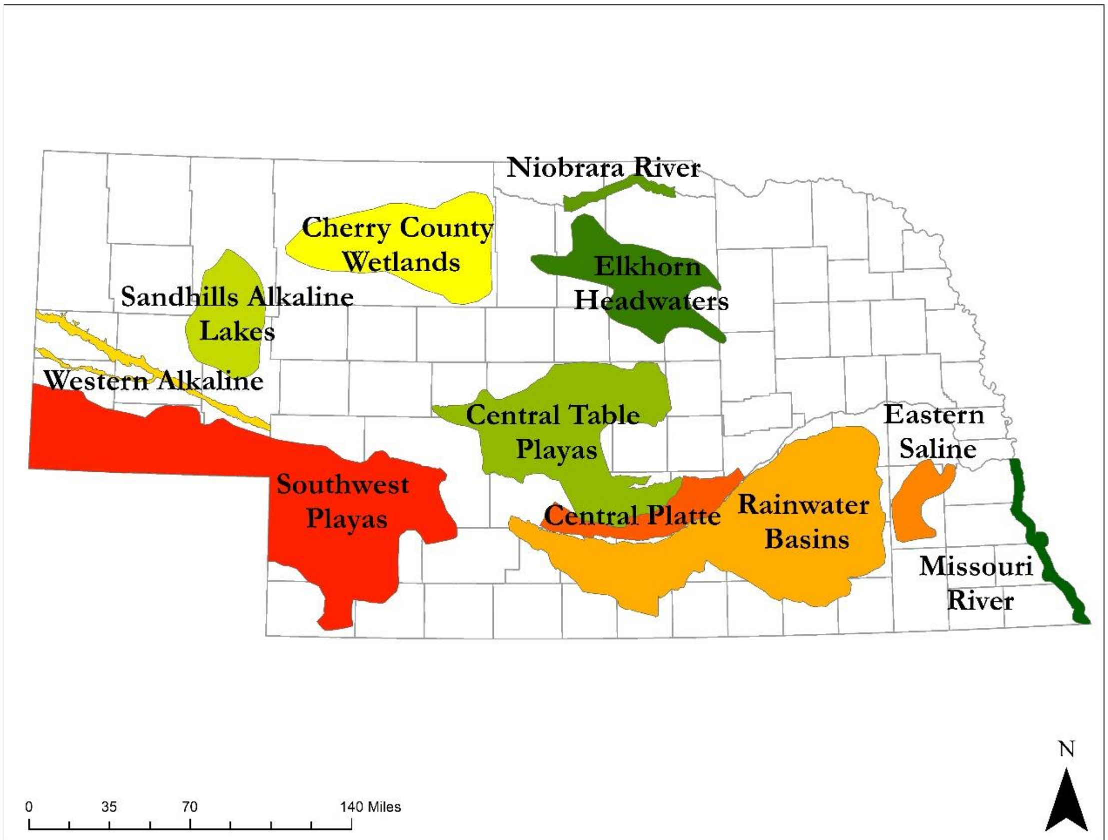

Figure 4.1. Field testing occurred from June to August 2013 at 40 wetland sites located in the Niobrara River (NR), western alkaline (NPR), southwest playas (SWP), and sandhills alkaline lakes (SALK) wetland complexes.

Method Validation

Method validation is the process of determining the relationship between NeWRAM condition scores and alternative measures of ecological condition (Stein et al. 2009). In general, I follow the validation methods described by Stein et al. (2009), where the overall validation process for evaluating the efficacy of NeWRAM involves determining performance relative to three main factors: 1) *responsiveness*, the ability of the method to discern amongst condition categories, 2) *range* and *representativeness*, the ability of the method to measure the variability of condition present on the landscape, and 3) *redundancy*, the degree to which individual NeWRAM metrics measure the factors of condition (Stein et al. 2009).

Responsiveness

Responsiveness refers to the ability of NeWRAM condition metrics and condition scores to discern the condition of wetland sites. The responsiveness of NeWRAM was measured using Spearman's ρ because all condition metrics were non-normal. NeWRAM was developed based upon *a priori* assumptions in regard to the relationship among both metrics and the final condition score. I tested relationships among each metric and the condition score relative to previously described FQAI and vegetative community metrics (see Chapter 2 and Chapter 3 for descriptions). If measured associations varied from expected relationships, it was assumed that metrics are either ineffective or need to be modified for future inclusion in NeWRAM. To test for the ability of NeWRAM to differentiate among condition categories, I used Kruskal-Wallis tests to compare condition categories inferred from Mean C among individual NeWRAM metrics as well as condition scores. I used post-hoc Dunn's tests to infer differences among condition categories. All analyses were conducted in the program R v.3.5.0 (R Core Team 2018).

Range and Representativeness

Range and representativeness measure the ability of NeWRAM to capture the assumed distribution of ecological conditions that exist on the landscape. I plotted the distribution of individual NeWRAM metrics and condition scores to view the overall spread of resulting scores. Because I randomly selected sites within each complex, the general assumption was that results will be normally distributed; however, departure from normality was not necessarily indicative of invalid metrics of condition scores due variability in wetland alteration, management, and land use among complexes and regions in Nebraska. In some cases, scoring categories may need to be adjusted by redefining thresholds between scores within a metric.

Redundancy

Redundancy measures the degree to which multiple metrics measure to same variability in ecological condition within a wetland site. I tested for redundancy using Spearman's ρ correlation. Because the goal of individual metrics is to measure aspects of the ecological condition of wetland sites, I assumed that potentially high correlation exists among individual metrics. I did not remove redundant metrics from NeWRAM, but instead explicitly acknowledge that correlation exists among metrics but does not necessarily affect the validity of NeWRAM.

RESULTS

I conducted NeWRAM assessments at 40 wetland sites located in four different wetland complexes, mostly in western Nebraska. Rapid assessment methods are defined by the ability of observers to conduct office and field-based assessments within eight hours (Fennessy et al. 2007). I was unable to calculate the exact amount of time required to complete a NeWRAM assessment; however, complete wetland assessments including level-2 and level-3 data collection associated with the National Wetland Condition Assessment and NeWRAM rarely took longer than four hours per site. The determining factor for the length of time assessments took was largely based upon the complexity of the wetland vegetative community. Additionally, office based metric calculations can be conducted concurrently for multiple wetland sites, which reduces the overall time to conduct NeWRAM assessments.

Prior to conducting method validation, I made assumptions about the relationship among NeWRAM condition scores and individual metrics and Level-3 assessment metrics (Table 4.15). I designed the NeWRAM methodology and individual metrics to be positively correlated with other measures of wetland condition. Therefore, the general assumption was that both condition scores and individual metrics will be positively correlated with FQAI scores and the proportion of native plant species and negatively correlated with the relative cover of non-native invasive species.

Table 4.15. Expected correlations between NeWRAM condition scores and individual attributes and Level-3 metrics. The nature of the relationship is indicated by "+" or "-".

Level-3 Metric	**Definition**	**NeWRAM Condition Score**	**V1**	**V3**	**V4**	**V5**	**V6**	**V7**
FQAI	Standardized Mean C score described in "Assessing and Comparing Nebraska's Wetland Vegetative Communities"	+	+	+	+	+	+	+
Native Species	The proportion of native species observed during wetland vegetative community surveys	+	+	+	+	+	+	+
Invasive Species	The relative cover of all non-native invasive species observed during wetland vegetative community surveys	-	-	-	-	-	-	-

Responsiveness

I found all NeWRAM scores and metrics to be significantly correlated with most Level-3 metrics tested (Table 4.16). The nature of the expected relationships was consistent with the relationships found using Spearman ρ. NeWRAM condition scores were strongly correlated with all three Level-3 metrics. Moderate to strong correlations were also found between all three Level-3 metrics and buffer condition (V4), vegetative composition (V5), and stressors to wetland hydrology (V6). Weak correlations were found between Level-3 metrics and watershed land cover (V1), buffer width and continuity (V3), and wetland land use (V7).

I tested the efficacy NeWRAM condition scores and individual metrics for differentiating among condition categories using Kruskal-Wallis tests with post-hoc Dunn's tests to determine difference among condition categories. Different NeWRAM metrics showed varying degrees of ability to differentiate among condition categories (Figure 4). Although there was a significant difference among condition categories for watershed land cover (V1; $X^2 = 21.19$, df = 4, p <0.001), stressors to wetland hydrology (V6; $X^2 = 43.85$, df = 4, p <0.001), and wetland land use (V7; $X^2 = 10.96$, df = 4, p = 0.03), the ability of these metrics to differentiate among condition categories was limited (Figures 4.2a, 4.2e, and 4.2f). A similar pattern was observed for buffer width and continuity (V3; $X^2 = 14.34$, df = 4, p = 0.01) and buffer condition (V4; $X^2 = 26.26$, df = 4, p <0.001) with difference occurring only among "Excellent" and "Poor" and "Very Good" and "Poor" condition categories (Figures 4.2b and 4.2c). Only vegetative composition (V5; $X^2 = 22.50$, df = 4, p <0.001) allowed for the differentiation of the

“Excellent” condition category from “Good”, “Fair”, and “Poor” condition categories (Figure 4.2d), although it still provided little ability to differentiate among other condition categories. Similar to individual attributes, NeWRAM condition scores provided the ability to differentiate among “Excellent” and “Very Good” and all other condition categories, but did not support differentiation among “Good” or worse condition categories (X^2 = 45.32, df = 4, p <0.001) (Figure 4.3).

Table 4.16. Relationship between NeWRAM condition scores and metrics and Level-3 metrics. Correlations are provided as Spearman's ρ correlation coefficients. Level-3 metrics are defined in Table 17.

NeWRAM Metric	Level-3 Metric	ρ	*P*
	Mean C	0.583	<0.001
Condition Score	Native Species	0.667	<0.001
	Invasive Species	-0.596	<0.001
	Mean C	0.340	0.001
V1	Native Species	0.306	0.001
	Invasive Species	-0.131	0.174
	Mean C	0.262	0.006
V3	Native Species	0.314	<0.001
	Invasive Species	-0.114	0.238
	Mean C	0.425	<0.001
V4	Native Species	0.586	<0.001
	Invasive Species	-0.488	<0.001
	Mean C	0.445	<0.001
V5	Native Species	0.617	<0.001
	Invasive Species	-0.868	<0.001
	Mean C	0.544	<0.001
V6	Native Species	0.550	<0.001
	Invasive Species	-0.382	<0.001
	Mean C	0.201	0.036
V7	Native Species	0.333	<0.001
	Invasive Species	-0.248	0.009

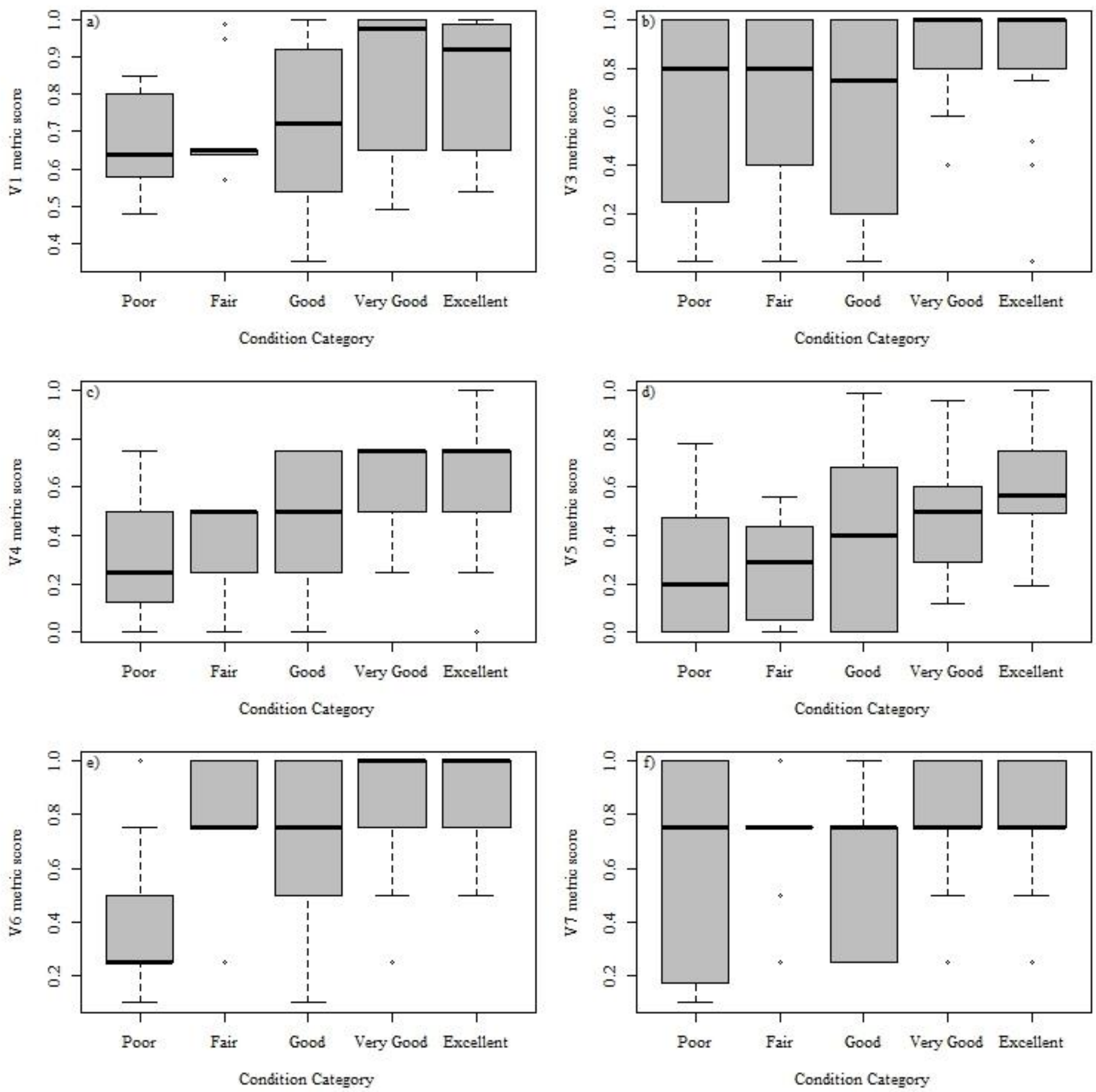

Figure 4.2. Relationships between the condition categories determined from standardized Mean C scores and a) watershed land cover (V1), b) buffer width and continuity (V3), c) buffer condition (V4), d) vegetative composition (V5), e) stressors to wetland hydrology (V6), and f) wetland land use (V7).

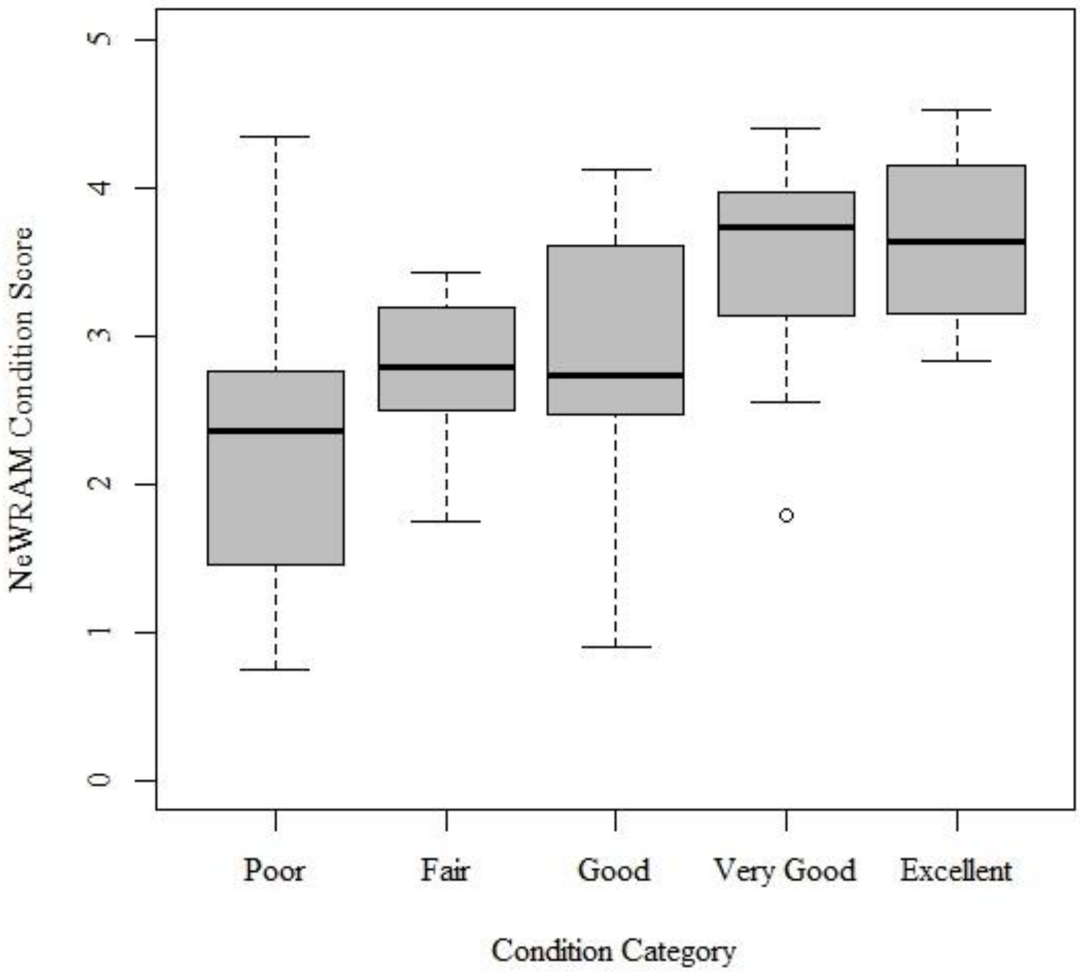

Figure 4.3. Relationship between the condition categories determined from standardized Mean C scores and NeWRAM condition scores.

Range and Representativeness

I tested NeWRAM condition scores and individual attributes as well as Level-3 metrics for normality using Shapiro-Wilk tests for normality. All NeWRAM metrics and Level-3 metrics were non-normal (Table 4.17). Given the typical nature of ecological data, these results are not surprising. All NeWRAM individual metrics showed distributions with scores dispersed throughout the potential ranges of 0 - 1 for each individual metric (Figure 4.4). NeRAM condition scores appear nearly normal and also are indicative of scores dispersed throughout the potential range from 0 – 5 (Figure 4.5).

Table 4.17. Results of Shapiro-Wilks normality tests for NeWRAM and Level-3 metrics. Departures from normality are presented in terms of Shapiro-Wilk W.

NewRAM Attributes	**Shapiro-Wilk *W***	***P***
Condition Score	0.93	<0.001
V1	0.90	<0.001
V3	0.76	<0.001
V4	0.87	<0.001
V5	0.95	<0.001
V6	0.82	<0.001
V7	0.79	<0.001
Level-3 Metrics	**Shapiro-Wilk *W***	***P***
Mean C	0.90	<0.001
Proportion of Native Species	0.76	<0.001
Relative Cover of Non-Native Invasives	0.82	<0.001

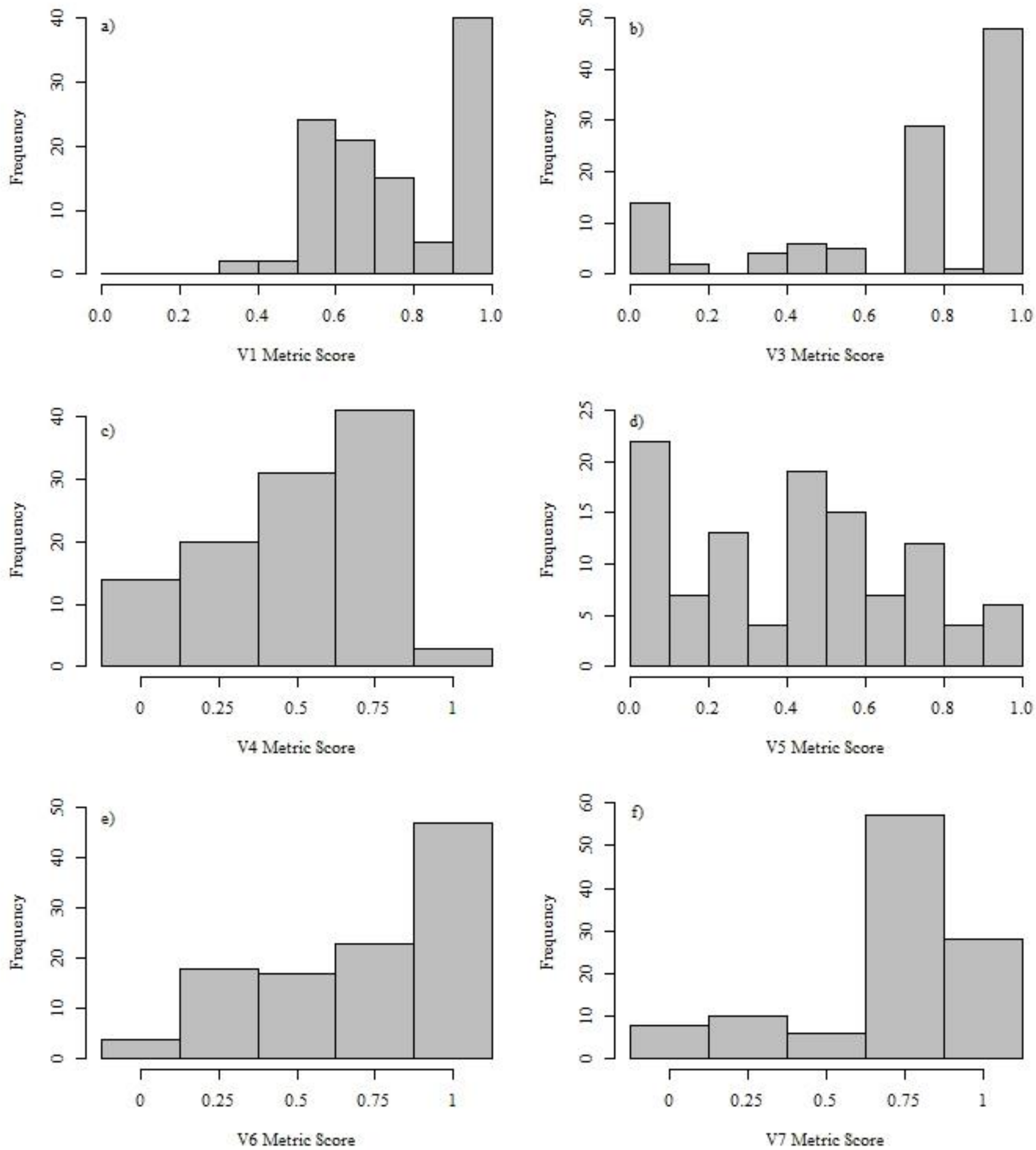

Figure 4.4. Distributions of NeWRAM metric scores for a) watershed land cover (V1), b) buffer width and continuity (V3), c) buffer condition (V4), d) vegetative composition (V5), e) stressors to wetland hydrology (V6), and f) wetland land use (V7).

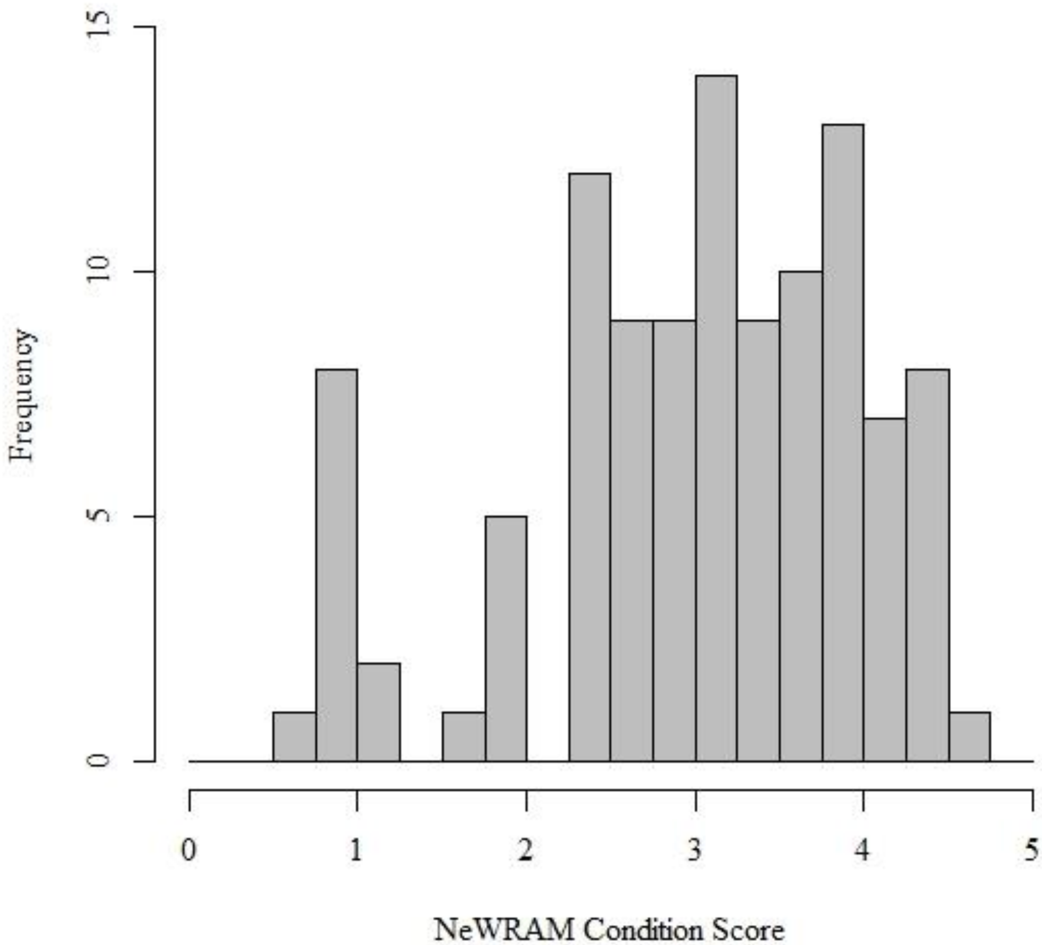

Figure 4.5. Distribution of NeWRAM condition scores incorporating all individual metrics. Potential scores range from 0 to 5, but in reality likely vary between 0.1 and 4.99 as only non-wetlands could receive a score of 0 and no perfect wetland sites exist on the landscape.

Redundancy

Correlation among individual NeWRAM metrics was significant and generally moderate to strong among all metrics (Figure 4.6). Because each metric is intended to measure the ecological condition of an individual aspect of wetland condition and condition is dependent upon multiple factors, the high correlation among metrics was expected. To test for potential effects of redundancy I conducted principal components analysis (PCA) and ran correlation between the first principal component (PC1) and NeWRAM condition scores and Mean C. Both NeWRAM condition scores and Mean C were significantly correlated with PC1 scores (Spearman's $\rho = -0.98$, $P < 0.001$ and $\rho = -0.57$, $P < 0.001$ respectively). Additionally, NewRAM condition scores and Mean C are also significantly correlated (Spearman's $\rho = 0.58$, $P < 0.001$). Results are indicative that NeWRAM condition scores and metrics are effective in capturing the potential range of wetland condition represented on the landscape.

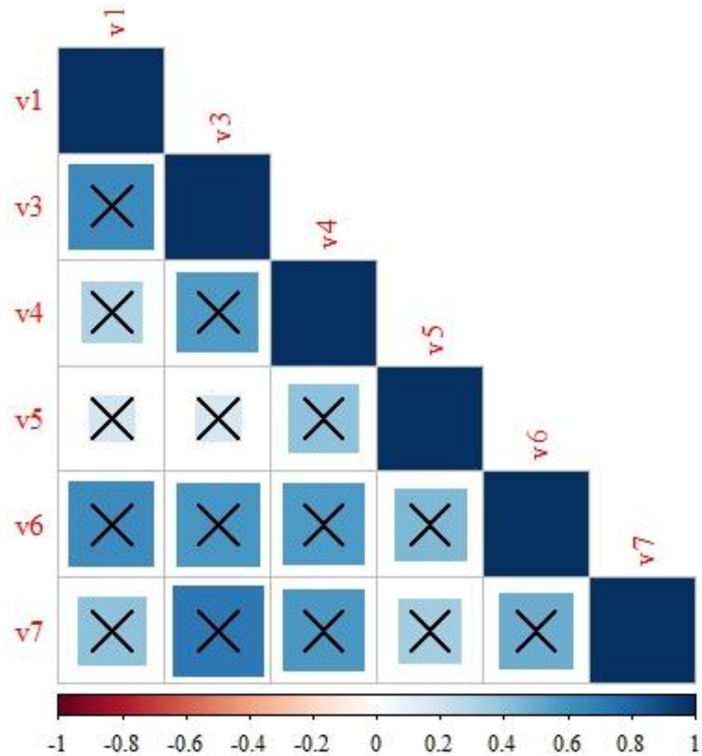

Figure 4.6. Results of Spearman's correlation comparisons among individual NeWRAM metrics. The color and size of squares indicate the Spearman ρ, while black X's indicated significance at α = 0.05.

Discussion

I developed, field-tested, and validated the Nebraska Wetland Rapid Assessment Method (NeWRAM v1.0) based upon factors suggested by Fennessy et al. (2007), methods described by Stein et al. (2009), and input from the Core Team. After reviewing 40 rapid assessment methods from around the United States, Fennessy et al. (2007) described four factors important in the development of any effective rapid assessment method: 1) takes less than eight hours for field and office assessment, preparation, and analysis, 2) includes an on-site field assessment, 3) measures ecological condition, and 4) can be validated using comprehensive ecological data. Each of these factors was considered during the development and field-testing of NeWRAM.

Wetland rapid assessment methods are partially defined by their ability to rapidly collect ecological data with a total implementation time of less than eight hours (Fennessy et al. 2007). During June – August of 2013, I field-tested NeWRAM v1.0 at 40 wetland sites in four wetland complexes. I conducted on-site rapid assessments concurrently with intensive Level-3 ecological data collection and USA-RAM. Because NeWRAM was conducted in conjunction with other ecological assessments I was unable to track the exact amount of time required; however, the collection of Level-3 ecological data, USA-RAM, and NeWRAM at a single wetland site never exceeded four total hours. Therefore, it is reasonable to assume that conducting ecological assessment using NeWRAM does not exceed the four hours, well under the eight hour time limit suggested by Fennessy et al. (2007).

Individual NeWRAM Metrics

In order to validate NeWRAM I assessed the responsiveness, range and representativeness, and redundancy of individual NeWRAM metrics and condition scores. I assessed the responsiveness of NeWRAM metrics by comparing each to Level-3 metrics using Spearman's correlation. I found moderately strong to strong correlations among buffer condition (V4), vegetative composition (V5), and stressors to wetland hydrology (V6). Low to moderate correlations were found among Level-3 metrics and watershed land cover (V1), buffer width and continuity (V2), and wetland land use (V7). These results suggest that NeWRAM metrics V4, V5, and V6 are effective for measuring the ecological condition of wetland sites, while metrics V1, V2, and V7 may individually be ineffective. When compared with Mean C scores for respective sites, Spearman's correlations varied between 0.201 and 0.617 for individual NeWRAM metrics. These results are consistent with results from the California Rapid Assessment Method (CRAM), where correlations among individual metrics and Level-3 metrics varied between 0.217 and 0.567 (Stein et al. 2009). These results suggest that despite relatively low correlations among individual metrics, in most cases metrics adequately measure variation in the ecological condition of wetlands.

Although individual metrics can effectively measure variation in wetland conditions, most metrics were unable to differentiate among pre-defined condition categories based on standardized Mean C scores. Most metrics were able to differentiate among "Excellent" and "Very Good" condition sites relative to "Poor" condition sites, but the ability to differentiate among "Fair", "Good", and "Very Good" condition sites was limited due to significant overlap in individual metric scoring among these categories. The distributions of individual metric scores indicate an ability to assess a range of condition by each NeWRAM metric score.

Additionally, I found relatively strong correlations among individual NewRAM metrics, which was not unexpected given that each metric is intended to measure one or more aspects of wetland condition and function. There is inevitably overlap in aspects of wetland condition and function measured by individual NeWRAM metrics; therefore, strong correlations were not unexpected and do not invalidate NeWRAM or individual NeWRAM metrics. These results suggest that the method in which attributes are scored and combined into a condition score is effective in measuring the overall variability in wetland condition.

Analysis of responsiveness, range and representativeness, and redundancy can be used to support the efficacy of individual NeWRAM metrics for measuring one or more aspects of the ecological condition of wetlands in Nebraska. Results of responsiveness and range and representativeness analysis indicate that some NeWRAM metrics are more effective in individually measuring the ecological condition than others. In particular, the low correlation and limited distribution of metric scores of V1 and V7 indicate a weak ability of these metrics in measuring condition and function. Additionally, no individual metrics were able to effectively differentiate among condition categories derived from Mean C scores. These results suggest that metrics should either be reconsidered for inclusion in the NeWRAM methodology or scoring methods should be adjusted. Based upon local knowledge of wetlands and general knowledge in regard to wetland ecology, metrics are likely important in determining the ecological of wetland sites. Therefore, it does not seem pertinent that metrics be removed, rather the method for scoring should be reconsidered. The current scoring method limits potential scoring to only five categories, which does not allow for much variation in scoring among sites. Scoring methods should likely be adjusted to represent scoring ranges and definitions similar to those of the evidence-based approach described by Johnson et al. (2013) for the development and implementation of FACWet in Colorado (Stein et al. 2009).

NeWRAM Condition Score

Similar to individual NeWRAM metrics, I tested the responsiveness and range and representativeness of NeWRAM condition scores. I found a strong correlation between NeWRAM condition scores and Mean C, the proportion of native plant species, and relative cover of non-native invasive species. I found a moderately strong correlation between NeWRAM condition scores and all Level-3 metrics ($\rho = 0.58$, $\rho = 0.67$, and $\rho = 0.60$ respectively). These results are slightly lower than correlations from CRAM and Level-3 metric scores ($\rho = 0.642$ and $\rho = -0.594$) (Stein et al. 2009) and much lower than correlation found among WRAP scores and landscape development indices for emergent and forested wetlands ($\rho = -0.92$ and $\rho = -0.82$) (Reiss and Brown 2007). Although these results indicate a slightly lower correlation relative to Level-3 metrics than other similar methods, this does not necessarily indicate an inferior or ineffective method.

In almost all instances, the development of wetland rapid assessment methodologies involves two or more separate methods. For example, the California RAM involves individual methodologies for estuarine, riverine, and depressional wetlands (Sutula et al. 2006, Stein et al. 2009). Similarly, the Ohio RAM involves methods for emergent, forested, and scrub shrub wetland types (Mack 2001). During the development of NeWRAM, it was decided to develop a single method for assessing all extant wetland types in Nebraska. Because I am using a single methodology for all wetlands, it might be expected that the correlation between NeWRAM condition scores and Level-3 metrics might be lower than RAMs based upon multiple methods for each wetland type. Currently, the correlation between NeWRAM and Level-3 metrics falls at the low end of correlation of similar RAM methods. This suggests that with some changes to NeWRAM metric scoring and testing of additional metrics, I can expect an increase in correlation similar to that found by Stein et al. (2009) after changes to metric scoring.

CONCLUSIONS

In its current form, NeWRAM v1.0 yields a moderately strong correlation among condition scores calculated from NeWRAM and Level-3 metrics. As it stands, I do not recommend the use of NeWRAMv1.0 for official regulatory or monitoring purposes. Three of the individual NeWRAM metrics currently use scoring systems limited to five condition categories. By expanding the scoring of the metrics to reflect systems similar to the evidence-based metric scoring described by Johnson et al. (2013), one would expect an increased correlation among these metrics and condition scores with Level-3 metrics due to increased responsiveness and range and representativeness. Furthermore, some additional metrics should be considered for inclusion in future versions such as habitat connectivity variables including neighboring wetland and riparian habitat loss and barriers to migration and dispersal. Any proposed and accepted changes will be incorporated into NeWRAM v2.0.

In addition to changes to individual NeWRAM metric scoring and the testing of new variables, multiple scoring methods should be examined. The method should also be tested by multiple teams at the same wetlands representing a range of condition, within mitigation sites prior to and post restoration, and at the same wetland site during various points of the sampling season from May through August. Results of such sampling will inform us in regards to the reproducibility of results using NeWRAM. In addition, the NeWRAM methodology should be tested at additional wetland sites where Level-3 data such as invertebrate, water quality, or bird data are available. After such testing is complete and changes are incorporated, the NeWRAM methodology should be applicable for assessing mitigation and measuring the ecological condition of wetlands for regulatory and monitoring applications.

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CHAPTER 5

AN ASSESSMENT OF STATE-WIDE LANDSCAPE CONDITION MODELS FOR MEASURING THE ECOLOGICAL CONDITION OF WETLANDS IN NEBRASKA

INTRODUCTION

Ecological condition commonly refers to the condition and function of the biological, physical, and chemical attributes and interactions attributed to a given natural ecosystem. Anthropogenic changes in the landscape directly and indirectly affect change in the biological, physical, and chemical attributes of natural ecosystems, resulting in profound and lasting impacts on the ecological condition and function. These relationships have led to an increase in the application of landscape and land use indices as predictors of ecological condition and ecosystem function. Such indices have been used to predict the ecological condition of multiple natural habitats including grassland (Bakker et al. 2002, Collinge et al. 2003, Mitchley and Xofis 2005), streams and rivers (Richards et al. 1996, Roth et al. 1996, Gergel et al. 2002), and wetlands (Houlahan et al. 2004, Houlahan et al. 2006, Mack 2006). Additionally, such indices may be applied at multiple spatial scales including watershed (Brooks et al. 2004), state (Shappell et al. 2016), and continental (Hak and Comer 2017). Such indices, however, must be ecologically relevant, relating pattern to process, and done so at an appropriate scale for the given ecological system and measured responses (Li and Wu 2004).

Land use surrounding wetlands result in direct and indirect impacts on the ecological condition and function. In most instances, it is generally assumed in landscape and land use indices that greater anthropogenic change and higher intensity activities (i.e. urbanization and agriculture development) result in greater impact on ecological condition and processes. Multiple methods exist for measuring the impact of surrounding land use. The simplest involves, determining the proportion of one or a few land uses in given area surrounding a wetland site or sites. For example, in the Upper Juniata watershed of Pennsylvania, Wardrop et al. (2007) used the percentage of forested cover in a 1-km buffer surrounding wetland sample points as a landscape measure of wetland condition. Alternatively, landscape condition may also be measured using combined measures of land use, typically referred to as landscape condition indices. One such index is the Landscape Development Intensity Index, which measures cumulative landscape condition based on the relative cover of land uses surrounding a site and the intensity of those land uses using a measure of energy per unit area (Brown and Vivas 2005). Such an approach has been successfully applied in both Florida (Cohen et al. 2004, Brown and Vivas 2005) and Ohio (Mack 2006) for measuring wetland condition based upon surrounding land uses.

To be relevant to ecological condition, landscape condition indices should be ecologically relevant (Li and Wu 2004). Ecological relevance may refer to either the presence of a known or assumed relationship between landscape condition and the ecological system or processes or the scale at which inference is made. The response of ecological systems to landscape condition indices is often measured using community data from various taxa including birds (Whited et al. 2000, Bakker et al. 2002, Fairbairn and Dinsmore 2001), insects (Collinge et al. 2003, Kennedy et al. 2013), amphibians (Houlahan and Findlay 2003, Buskirk 2005), and plants (Cohen et al. 2004, Houlahan et al. 2006, Mack 2006) and may include metrics such as richness, diversity, health, or sensitivity to change (i.e. coefficients of conservatism). Use of particular taxa for inference, however, should be linked to relevant landscape factors via ecological processes or functions. For example, increases in nutrients, in particular phosphorous and nitrogen, may result in changes to wetland vegetative community composition (Galatowitsch et al. 2000, Keddy 2000, Pauli et al. 2002, Woo and Zedler 2002); further, increases in wetlands nutrients are directly attributable to landscape factors, such as high proportions of intensive row crop agriculture in the surrounding landscape (Scanlon et al. 2007). This intuitive relationship implies that wetland vegetative communities may be used to assess the efficacy landscape condition indices, particularly in agriculturally dominated landscapes.

In Nebraska, no landscape condition assessment method has been tested or applied individually for assessing the ecological condition of wetlands. This is not surprising given the limited number of ecological assessment methods used in the state and, in general, limited regional scope of their application. Metrics of landscape condition, however, have been used in conjunction with other metrics including hydrologic alterations and vegetative community characteristics to assess the ecological condition of wetlands in Nebraska (Stutheit et al. 2004, NRCS 2009). For example, Stutheit et al. (2004) include land use within the wetland catchment as a variable to assess wetland function in the Rainwater Basins of Central Nebraska. Similarly, alterations to the landscape surrounding wetlands are assessed for riverine, playa, sandhill, and slope wetlands in the Nebraska Wetland Functional Assessment Protocol (NRCS 2009). Despite the inclusion of landscape metrics in these methods, thus recognizing that landscape factors affect the ecological condition or function of wetlands, no standalone landscape condition model has been developed for use in the state.

The availability of level 3 vegetative community assessment data from 109 wetlands in 11 wetland complexes across Nebraska provides a unique opportunity to test the efficacy of a landscape condition model for use across the state. Therefore, the primary goal of this research was to assess the efficacy of landscape as a predictor of the ecological condition of wetlands. I tested three different methods of measuring landscape condition in varying buffer widths (100 m, 500 m, and 1000 m) including the proportion of natural landcover, the Landscape Development Intensity Index (Brown and Vivas 2005, Mack 2006) and the NatureServe Landscape Condition Model (Hak and Comer 2012, 2017). The relationship among estimated landscape condition model scores and vegetative community metrics was assessed using simple correlation as well as linear regression using multi-model inference.

METHODS

Study Sites

Vegetative community data was collected at 109 wetland sites in 11 wetland complexes located across Nebraska (Figure 5.1). Wetland complexes generally aligned with Biologically Unique Landscapes (BULs) designated by the Nebraska Game and Parks Commission. Up to nine sites within each complex were randomly selected using a randomized block design in which a “universe” of potential wetland sites were defined in ArcGIS using National Wetlands Inventory mapping units, hydric soils from the

SSURGO databases selected to align with desired vegetative communities, and wetland complex boundaries. Potential wetland sites were assigned random numbers and landowners were contacted to obtain permission to access sites using the randomly assigned order. Due to the logistics of working with private landowners, more potential wetland sites were selected than necessary. In addition, a single “reference standard” wetland site was selected within each complex based upon the knowledge of local managers and land owners. All sites were visited once between May and August of 2011 – 2014.

Natural Wetland Buffer Metrics

The maintenance of natural buffers surrounding wetlands in an important component in protecting the ecological condition and maintaining natural functions in natural systems. While the distance of such buffers for differing functions and aspects of ecological condition is variable (i.e., maintaining plant communities versus amphibian communities), in general it is agreed that a minimum of a 100 m natural buffer is required in most instances. As a part of Level 2 and Level 3 assessments, I measured different components of buffer integrity including the width and continuity and qualitative condition and stress.

I determined buffer width and continuity in ArcGIS 10.3 using a combination of aerial photography and land use maps. To do so, a 100 m buffer was placed around all wetland sites. The overall width was estimated as the mean width in the eight the cardinal and ordinal directions. Continuity was estimated as the percentage of the wetland that has a buffer of at least 5 m in 5% increments. The final buffer width and community metric (Buff_width) was determined using a summary rating table that reconciles the mean width with estimated continuity, resulting in a final value between 0 and 1.

Buffer condition (Buff_stress) was assessed as a component of the Level 2 (Nebraska Wetland Rapid Assessment Method) and Level 3 assessment techniques. It is comprised of two components, the presence and severity of stressors and the presence and coverage of non-native invasive plant species. I determined a final quantitative stress value by reconciling these factors into a single score (see Appendix B Tables 7, 8, and 9 for descriptions of categories and scoring).

The final buffer metric (Buff_cond) was determined by multiplying the Buff_width score by the Buff_stress score as a comprehensive measure of the contiguousness and condition of the natural buffer surrounding wetland sites.

Proportion of Natural Landcover

The simplest measure of landscape condition is the proportion of landcover of a given land class surrounding a wetland site. In Pennsylvania, Wardrop et al. (2007) used the proportion of forest cover in a 1000 m buffer surrounding wetland sites as a measure of landscape condition. In its simplest form, this merely represents what the assumed natural landcover is in the forested watershed where this study occurred. Since this study incorporates wetlands across Nebraska that occur in varying natural landscapes ranging from riparian forest to grasslands, I used the proportion of all natural landcover in buffers surrounding wetland sites, rather than just a single natural landcover. I determined landcovers from the Nebraska Landcover Map (Bishop et al. 2001, Rainwater Basin Joint Venture 2012) by reclassifying existing landcover into two classes, modified and natural, using the ‘reclassify’ tool from the Spatial Analyst Toolbox in ArcGIS 10.3. I extracted the proportion of cover in 100 m, 500 m, and 1000 m buffers surrounding wetland sites using the 'isectpolyrast' tool in the Geospatial Modelling Environment 0.7.4.0, with both thematic and proportion options set to 'True' (Beyer 2010).

Landscape Development Intensity Index (LDI)

Previous studies have used only % native land-cover to calculate a score ranging from 0 to 100% (Wardrop et al. 2007). This method, however, fails to address the varying impacts that alternative land-uses in the surrounding habitat matrix have on the wetlands they surround. For example, grazed rangelands will have less of an impact on a wetland than intensive row crop agriculture or urban development (Brown and Vivas 2005). This would likely result in an overestimate of the quality of buffers that surround wetlands. Therefore, I used % land cover and an index of landscape development intensity (LDI) to calculate landscape level condition scores, which allow for better quantification of human disturbance (Mack 2006). The equation used to calculate an LDI score is,

$$LDI_{Total} = \sum \%LU_i \times LDI_i$$

where, LDI_{Total} = the LDI score for the landscape surrounding a wetland, $\%LU_i$ = percent of the total area in a particular land use, and LDI_i = the landscape development coefficient associated with that land use and is measured in solar energy joules/ha x yr^{-1} (Brown and Vivas 2004). Although the LDI coefficients were originally used in Florida, studies from other states have used the same coefficients and found strong relationships between LDI scores and rapid and intensive assessment methods (Mack 2006). This suggests that the same LDI coefficients may be applied in Nebraska (Table 5.1).

Table 5.1. Land cover categories and their associated ranks. Ranks represent the varying impacts of anthropogenic land covers between urban development and natural habitats. Land cover classes are based on the Nebraska Landcover Map (Bishop et al. 2001, Rainwater Basin Joint Venture 2012). For these analyses, existing landcovers were reclassified into 12 broad land use classes. Ranks are adapted and inverted from the Landscape Development Intensity Index coefficients developed by Brown and Vivas (2005) and Mack (2006).

Land Cover Classes	**NE r_i coefficients**
Natural	1.00
Water	1.00
Orchard/Vineyard	3.68
Row Crops	4.54
Recreational/Open Space	6.92
Roads/Highways	8.05
Developed, Low Intensity	7.47
Developed, High Intensity	7.55
Industrial	8.32
Urban	9.42

NatureServe Landscape Condition Model* (*LCM)

The NatureServe Landscape Condition Model (LCM) depicts cumulative anthropogenic impact on the landscape by synthesizing stress into 30 x 30 m pixels. The LCM is comprised of 13 landscape variables including transportation, development, utility, and lands use stressors (Table 5.2). Model development was largely based on methods described by Comer and Hak (2012), Hak and Comer (2017), and Shappell et al. (2016). All synthesis and development were conducted in ArcGIS 10.2 (ESRI 2013) and Ecological Modelling Environment 0.7.3.0 (Beyer 2015). While the landscape model was developed within the context of measuring the ecological condition of wetlands, the resulting model has multiple applications for measuring landscape or site-specific stress.

Model Inputs

Statewide transportation data including roads, highways, and railroads were included as landscape stressors (Table 5.2). All road transportation stressor data was derived from the 2010 transportation TIGER vector data set (https://dnr.nebraska.gov/data/transportation). Individual road category shapefiles (local, rural, secondary road, state highway, and interstate highway) were created using the select by attribute tool and exported as vector shapefiles, resulting in five individual roads shapefiles of increasing size and impact. Active railroad line vector data were obtained as 2010 TIGER shapefiles from the Nebraska Department of Natural Resources (https://dnr.nebraska.gov/data/transportation).

Development and land use/landcover stressor variables were extracted from the Nebraska Landcover Map (Bishop et al. 2011, Rainwater Basin Joint Venture 2012). Land use/landcover categories were reclassified using the reclassify tool into 6 general categories including three development categories (high intensity, medium intensity, and low intensity), developed open space (e.g. golf courses, parks, etc.), high intensity row crop agriculture (eg. soy beans and corn), and low input row crop agriculture (e.g. cereal grains) (Table 5.2). Because natural land use categories (e.g. wetlands, forests, grasslands) are not considered stressors, they were excluded from further analysis. Although it is possible that many grassland and wet meadow areas fall on actively grazed ranchlands, cattle may actually represent and important management tool in maintaining ecosystem diversity and function (Hayes and Holl 2003). Historically, grasslands and wet meadows in the Great Plains were maintained through grazing by ungulates such as bison (*Bison bison*), a role that has recently been occupied by cattle (*Bos taurus*), but both have been shown to perform well in maintaining species diversity and structural composition of grassland sites (Towne et al. 2005, Allred et al. 2011). As cattle may act as an important component in maintaining the ecological integrity of grasslands and cattle ranches are not independently mapped as agriculture, but rather considered grasslands, they are excluded as a landscape stressor for this analysis. New raster files were created for each individual land use/landcover category 30 x 30 m grids.

Data on the location of oil and gas wells were also incorporated as landscape stressors (Table 5.1). A locality point shapefile for all active oil and gas wells was obtained from the Nebraska Oil and Gas Conservation Commission (http://www.nogcc.ne.gov/NOGCCPublications.aspx). Most of the oil and gas wells are located in southwest Nebraska, with a preponderance occurring in the Southwest Playa wetland complex. The inclusion of additional utilities data included powerline corridors would be ideal (Shappell et al. 2016), but such data is protected and not readily available for public use; therefore, it is not included as a landscape stressor in this data set.

Calculations

Following Comer and Hak (2012) and Shappell et al. (2016) I assumed that the ecological impact of any given stressor decreases to 0 within 2000 m. To limit estimated impact of stressors, I prepared each of the 13 stressor layers by creating a 2000 m calculation envelope using the 'Euclidian distance' tool. Functionally, this converted each stressor input into 30 x 30 m raster grid extending 2000 m from the location of a given stressor. For vector data such as roads, this creates linear calculation envelopes encompassing roads, whereas for oil and gas wells that are mapped as points, this results in circular calculation envelopes surrounding each point. Cell values within each calculation envelope were equal to the distance from the stressor. Cells beyond the calculation envelope were assigned null values.

The stressor impact for each raster cell was calculated using a sigmoidal decay function rather than linear decay function to represent that impacts are more severe closer to the stressor but decrease in a non-linear manner as distance from the stressor increases. Each of the 13 stressors was assigned one of six potential sigmoidal decay functions representing varying degrees of stress attenuation (Figure 5.2). Stressors values for each raster cell were calculated independently for each stressor as follows:

$$val = \frac{1}{1 + \exp(\left(\frac{x}{c} - a\right) * b)} * w$$

The shape of the curve is primarily defined by two variables, *a* that shifts the inflection point away from 0, where a high value is indicative of impacts that remain high, and *b* that sets the slope as impacts decrease (Table 5.2). A constant c limited the distance of calculations, where $c = \frac{dist}{20}$ and *dist* = 2000 m.

Stressor weights (w) were assigned to individual stressors following Grunau et al. (2012), Comer and Hak (2012), and Shappel et al. (2016) (Table 5.1). Low values of w are indicative of assumed lower ecological impacts of a stressor, whereas high values are indicative of assumed greater ecological impacts of a stressor. As such, a stressor such as oil or gas wells is assumed to have low impact and thus assigned a stressor weight of 100 and a stressor such as high intensity development or highway is assigned a stressor weight of 500. The final raster value was calculated using the 'Raster Calculator' tool in ArcGIS 10.3 as the sum of rater scores from the 13 stressor raster layers divided by 4171.89 (the maximum possible raster sum) and multiplied by 100 to place final values on a scale of 0 to 100.

The condition of the landscape within 100 m, 500 m, and 1000 m buffers was determined using the 'isectpolyrst' tool in the Geospatial Modelling Environment 0.7.4.0. This tool extracts the mean raster score within each specified buffer. I calculated the final index score by subtracting the buffer mean from 100, resulting in an assumed positive relationship between vegetative community metrics and the calculated NatureServe Landscape Model score.

Table 5.2. Landscape stressors incorporated into the Nebraska Landscape Condition Model including function types, variable values (a, b, c, and w), and decay distances. The inflection point and slope are defined by *a* and *b*. The variable *c* limits the maximum distance at which a stressor impacts a wetland to 2000 m. The variable *w* defines the weight of the stressor.

Stressor	**Distance Decay Function**	**a**	**b**	**c**	**w**	**Decay Distance (m)**
Transportation						
Local, Urban	Y3	1	5	100	300	200
Rural	Y2	0.5	10	100	200	100
Secondary Roads	Y4	2.5	2	100	400	500
State Highway	Y5	5	1	100	450	1000
Interstate Highway	Y5	5	1	100	500	1000
Active Rail Lines	Y2	0.5	10	100	500	100
Development						
High Intensity	Y6	10	0.5	100	500	2000
Medium Intensity	Y4	2.5	2	100	400	300
Low Intensity	Y4	2.5	2	100	400	300
Utility						
Oil/Gas Wells	Y1	0.25	20	100	100	50
Land Use/Landcover						
Open Space	Y3	1	5	100	300	200
High Intensity Row Crop	Y3	1	5	100	300	200
Low Intensity Row Crop	Y3	1	5	100	300	200

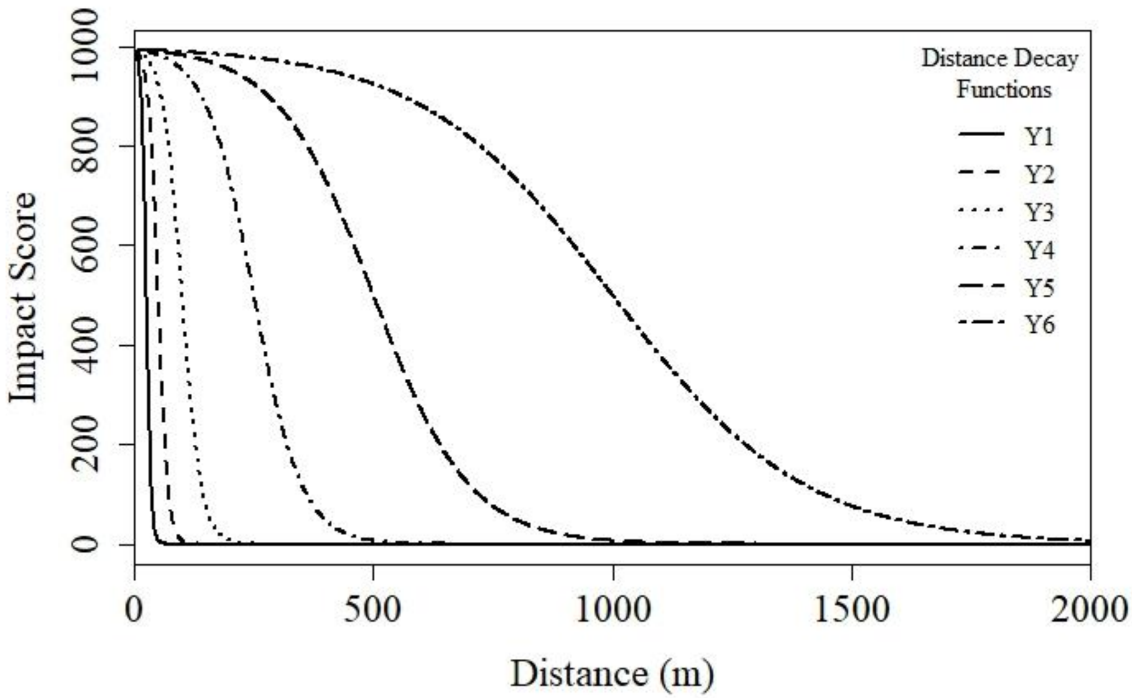

Figure 5.1. Distance decay curves used to model the decrease of ecological stress as distance increases from stressors. Stressors modeled with the Y1 curve were assumed to have impacts that decreased rapidly (e.g., oil and gas wells); whereas, stressors modeled with the Y6 curve were assumed to have impacts that decreased gradually (e.g., high intensity development).

Statistical Analyses

Responsiveness of Landscape Analysis Methods to Vegetative Community Metrics

I assessed the responsiveness of the buffer metrics, LDI scores, and LCM scores relative to vegetative community metrics (Mean coefficient of conservatism, proportion of native species, and cover of invasive species). I measured the responsiveness of buffer metrics and landscape model scores using Spearman's ρ correlation. I generally assumed that a strong positive relationship should exist between Mean C and proportion of native species and all buffer metrics and landscape condition model scores. In contrast, I expected a strong negative relationship between cover of invasive species and both buffer metrics and landscape condition model scores. To test for the ability of buffer and landscape metrics to differentiate among condition categories, I used Kruskall-Wallis tests to compare condition categories inferred from Mean C among individual buffer and landscape metrics. I used *post-hoc* Dunn's tests to infer differences among condition categories. Analyses were conducted in the program R v.3.5.0 (R Core Team 2018).

Multi-model Inference

To model the relationship between Mean C scores and buffer metrics and landscape condition model scores I used an information theoretic approach to model selection and multi-model inference. I fit generalized additive models (GAMs) using the "gam" function with a gaussian distribution using the "mgcv" package (Wood 2011) in R v.3.5.0 (R Core Team 2018). GAMs are a semi-parametric regression modeling technique that employs automated smoothing methods to allow for non-linear response curves (Wood 2016). I assessed an *a priori* set of 20 candidate models representing hypothesized relationships between Mean C scores and buffer metrics and landscape condition models at varying spatial scales. Model rank and fit was assessed using Akaike's information criterion (AIC; Burnham and Anderson 2002). I assessed the relative importance of each model using the difference in AIC (ΔAIC) of each model relative to that of the model with the lowest AIC_c in addition to model weights (w_i). To infer differences between closely ranked models, I made pairwise comparisons of models using ANOVA and likelihood ratio tests. The topel model was determined based on model weights and fit was assessed using adjusted R^2 and percent deviance explained.

RESULTS

I calculated three buffer metrics as well as LDI and LCM at 100 m, 500 m, and 1 km spatial scales for 109 wetland sites across Nebraska. Vegetative metrics including proportion of native species, cover of invasive species, and mean coefficient of conservatism were previously calculated for these wetland sites. As previously discussed (see Chapter 2 and Chapter 3), proportion of native species, cover of invasive species, and Mean C scores were variable both with and among complexes. Perhaps the largest disparity, however, occurred in Mean C scores for both the MR and NPR complexes in which nearly all sites scored below -8 or "poor" condition (Figure 5.2). Due to this departure of all sites from assumed reference standard condition and a similar pattern not being observed in landscape and buffer metrics, these complexes were removed from further analysis.

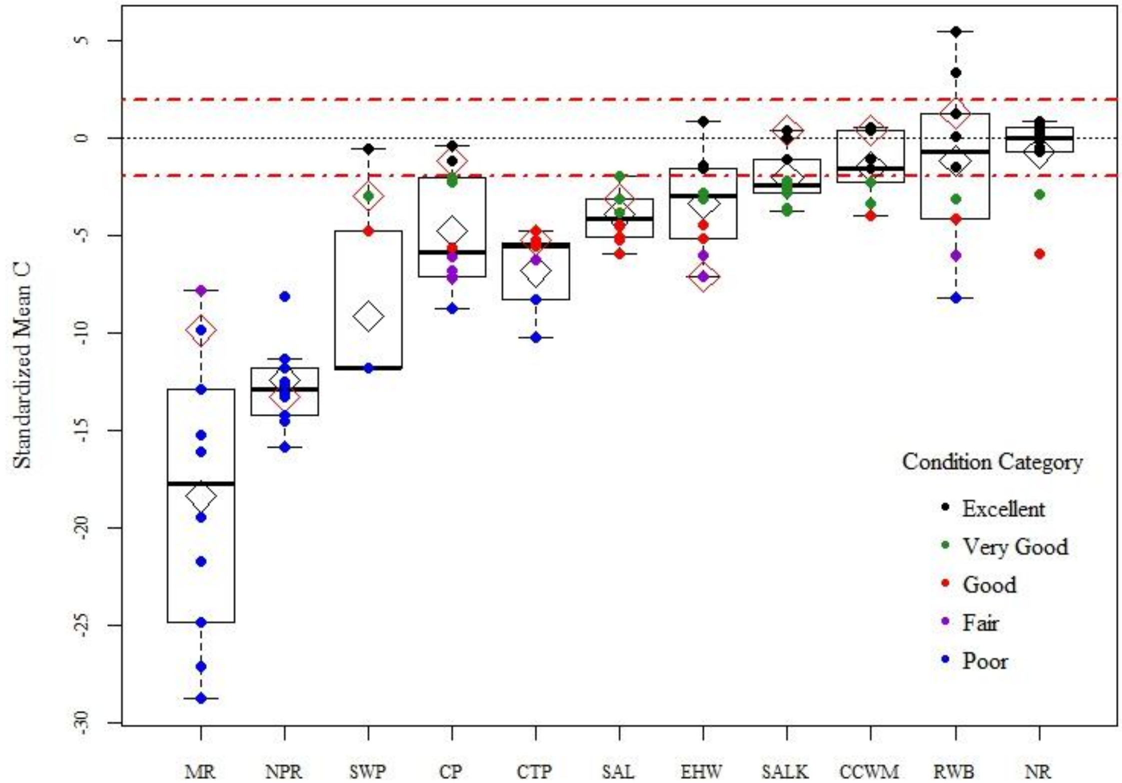

Figure 5.2. Results of standardized Mean C scores for the 11 wetland complexes sampled across Nebraska. Standardized Mean C scores provide an easy way to interpret measure of the ecological condition of wetlands based upon vegetative community surveys and estimates of reference standard wetland condition. The zero line indicates the estimated reference standard condition. Red lines on either side of zero indicate the 95% confidence intervals surrounding the estimated reference standard ("Excellent") condition, with points falling within these confidences intervals being considered reference standard. Subsequent condition categories occur at intervals of approximately 4, 6, 8, and 10 standard deviations ("Very Good", "Good", "Fair" and "Poor", respectively) from the estimated reference standard condition. Black open diamonds indicate complex means, while red open diamonds indicate the score from references standard sites.

Natural Wetland Buffer Metrics

I calculated scores for three buffer metrics, one that measures the width and continuity of the natural buffer up to 100 m surrounding wetland sites (Buffer Width and Continuity), one that measures stress to the integrity of the natural buffer (Buffer Stress), and that last which measures the interaction between the previous two metrics (Buffer Condition) (Figure 5.3). In most instances, Buffer Width and Continuity was high at most wetland sites and within most wetland complexes (Figure 5.3a). In particular, this metric was consistently high in the multiple sandhills wetland complexes (EHW, SALK, CCWM, and NR). Buffer width and continuity were variable in the three playa wetland complexes (SWP, CTP, and RWB), with all having at least one site with no natural buffer (Figure 5.3a).

In almost all instances, natural buffers were impacted by at least some level of stress (Figure 5.3b). Most sites showed mid-level stress with scores between 0.2 and 0.8. Generally, the complexes with the lowest buffer stress scores also had the lowest standardized Mean C scores. Only three complexes had at least one wetland site with no noticeable buffer stress (SALK, CCWM, and NR), with all three complexes located in association with the Nebraska Sandhills region.

The metric Buffer Condition combines the previous two metrics as a measure of both buffer extent and condition. Buffer Condition results are very similar to those of Buffer Stress, with most complexes having Buffer Condition scores between 0.2 and 0.8 (Figure 5.3c). Similar to Buffer Stress metric scores, Buffer Condition metric scores were highest in the Nebraska Sandhills complexes (EHW, SALK, and CCWM). Only two complexes contained at least one wetland site with a perfect Buffer Condition metric score.

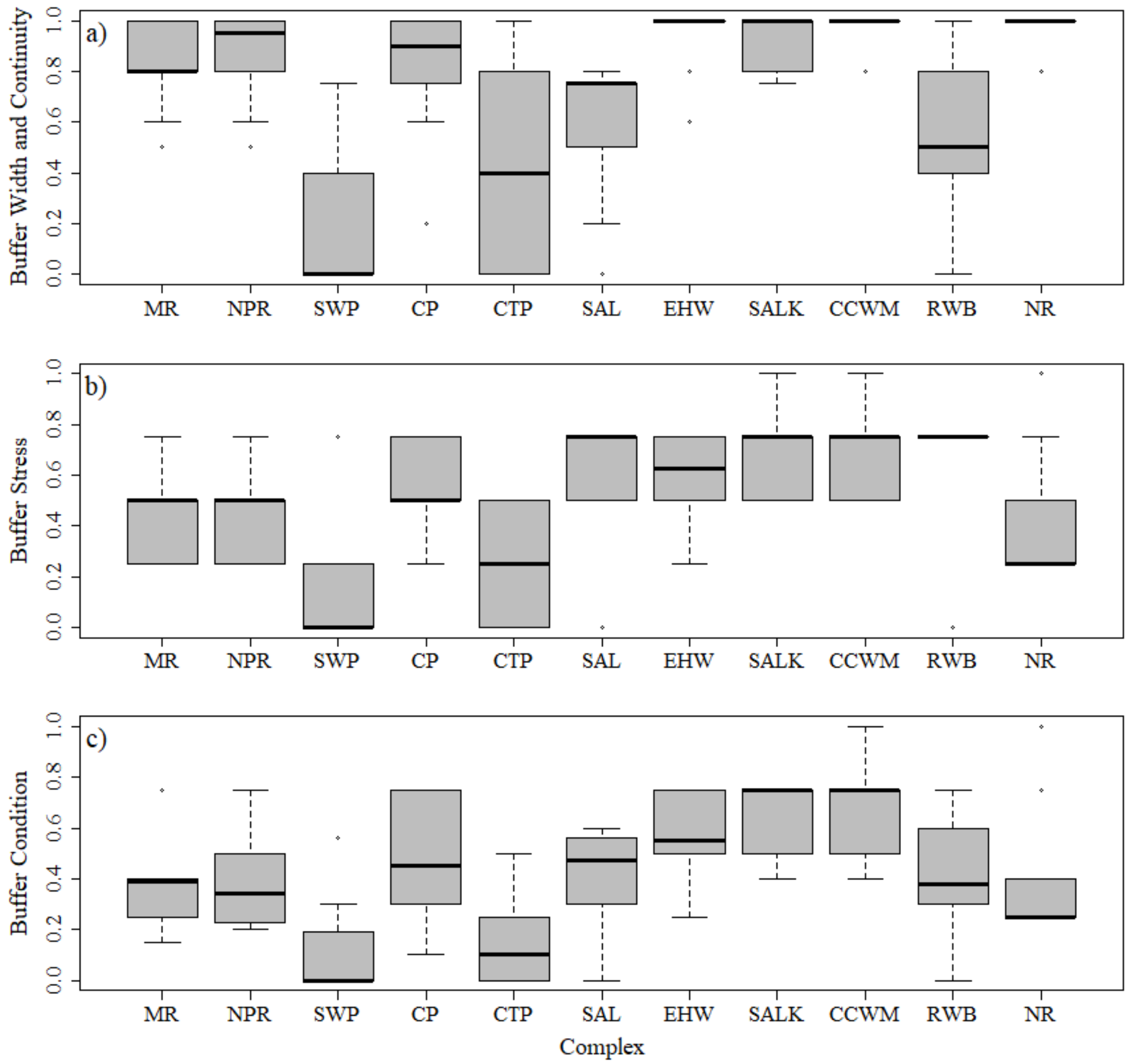

Figure 5.3. Results of three buffer metric scores a) Buffer Width and Continuity, b) Buffer Stress, and c) Buffer Condition for 109 wetland sites in Nebraska. In all instances, the dark bars indicate median score, boxes indicate interquartile range, and bars indicate 1.5 * the interquartile range. Points are indicative of potential outliers.

Proportion of Natural Land Cover

Proportion of natural cover in concentric buffers surrounding wetland sites represents the simplest measure of landscape condition. Proportion of natural land cover surrounding wetland sites varied from 0 – 1, but in general was less than 1 (Figure 5.4). Variability in land cover changed as the size of buffers increased from 100 m to 1 km, with two patterns emerging. In complexes with higher variability at 100 m, variability decreased at larger spatial scales. In contrast, complexes with less variability at the 100 m spatial scale showed an increase in variability as spatial scales increased. Similar to buffer metrics, the wetland complexes located in the Nebraska Sandhills (EHW, SALK, CCWM, and NR) had much higher proportions of natural landcover than wetland complexes embedded in agricultural and urban habitat matrices (SWP, CP, CTP, SAL, and RWB).

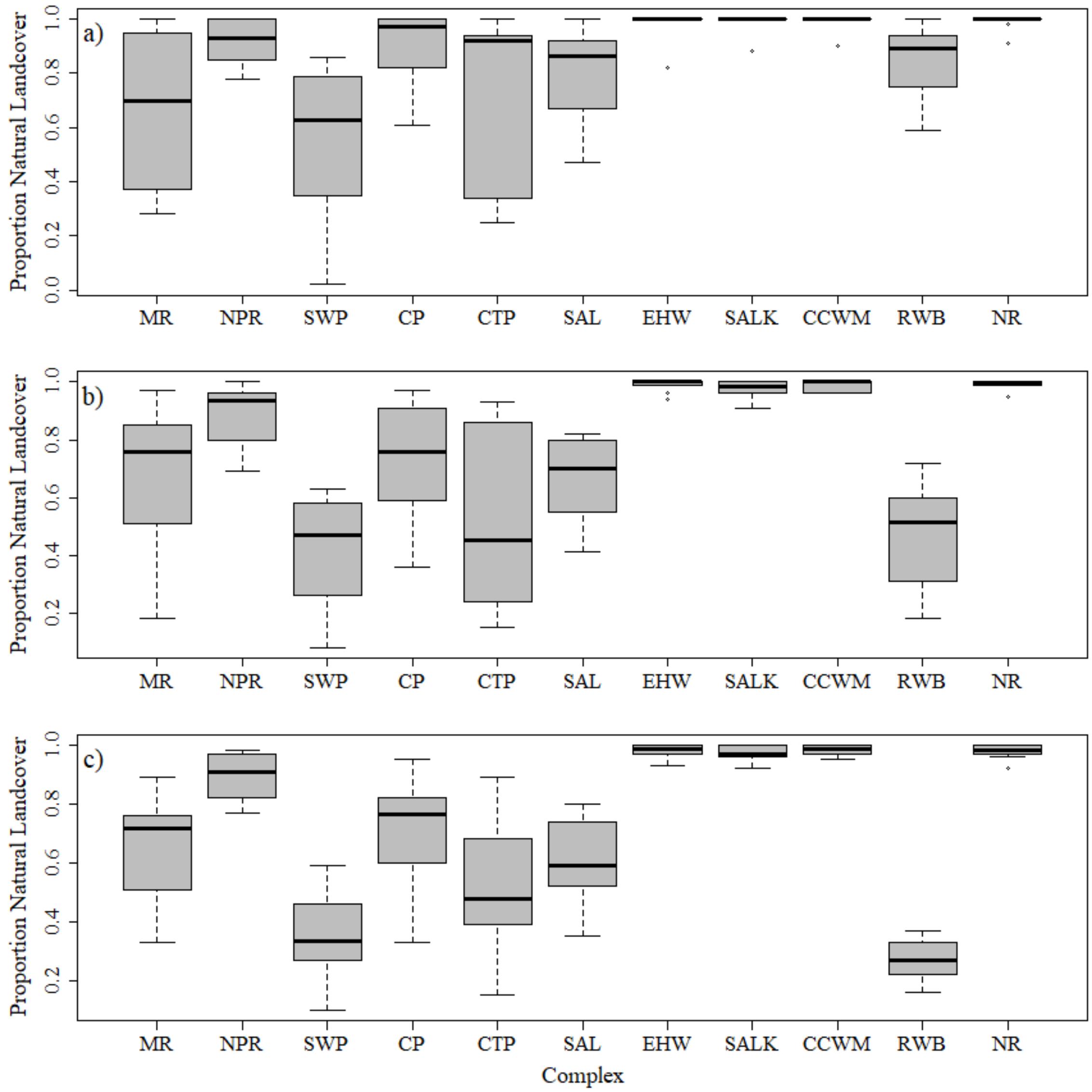

Figure 5.4. The proportion of natural land cover surrounding 109 wetland sites across Nebraska at three spatial scales: a) 100 m, b) 500 m, and c) 1 km. In all instances, the dark bars indicate median score, boxes indicate interquartile range, and bars indicate 1.5 * the interquartile range. Points are indicative of potential outliers.

Landscape Development Intensity (LDI) Index

The LDI attempts to measure the impacts of anthropogenic activities on the landscape based upon the assumed energy that is required to maintain differing land use types. Rather than focus solely on natural land use, it takes into consideration 10 land use categories. LDI is scored on a scale from 1 – 10. Although there is some variability at differing spatial scales, scores for all sites varied from 4 – 10 (Figure 5.5). Similar to Proportion of Natural Land Cover, LDI scores were highest in the wetland complexes located in the Nebraska Sandhills (EHW, SALK, CCWM, and NR), varying between 9 and 10 at 500 m and 1 km spatial scales. In all complexes, variability decreased the spatial scale used to calculate LDI surrounding wetland sites increased.

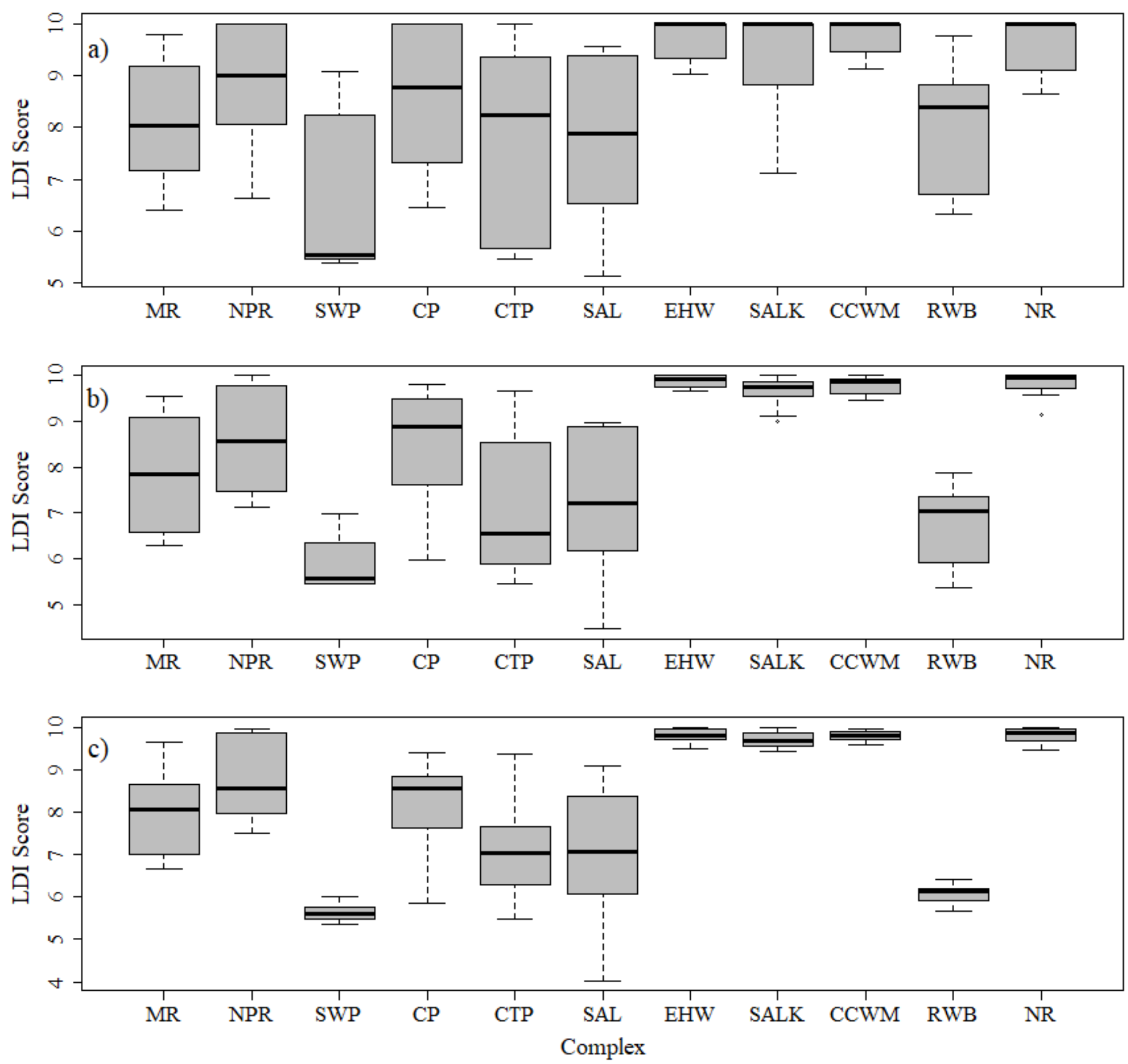

Figure 5.5. Landscape Development Intensity Index scores for 109 wetland sites across Nebraska at three spatial scales: a) 100 m, b) 500 m, and c) 1 km. In all instances, the dark bars indicate median score, boxes indicate interquartile range, and bars indicate 1.5 * the interquartile range. Points are indicative of potential outliers.

NatureServe Landscape Condition Model (LCM)

I used the LCM to similarly measure anthropogenic impact on the landscape surrounding 109 wetlands. In contrast to the LDI, which assumes that impacts of land use have the same impact regardless of distance from a wetland, the LCM uses varying decay functions with the assumption that impacts of anthropogenic landscape factors decrease as distance from the wetland edge increases. In general, LCM scores were much less variable than the other measures of landscape condition ranging from approximately 50 – 100 (Figure 5.6). The SAL wetland complex had the most variable LCM scores, with the wetland complexes associated with the Nebraska Sandhills scoring the highest, although all complexes had at least one site that scored between 90 and 100. Similar to the LDI Index scores, variability in scores decreased as landscape scale increased from 100 m to 1 km.

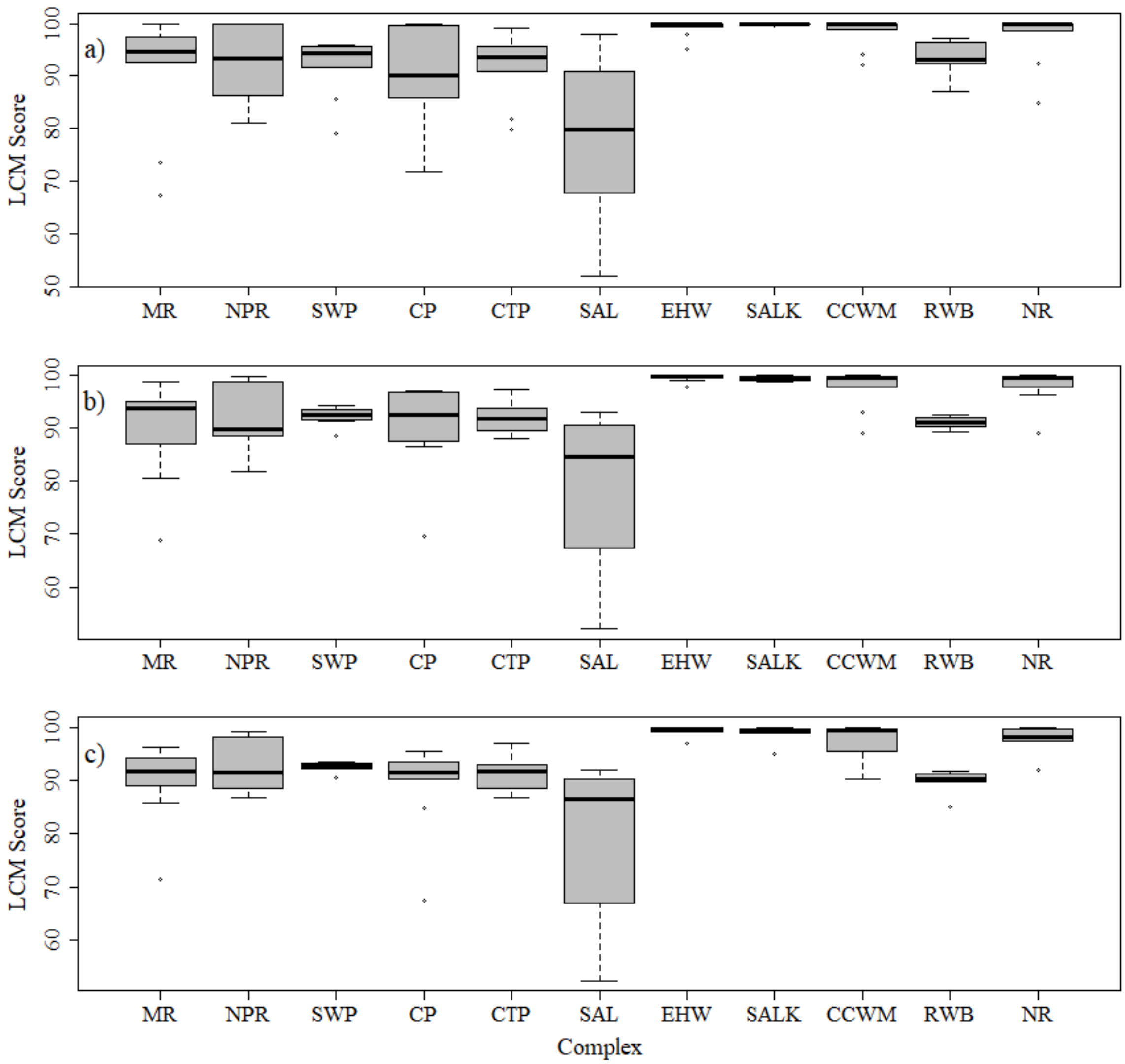

Figure 5.6. NatureServe Landscape Condition Model scores for 109 wetland sites across Nebraska at three spatial scales: a) 100 m, b) 500 m, and c) 1 km. In all instances, the dark bars indicate median score, boxes indicate interquartile range, and bars indicate 1.5 * the interquartile range. Points are indicative of potential outliers.

Statistical Analyses

Responsiveness of Landscape Analysis Methods to Vegetative Community Metrics

I used Spearman's ρ correlation to assess the responsiveness of landscape metrics at various spatial scales to vegetative metrics. I found low to moderate correlation between standardized mean coefficient of conservatism (Mean C) and landscape condition metrics, with the strength of the correlation decreasing as landscape scale increases (Table 5.3). Similar trends were observed for the relationship between the proportion of native species (prop.nat; Table 5.4) and cover of invasive species (cov.inv; Table 5.5). The strongest correlation for both Mean C and prop.nat occurred with the buffer condition metric Buff_cond, which incorporates the buffer extent and buffer stressors. For cov.inv, the strongest correlation was found with the buffer condition metric Buffer_stress, which was not surprising given that the presence of invasive species in the buffer is a stressor. In all instances for all landscape metrics tested, the strength of the correlation decreased as distance from the wetland increased (Buffer Condition Metrics > 100 m > 500 m > 1 km).

Buffer metrics showed differing degrees of ability to differentiate among condition categories. I found a significant difference among condition categories for all buffer metrics (Buff_width: $X^2_{4,84} = 25.98$, $p < 0.001$; Buff_stress; $X^2_{4,84} = 27.54$, $p < 0.001$; Buff_cond: $X^2_{4,84} = 127.54$, $p < 0.001$) (Figure 5.7). For Buff_width, I found a significant difference among "Poor" and "Exellent" and "Very Good" categories; however, I was unable to differentiate among all other condition categories (Figure 5.7a). Similarly, for Buff_stress I found significant differences among "Poor" and both "Excellent" an "Very Good", but not among all other condition categories (Figure 5.7b).

The same relationship was observed for Buff_cond, with only “Poor” significantly different from both “Excellent” and “Very Good” categories (Figure 5.7c).

Despite the fact that I found a significant difference among condition categories for proportion of natural landcover at all spatial scales (100 m: $X^2_{4,84}$ =124.99, p < 0.001; 500 m; $X^2_{4,84}$ = 23.42, p < 0.001; 1 km: $X^2_{4,84}$ = 20.76, p < 0.001), the degree to which differences in categories could be inferred was weak (Figure 5.8). At all three spatial scales (100 m, 500 m, 1 km), I found a significant difference among “Poor” and “Exellent” and “Very Good” categories; however, I was unable to differentiate among all other condition categories (Figure 5.8a; Figure 5.8b; Figure 5.8c).

I found a significant difference among condition categories for LDI scores at all spatial scales (100 m: $X^2_{4,84}$ = 22.96, p < 0.001; 500 m: $X^2_{4,84}$ = 25.09, p < 0.001; 1 km: $X^2_{4,84}$ = 24.78, p < 0.001), but the degree to which differences in categories could be inferred was similarly weak relative to proportion of natural landcover (Figure 5.9).

A significant difference among condition categories for LCM scores was found at all spatial scales (100 m: $X^2_{4,84}$ = 15.99, p < 0.001; 500 m; $X^2_{4,84}$ =14.49, p = 0.01; 1 km: $X^2_{4,84}$ = 11.48, p = 0.02); however, the degree to which differences in categories could be inferred was very weak (Figure 5.10). *Post hoc* Dunn’s tests indicated no significant differences among condition categories at all spatial scales with pairwise comparisons.

Table 5.3. Spearman’s ρ correlation for standardized mean coefficient of conservatism (Mean C) and buffer and landscape metrics.

Mean Standardized Coefficient of Conservatism (Mean C)		
Buffer Condition Metrics		
Landscape Metric	*Spearman's ρ*	*p*
Buff_width	0.443	<0.001
Buff_stress	0.491	<0.001
Buff_cond	0.509	<0.001
Landscape Condition at 100 m		
Landscape Metric	*Spearman's ρ*	*p*
nat.100m	0.444	<0.001
LDI.100m	0.452	<0.001
LCM.100m	0.326	0.002
Landscape Condition at 500 m		
Landscape Metric	*Spearman's ρ*	*p*
nat.500m	0.430	<0.001
LDI.500m	0.446	<0.001
LCM.500m	0.335	0.001
Landscape Condition at 1 km		
Landscape Metric	*Spearman's ρ*	*p*
nat.1km	0.369	<0.001
LDI.1km	0.427	<0.001
LCM.1km	0.273	0.010

Table 5.4. Spearman's ρ correlation for proportion of native species (prop.nat) and buffer and landscape metrics.

Proportion of Native Species (prop.nat)		
Buffer Condition Metrics		
Landscape Metric	*Spearman's ρ*	*p*
Buff_width	0.272	0.009
Buff_stress	0.367	<0.001
Buff_cond	0.589	<0.001
Landscape Condition at 100 m		
Landscape Metric	*Spearman's ρ*	*p*
nat.100m	0.357	<0.001
LDI.100m	0.415	<0.001
LCM.100m	0.211	0.047
Landscape Condition at 500 m		
Landscape Metric	*Spearman's ρ*	*p*
nat.500m	0.300	0.004
LDI.500m	0.337	0.001
LCM.500m	0.215	0.042
Landscape Condition at 1 km		
Landscape Metric	*Spearman's ρ*	*p*
nat.1km	0.241	0.023
LDI.1km	0.295	0.005
LCM.1km	0.163	0.125

Table 5.5. Spearman's ρ correlation for cover of invasive species (cov.inv) and buffer and landscape metrics.

Cover of Invasive Species (cov.inv)		
Buffer Condition Metrics		
Landscape Metric	*Spearman's ρ*	*p*
Buff_width	-0.123	0.249
Buff_stress	-0.489	<0.001
Buff_cond	-0.403	<0.001
Landscape Condition at 100 m		
Landscape Metric	*Spearman's ρ*	*p*
nat.100m	-0.143	0.179
LDI.100m	-0.126	0.24
LCM.100m	-0.055	0.608
Landscape Condition at 500 m		
Landscape Metric	*Spearman's ρ*	*p*
nat.500m	-0.086	0.425
LDI.500m	-0.099	0.356
LCM.500m	-0.054	0.613
Landscape Condition at 1 km		
Landscape Metric	*Spearman's ρ*	*p*
nat.1km	-0.012	0.911
LDI.1km	-0.084	0.436
LCM.1km	0.012	0.909

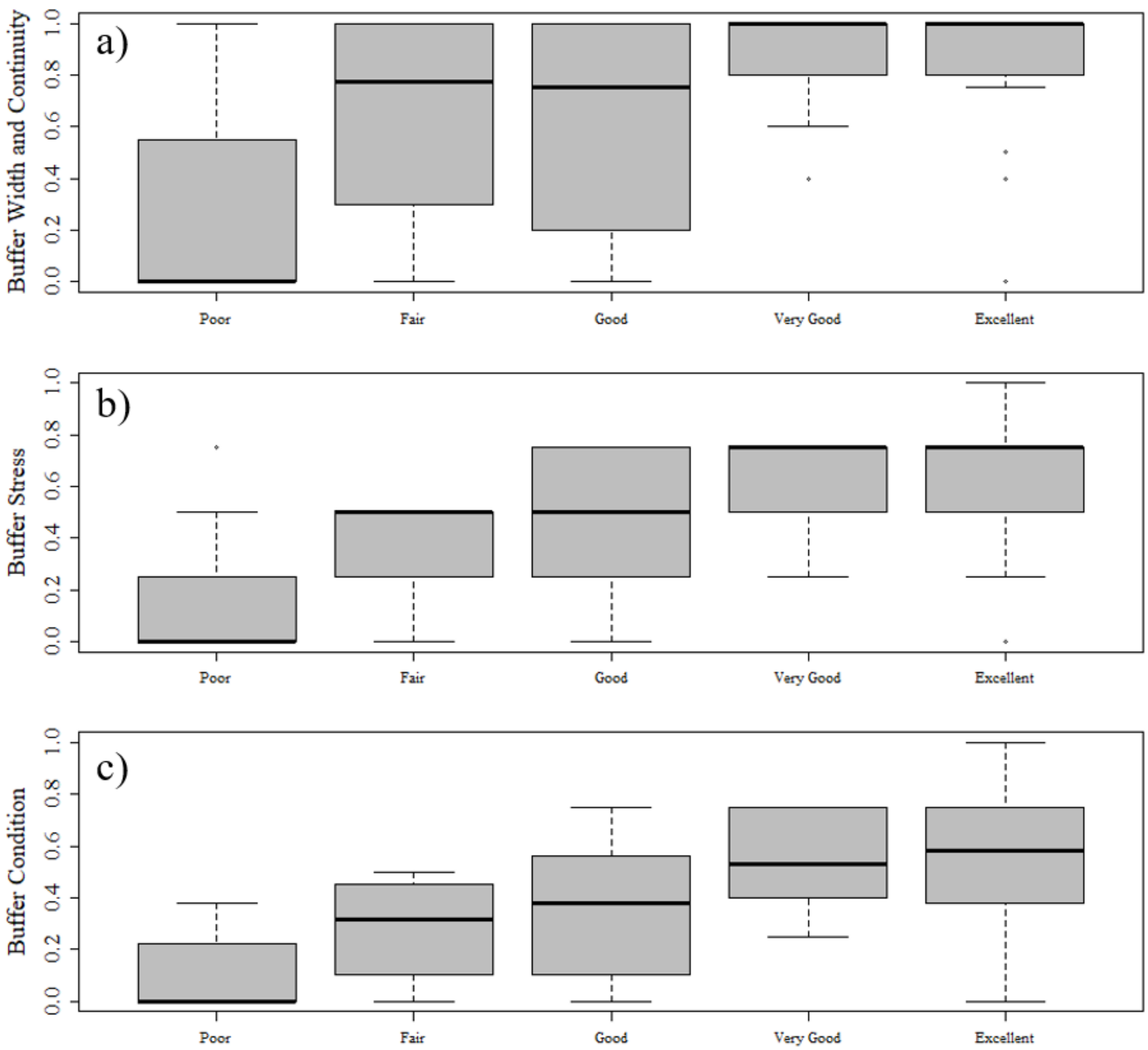

Figure 5.7. Comparison of wetland condition category as determined from standardized Mean C scores and three buffer metrics: a) Buffer width and continuity, b) Buffer Stress, and c) Buffer Condition.

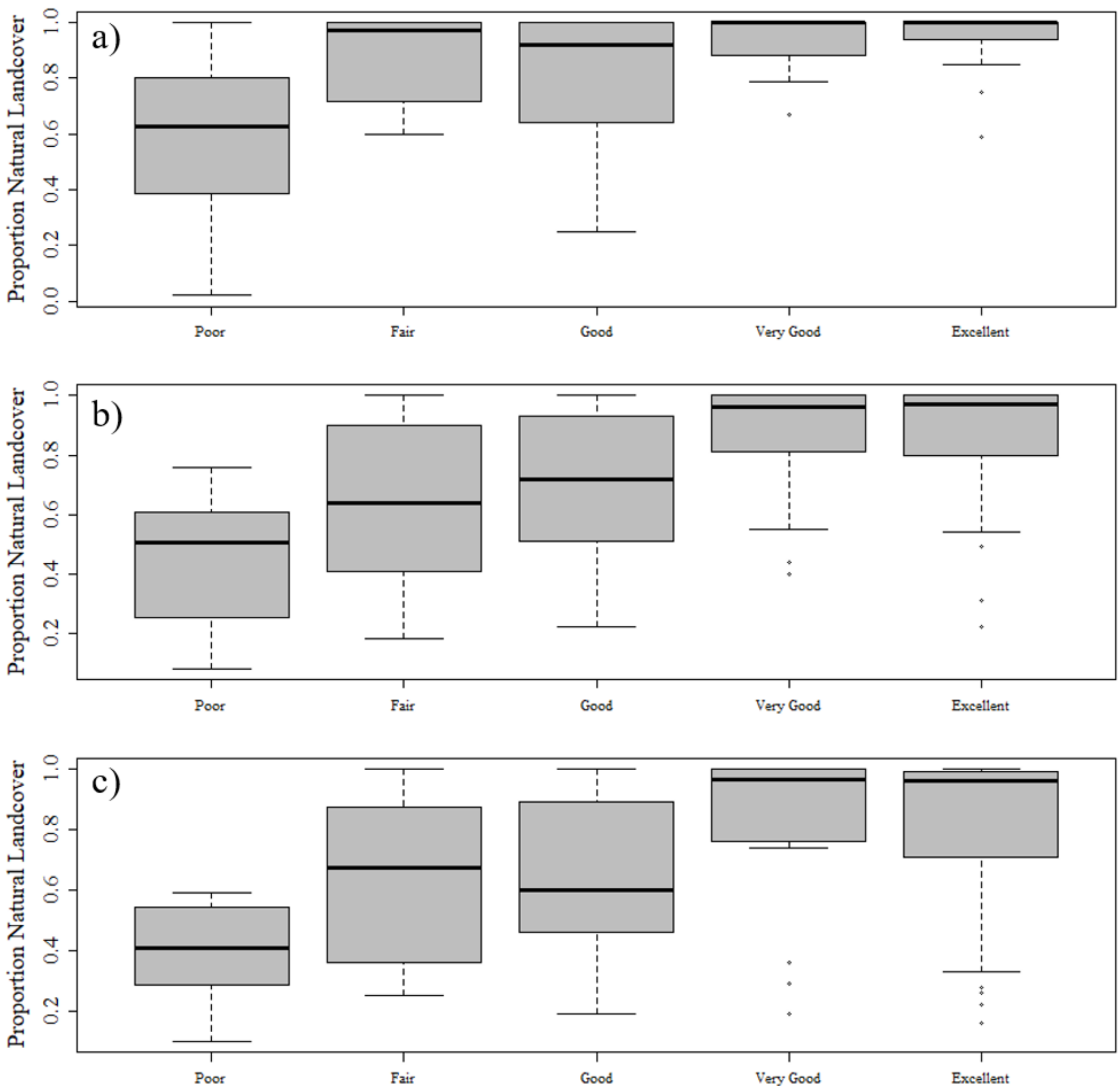

Figure 5.8. Comparison of wetland condition category as determined from standardized Mean C scores and proportion of natural land cover at three spatial scales: a) 100 m, b) 500 m, and c) 1 km.

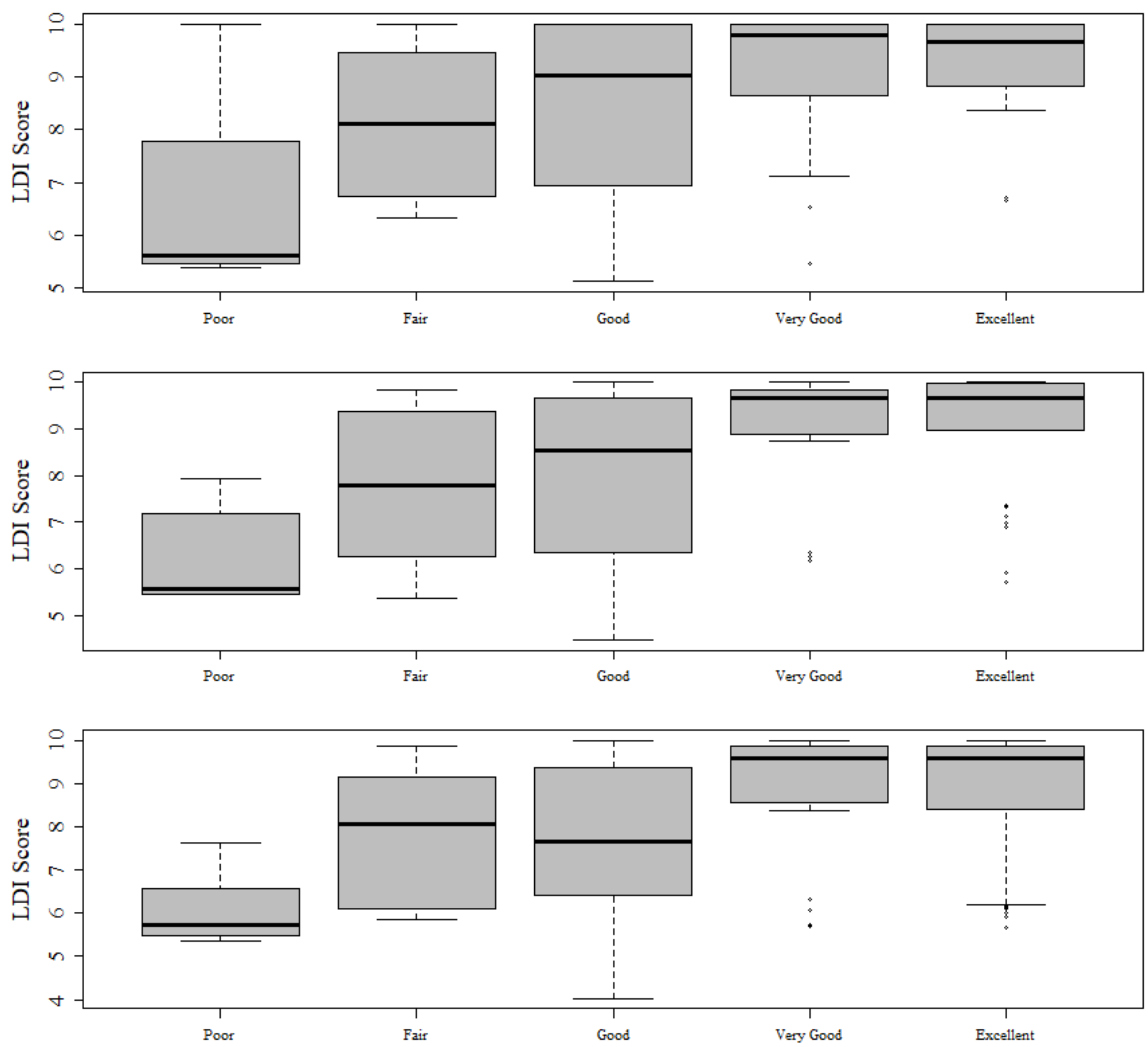

Figure 5.9. Comparison of wetland condition category as determined from standardized Mean C scores and LDI scores at three spatial scales: a) 100 m, b) 500 m, and c) 1 km.

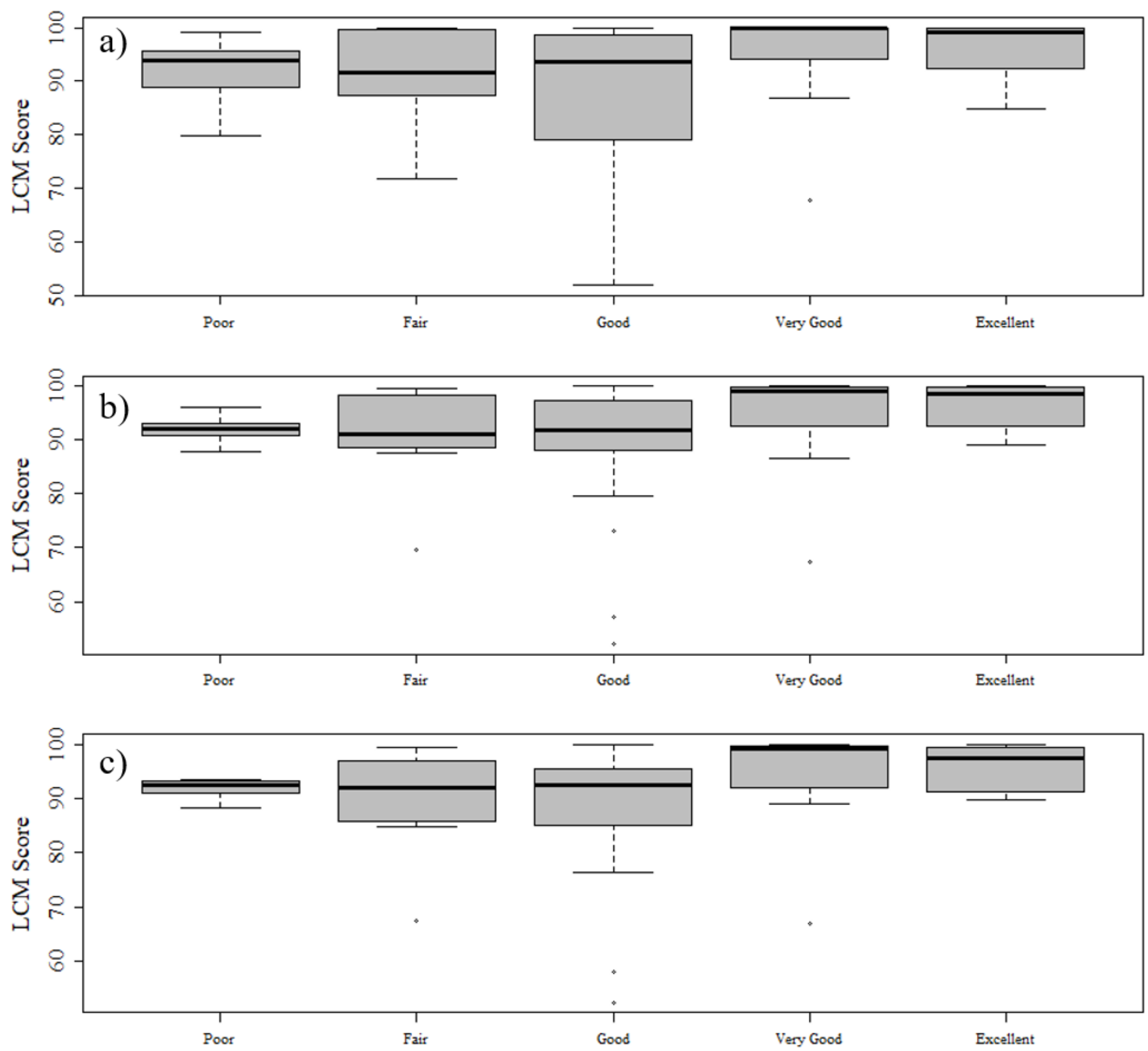

Figure 5.10. Comparison of wetland condition category as determined from standardized Mean C scores and LCM scores at three spatial scales: a) 100 m, b) 500 m, and c) 1 km.

Multi-model Inference

I used an information theoretic approach to multi-model inference to assess a suite of *a priori* predictive models to explain the relationship between Mean C and a suite of buffer and landscape metrics. Results of model selection are summarized in Table 5.6. The top model (meanc ~ s(Buff_cond) + s(nat.1km) had a model weight of 0.735, and R^2 value of 0.396 and explained 42.5% of the variation. Models including the covariate *Buff_cond* had comprised the model set with 0.95 cumulative model weight. Models incorporating solely landscape metrics at 500 m and 1 km spatial scales had model weights < 0.001. Predicted response curves for the top model indicate and increase in *Mean C* scores in relationship to increase in *Buff_cond* (Figure 5.11). The relationship between *Mean C* and *nat.1km* is more complex, with high *Mean C* scores associated with both low and high proportions of natural landcover in the landscape (Figure 5.11). Review of raw data indicates that this somewhat contradictory relationship is a result of increased buffer condition at sites with lower natural landcover in the landscape and also likely directed management to maintain wetland condition at sites with the presence of minimal or low-quality buffers.

Table 5.6. Model selection results for 20 candidate models predicting the relationship between Mean C and buffer and landscape metrics using generalized additive models (GAMs). AIC = Akaike's Information Criterion score; k = degrees of freedom; ΔAIC = difference in AIC score from top model; w_i = model weight; Cumulative w_i = cumulative model weight.

Model	**AIC**	**k**	**ΔAIC**	**w_i**	**Cumulative w_i**	**Adjusted R^2**	**Deviance Explained**
meanc ~ s(Buff_cond) + s(nat.1km)	449.92	6.34	0.00	0.735	0.735	0.396	42.5%
meanc ~ s(Buff_cond) + s(nat.500m)	453.22	6.64	3.29	0.142	0.877	0.375	40.8%
meanc ~ s(Buff_cond)	456.03	4.34	6.10	0.035	0.912	0.339	35.6%
meanc ~ s(Buff_cond) + s(LDI.500m)	456.36	6.58	6.44	0.029	0.941	0.352	38.6%
meanc ~ s(Buff_cond) + s(LCM.1km)	457.76	5.69	7.83	0.015	0.956	0.336	36.6%
meanc ~ s(LDI.100m)	457.78	7.69	7.86	0.014	0.970	0.349	39.1%
meanc ~ s(Buff_cond) + s(LCM.500m)	457.78	5.68	7.85	0.014	0.984	0.335	36.3%
meanc ~ s(Buff_cond) + s(LDI.1km)	460.84	5.92	10.91	0.003	0.987	0.314	34.4%
meanc ~ s(Buff_width) + s(LDI.100m)	461.01	4.57	11.09	0.003	0.990	0.303	32.3%
meanc ~ s(Buff_width)	461.24	3.77	11.31	0.003	0.993	0.295	30.9%
meanc ~ s(LDI.1km)	461.58	8.67	11.65	0.002	0.995	0.328	37.8%
meanc ~ s(Buff_width) + s(nat.100m)	461.85	4.26	11.93	0.002	0.997	0.294	31.2%
meanc ~ s(nat.100m)	462.87	3.00	12.95	0.001	0.998	0.276	28.4%
meanc ~ s(Buff_width) + s(LCM.100m)	463.07	4.65	13.15	0.001	0.999	0.287	30.8%
meanc ~ s(LDI.500m)	463.98	7.52	14.06	0.001	1.000	0.301	34.5%
meanc ~ s(nat.1km)	468.45	6.31	18.53	0.000	1.000	0.256	29.2%
meanc ~ s(nat.500m)	472.43	4.73	22.51	0.000	1.000	0.208	23.3%
meanc ~ s(LCM.500m)	485.42	4.12	35.50	0.000	1.000	0.078	10.0%
meanc ~ s(LCM.1km)	486.61	3.98	36.69	0.000	1.000	0.064	8.5%
meanc ~ s(LCM.100m)	487.7	3.83	37.78	0.000	1.000	0.051	7.1%

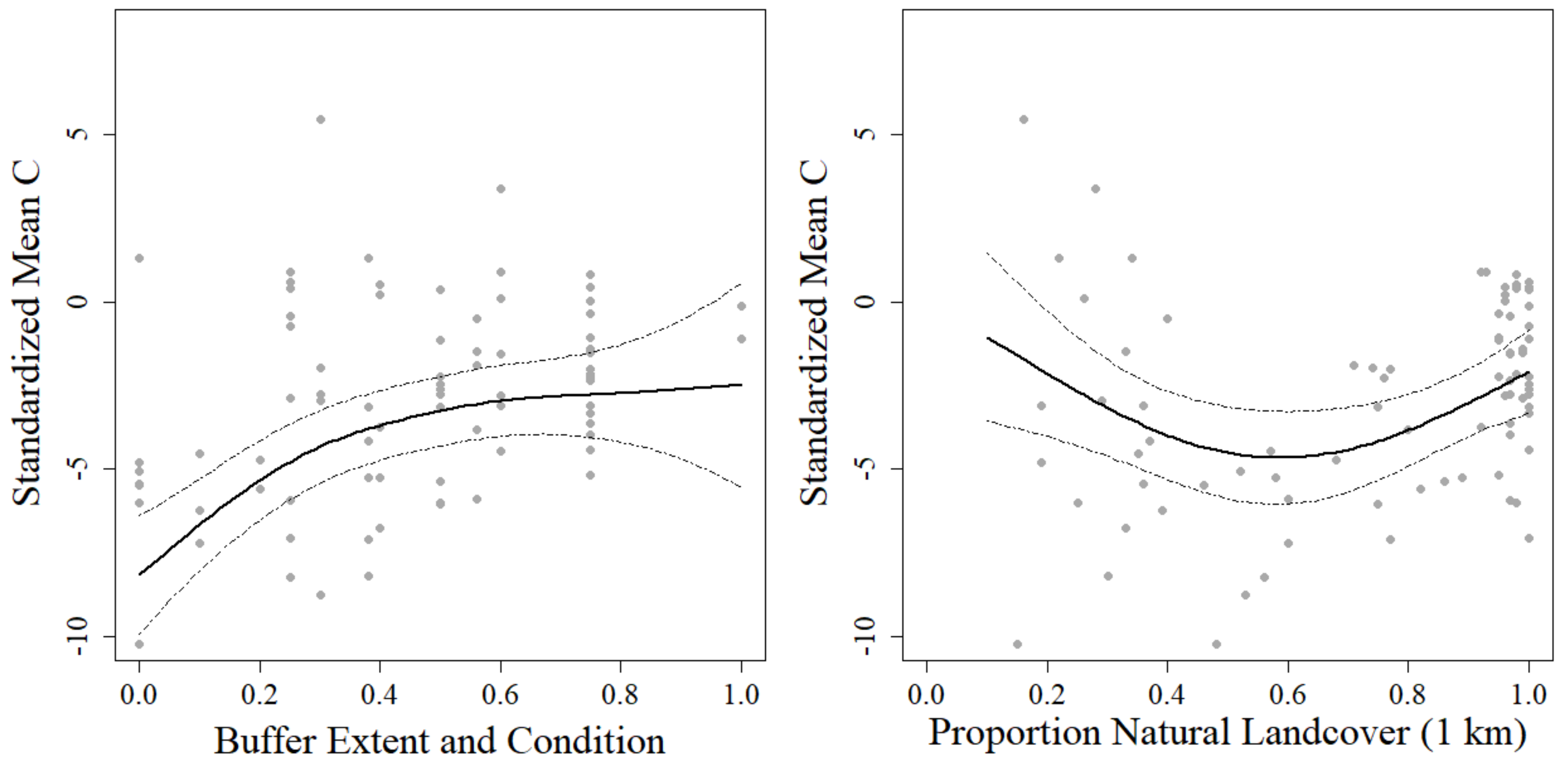

Figure 5.11. Response of Mean C scores to Buffer Condition (Buff_cond) and proportion of natural landcover within 1 km (nat.1km) from the top generalized additive model (meanc ~ s(Buff_cond) + s(nat.1km)).

DISCUSSION

In many instances, landscape condition at varying scales may be effective for measuring the ecological condition or function of wetlands (Houlahan and Findlay 2004, Houlahan et al. 2006, Mack 2006). I assessed the ability of simple metrics (e.g. buffer metrics and natural land cover) and more complex metrics (e.g. LDI and LCM) at multiple spatial scales for assessing the ecological condition of wetlands in Nebraska. In general, it seems that the extent and condition of natural buffers surrounding wetland sites is a better predictor of wetland condition than the condition of the landscape surrounding a wetland at larger spatial scales. Factors at larger spatial scales should not be ignored, however, particulary considering the moderate correlation between Mean C and buffer metrics. Further, this analysis focused on the sessile plant community rather than other more mobile wildlife, such as amphibians (Semlitsch and Brodie 2003).

The relative lack of a relationship between vegetative communities and landscape metrics and the inability to differentiate among most condition categories was somewhat surprising given previous results from other states. The simple metric of percent forest surrounding wetland sites was found to be a significant predictor of wetland condition in Pennsylvania (Wardrop et al. 2007). In Ohio, Mack (2006) a strong relationship between measures of wetland vegetative communities and LDI at 1000 m surrounding wetland sites for multiple wetland sites and multiple wetland types. Again, in New York state the more complex LCM was found to be a reasonable predictor of wetland condition across the entire state (Shappell et al. 2016). In all instances, landscape metrics, particularly at larger spatial scales failed to adequately measure the ecological condition of wetland sites in Nebraska. Further, it is interesting to note that the most simple landscape assessmen method (proportion of natural landcover) was more effective in determining the ecological condition of wetlands than more complex methods, particularly when considered in conjunction with the condition of natural buffers surrounding wetland sites.

Initially, it seemed that the failure of landscape metrics to measure wetland condition might relate to the fact that Nebraska is lacks diversity in landuse, with most of the state consisting of urban/suburban, agricultural, and natural land uses. Additionally, in most instances, land use was consistent within, but not among wetland complexes, leading to little variability and landscape condition scores within most complexes. Despite these observed relationships, standardization of landscape scores within wetlands did little to improve the responsiveness of landscape metrics. Although little variation in landscape condition existed within complexes, vegetative communities measured using Mean C were substantially more variable. It seems as though the potential impacts of landscape condition were mitigated by two factors, the presence and maintenance of natural buffers and natural landcover at 1 km surrounding most wetland sites and occurrence of active management efforts in and around many wetland sites assessed for this project. Further, I assessed only a single component of the ecological condition of wetlands, the vegetative community, implying that other measures of condition such as wildlife diversity and populations may in fact respond to measures of landscape condition where the vegetative community did not (Semlitsch and Brodie 2003). It is also conceivable that vegetative communities respond at a different spatial scale than was measured in this study; however, spatial scales assessed in this study are consistent with those used to measure vegetative response in other states (Mack 2006, Wardrop et al. 2007)

I found that the presence and maintenance of buffer condition was a significant predictor of the condition of wetland vegetative communities. The importance of natural buffers for maintaining the ecological condition and function of aquatic systems has long been understood (Castelle et al. 1994). Initial assessments of the efficacy of landscape condition to predict or measure the ecological condition of wetlands in Nebraska, as measured using vegetative community metrics, indicated a tenuous relationship between the two and even revealed that simpler metrics, such as LDI may be more effective than more complex measures such as LCM. However, the inclusion of measures of buffer extent and condition were found to be more important based on simple correlation and multi-model inference. In fact, in both instances, Buff_cond (a measure of buffer extent and condition) showed the highest correlation, predictive power in relation to wetland vegetative communities, and ability to differentiate among wetland condition categories defined using Mean C. This was followed by additional measure of buffer extent, condition, and landscape condition at 100 m, the distance at which buffer metrics were assessed in this study. While this relationship is not surprising given the understood importance of buffer condition, the near lack of relationship with complex measures of landscape condition and landscape condition at larger spatial scales was not expected.

It is apparent, however, that despite the relationship between buffer condition and Mean C, other factors also contribute to maintaining the ecological condition of Nebraska wetlands. Further, models measuring buffer extent and condition (the top five models in Table 5.6) and cumulatively garnered 95% of the total model weight with the top model (~ Buff_cond) only having 3.5% of the model weight. An example of this paradox where high quality wetlands are surrounded by a largely low-quality landscape is the RWB wetland complex. Many wetlands within this complex are nearly entirely surrounded by a landscape matrix dominated by row crop agriculture. Despite the inhospitable landscape, management efforts by multiple state and non-governmental agencies has led to the maintenance of wetlands and their native vegetative communities as well as maintenance or creation of natural vegetated buffers. Similar efforts also occur in the CP wetland complex, with large multi-agency efforts working to restore and maintain wetlands in the floodplains of the Central Platte River. Additionally, in the Nebraska Sandhills complexes, the perpetuation of lower impact grazing by ranchers and activities such as controlled burning likely mimic natural disturbance regimes, thus maintaining wetland condition. In instances where wetland condition is lower in these complexes, it anecdotally appears as though such sites are closer to roads, potentially allowing for the stressors such as the spread of invasive plant species propagules or altered hydrology to decrease wetland condition.

As previously noted, these results are not to say that landscape condition is not important in the maintenance of other aspects of wetland condition, such as wildlife habitat. It merely suggests that buffer condition may be more important in maintaining natural plant communities than surrounding land use at larger spatial scales, or that the maintenance of buffers in conjunction with other activities such as active management may mitigate the effects of the surrounding landscape on wetland condition. For example, Semlitsch and Brodie (2003) noted that a natural buffer of at minimum of 196 m is required to sustain many wetland amphibian species. Additionally, Houlahan and Findlay (2004) were able to detect effects of land use on nitrogen to phosphorus rations up 2250 meters from wetland sites, indicating that while plant communities may be maintained with smaller surrounding natural buffers, other factors are influenced at much larger spatial scales.

CONCLUSIONS

Landscape assessment methodologies applied in other regions and states were relatively ineffective for measuring the condition of wetland sites in Nebraska. While this may imply that additional methods may merit further testing, the success of such methods in measuring wetland condition in other states suggests that other factors may be involved. Specifically, the presence and maintenance of 100 m natural vegetative buffers appears to be a large component in the maintenance of the ecological condition of wetlands as measured using vegetative communities. Although 100 m buffers appear to be effective in helping to maintain high quality vegetative communities, other factors such as active management and the implementation of lower impact grazing techniques may also aid in maintaining wetland condition and function. These results are not to say that only a 100 m buffer is necessary to protect wetland function, as land use out to 2250 m is known to impact nitrogen and phosphorous inputs and a minimum of nearly a 200 m buffer is required for most amphibian species. Therefore, at a minimum, managers should strive to maintain at least a 100 m natural buffers surrounding wetland sites, but efforts should be made to expand the size of natural buffers to support additional wetland functions.

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CHAPTER 6

ASSESSING AMPHIBIAN DETECTION AND OCCUPANCY IN THE RAINWATER BASINS USING VOLUNTEER CALL SURVEYS

INTRODUCTION

Since the early 1990's, scientists have reported significant worldwide amphibian population declines, with notable extinctions occurring in in Australia and Central America (Stuart et al. 2004, Collins and Storfer 2003). Although causes for some declines are considered enigmatic, most can be attributed to habitat loss, the introduction of invasive species, and over exploitation for global pet and food trades (Stuart et al. 2004, Collins and Storfer 2003). The remaining declines are harder to classify, as many are likely caused by the synergistic effects of multiple stressors including those previously mentioned and less studied causes including emerging infectious diseases, such as *Batrachochytrium dendrobatidis* (*Bd,* chytridiomycosis, or chytrid) and ranavirus (Daszak et al. 2003, Daszak et al. 1999), global climate change, and contaminants (Stuart et al. 2004, Collins and Storfer 2003). The fact that most of the causes of declines are anthropogenic in origin makes it imperative to understand the regional and worldwide impacts of these factors on amphibian populations.

Amphibians have several physiological and ecological characteristics that make them susceptible to anthropogenic environmental disturbances. Both adults and larvae have thin, semi-permeable skin consequently making them sensitive to water borne toxicants including pesticides and fertilizers (Boyer and Grue 1995). Our understanding of amphibian population trends reveals dynamic adult breeding and thus larval populations with large fluctuations in size, making these populations sensitive to stochastic events (Trenham et al. 2003, Semlitsch 2000). Furthermore, due to their typically bi-phasic lifecycle, where larvae rely on permanent to temporary aquatic habitats and adults use both aquatic and terrestrial habitats, amphibians are likely exposed to multiple anthropogenic stressors at various landscape scales (Price et al. 2007, Cushman 2006, Houlahan and Findlay 2003). These characteristics make amphibian populations sensitive to environmental perturbations, and potentially good indicators of wetland habitat and environmental quality (Price et al. 2007, Micacchion 2002).

The Rainwater Basins (RWB) wetland complex is located in central Nebraska and is of critical importance for waterfowl migrating through the central flyway (LaGrange 2005). Although most recognized for their importance to waterfowl, Rainwater Basin wetlands also represent important habitat for eight of Nebraka's 11 native anuran species. Since 1900, it is estimated that 90% of the wetlands and 80% of the wetland area in the Rainwater Basins have been drained for agricultural conversion. The unique hydrogeomorphology of Rainwater Basin wetlands resulted in hydrologically isolated playa wetlands, ranging in size from less than one acre to more than one thousand acres. The distribution of isolated wetlands, relative proximity to a large population center, and presence of a gridded road system provide a unique opportunity to effectively monitor amphibian populations and communities over a large portion of the state.

Anurans are an important part of the ecosystem and may represent significant portion of the total biomass, particularly in isolated wetland systems (Gibbons et al. 2006). Significant effort has gone in to monitoring ponding of RWB wetlands and monitoring waterfowl due to their economic importance to the region, but minimal effort has been applied to monitoring additional taxa. Volunteer roadside call surveys have been successfully implemented at nationwide (AZA's FrogWatch), regional (Amphibian Research Monitoring Effort; ARMI) and state levels (e.g. Maryland; Weir et al. 2005), resulting in analyses suggesting broad declines of many species (Weir et al. 2014). Such data lend itself well to the application of detection and occupancy modeling (Weir et al. 2005, Weir et al. 2014). Two previous efforts have attempted to employ roadside surveys in the RWB, but have been abandoned. Further, differences of methodology relative to this study may not allow for effective monitoring or tracking of occupancy trends.

The primary goal of this study was assess amphibian detection and occupancy in the Rainwater Basins of south central Nebraska using data collected from volunteer roadside anuran call surveys. I coordinated volunteer roadside breeding call surveys at 124 wetland sites in the Eastern Rainwater Basin of southcentral Nebraska from 2014 - 2016. Amphibian detection and occupancy was assessed using single-species, single-season occupancy models for four species and for a small, four species community using covariates assumed to affect both detection and occupancy probabilities. Results inform researchers and managers as to the most appropriate methods and timing for anuran call surveys as well as factors related to amphibian species and community occupancy.

METHODS

Study Area

The Rainwater Basin region is located in central Nebraska encompassing all or part of 21 counties (Figure 6.1). Wetlands in the RWB are clay-lined closed-basins that receive water only from direct precipitation and overland runoff. Due to notable variations in rainfall between the eastern and western Rainwater Basins, I focused survey efforts in only the eastern portion of the region including all areas east of Grand Island, Nebraska (Figure 6.2). Historically, the Rainwater Basin region was a landscape dominated by grasslands with interspersed wetlands ranging in size from less than an acre to more than one thousand acres; however, 90% of historical wetlands have been destroyed with most remaining wetlands having suffering from degradation. Currently, the remaining wetlands tend to be isolated and surrounded by a landscape dominated by intensive row crop agriculture.

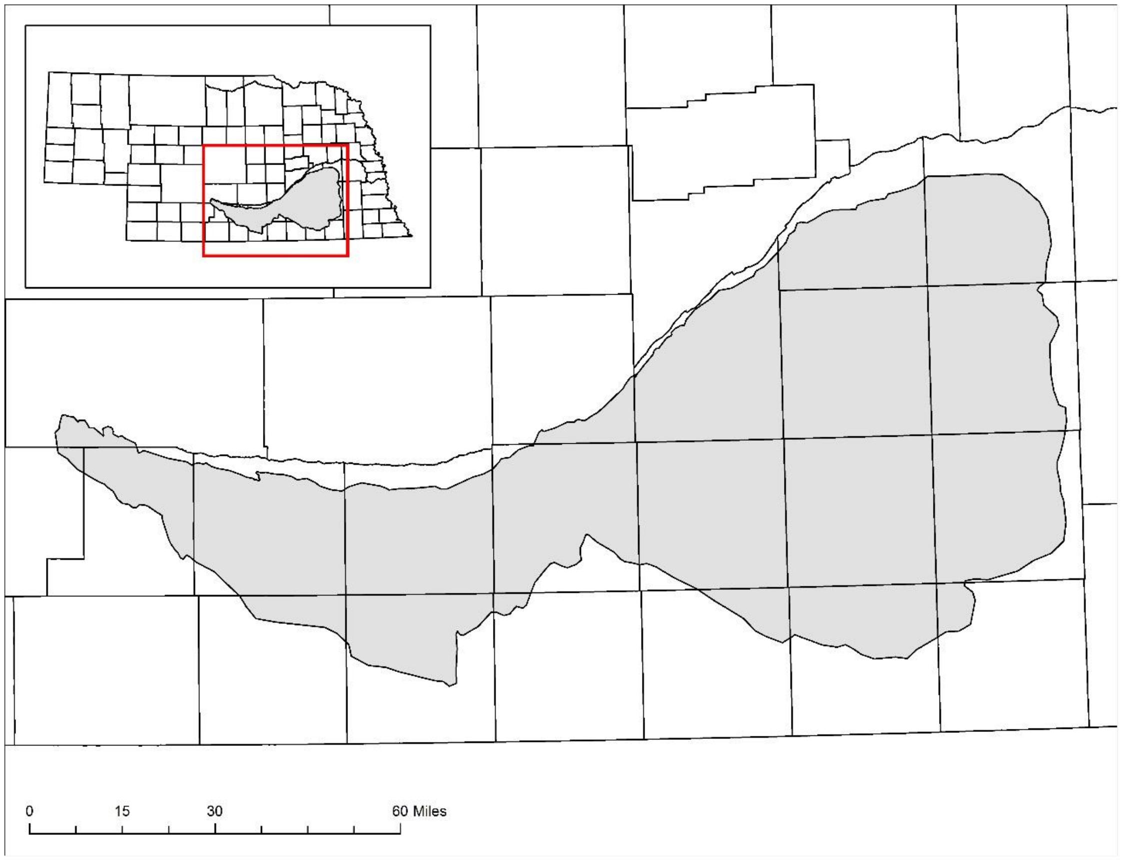

Figure 6.1. The Rainwater Basins region is located in south central Nebraska and encompasses all or part of 21 counties.

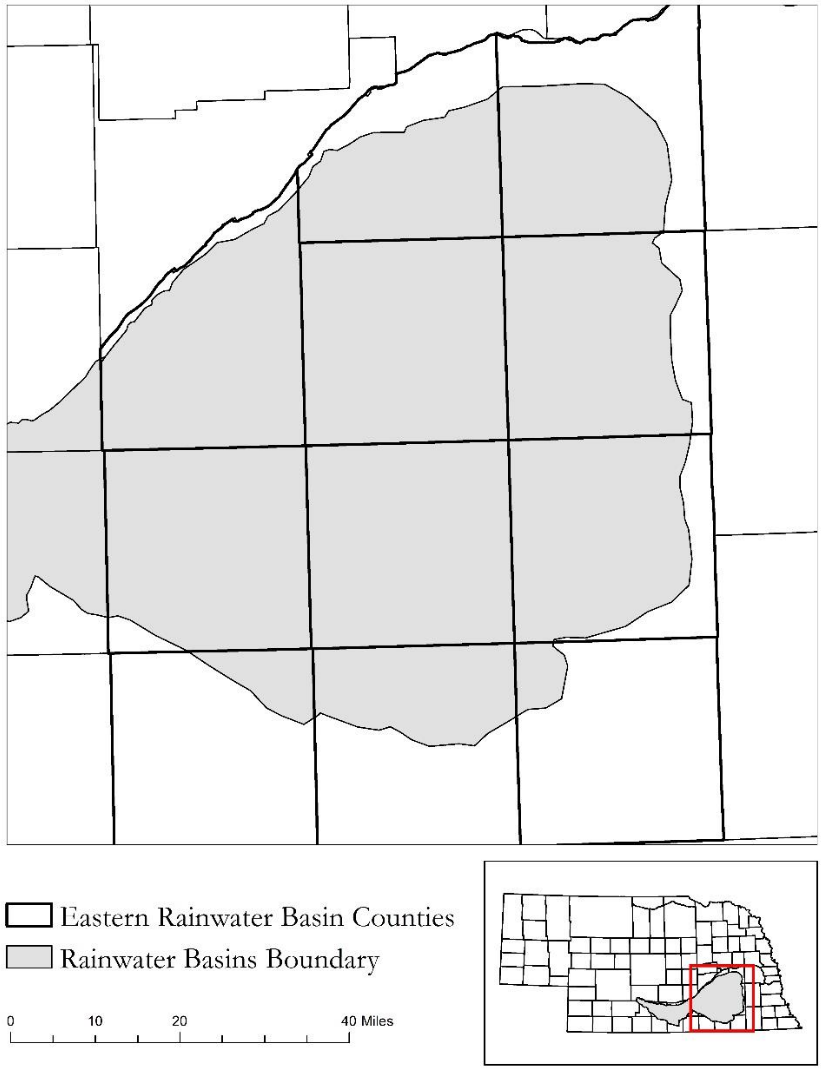

Figure 6.2. Roadside amphibian call surveys were conducted only in the eastern portion of the Rainwater Basins region, located east of Grand Island, NE.

Site Selection

During the 2013 sampling season surveys were conducted 117 survey points previously surveyed in both 2005 and 2006 (Figure 6.3). These sites represented a range of wetland types included temporary, semi-permanent, and permanent wetlands including those on both public and private lands. In some cases, roadside ditches were also included in surveys. Due to the fact that in many years wetlands included in these surveys are dry due to inter- and intra-annual variation in precipitation and little information was available for previous site selection and location, there was some difficulty in determining the exact wetlands surveyed. Although temporary wetlands and ditches may be seasonally important to RWB amphibians, in many years they may not provide habitat for a long enough time period and may represent ecological traps due to their temporary nature. Therefore, if the primary goal of surveys is the long-term monitoring of amphibian communities and population, monitoring efforts should instead focus on more semi-permanent wetlands that are more likely to have amphibians present in typical years. For these reasons, I selected new survey points for monitoring efforts in 2014 and beyond.

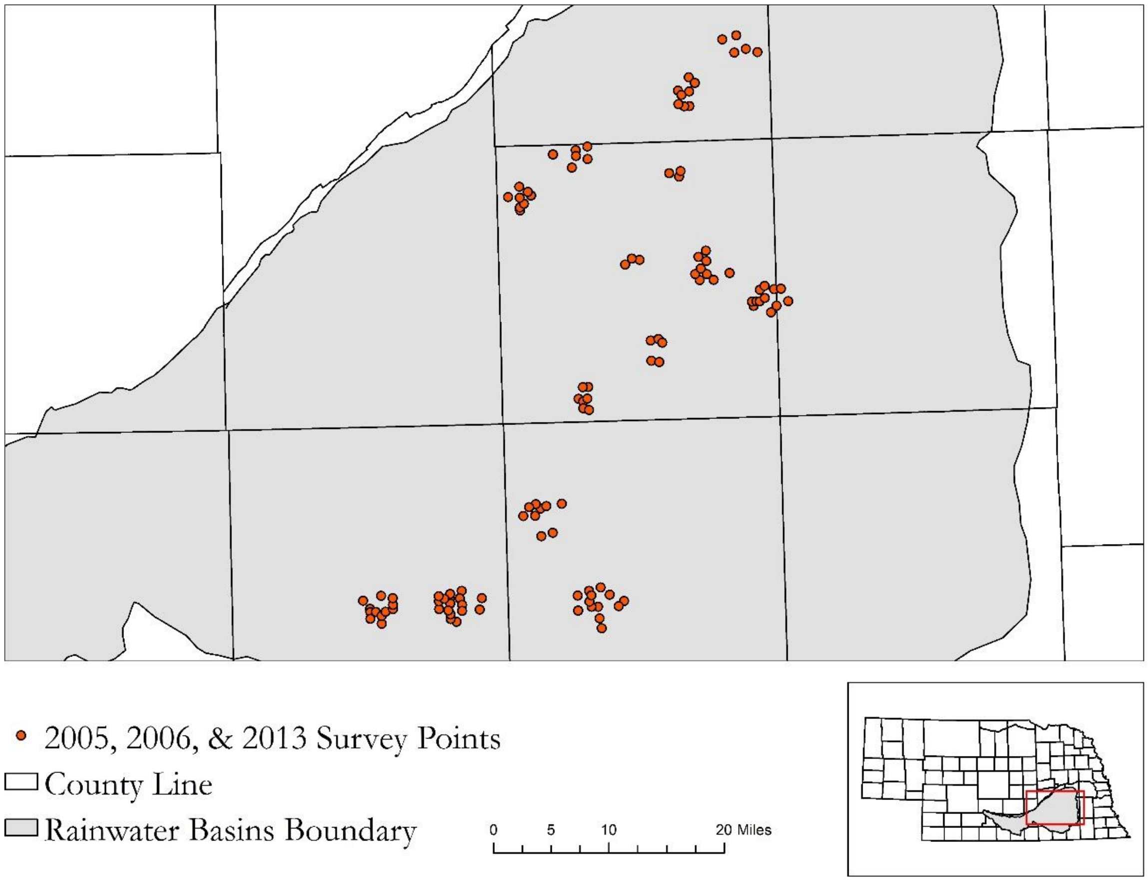

Figure 6.3. Volunteer roadside amphibian call surveys were conducted at 117 wetland sites in the eastern Rainwater Basins during the spring and summer of 2005, 2006, and 2013.

The primary goals of new site selection were to select semi-permanent wetlands for monitoring and assess differences in amphibian community use of five wetland types: agricultural re-use pits, private wetland surrounded at least in part by agriculture, wetlands enrolled in the Wetland Reserve Program (WRP), Wildlife Management Areas (WMA), and Waterfowl Production Areas (WPA). A universe of potential wetland sites was obtained by cross referencing sites with water present during the spring waterfowl migration for at least five years between 2005 and 2013 and located within 125 m from the nearest road. I then specifically defined wetlands within each category. For WRP, WMA, and WPA wetlands, I intersected previously defined wetlands with available boundaries defining each property type. For private wetlands, I selected only wetlands within 30 m (the pixel size for land-use raster layers) of active row crop agriculture. From the defined universe of potential sites, I randomly selected 25 wetlands from each category to include in sampling. In order to limit the distance among wetland sample points, private wetlands and pits were restricted to a five-mile radius surrounding the limited number of WRP, WMA, and WPA wetlands sites. The presence of wetlands and pits was verified via recent aerial photography and through pre-survey visits. Final wetland points were then divided into sample routes based upon proximity. Roadside sampling locations were located at the nearest point on the road to each wetland site. In total, 125 wetland sites, 25 of each wetland category, were selected for long-term monitoring (Figure 6.4).

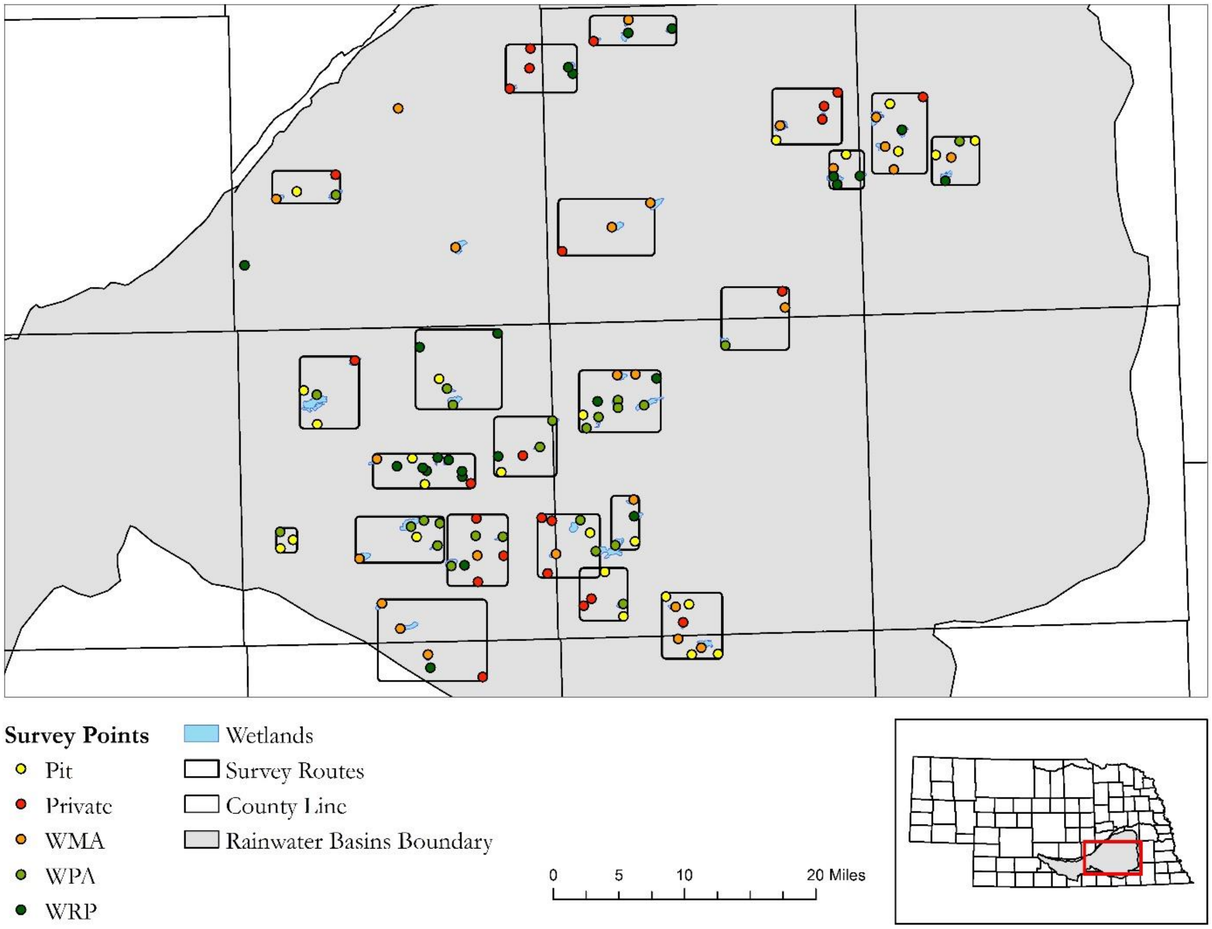

Figure 6.4. In 2014, I selected 125 new survey locations for volunteer roadside amphibian call surveys, representing 25 each of agricultural reuse pits, private wetlands surrounded at least in part by agriculture, Wildlife Management Areas (WMA), Waterfowl Production Areas (WPA), and Wetland Reserve Program wetlands (WRP). Sample points were divided into routes, which were assigned to volunteers. Each wetlands was surveyed four times between mid-May and mid-June.

Call surveys

Because anurans use vocalizations to communicate, anuran call surveys are a commonly applied and efficient method for studying the status of communities and populations (Dorcas et al. 2010). In general, an anuran call survey involves an observer listening to the vocalizations of male anurans and recording all of the species detected during a set length of time (Dorcas et al. 2010, McLeod et al. 2001). It is also simple and effective to train and use volunteers for such monitoring efforts, allowing for the sampling of more sites and larger areas. Examples of such successful efforts in include the Amphibian Research and Monitoring Initiative (ARMI), the North American Amphibian Monitoring Program (NAAMP), and FrogWatch USA (Weir et al. 2005, Weir et al. 2009).

Roadside amphibian breeding call surveys were performed by a team of volunteers during May and June of 2014 - 2016. In 2013, call surveys were conducted during a two-week period from April 28 – May 12 during which each site was visited twice. Due to colder than normal temperatures in the spring of 2013, resulting in delayed calling activity for many species, call surveys in 2014 and beyond were extended to four weeks in length and moved to the last two weeks of May and first two weeks of June during which each site was visited four times. These changes were incorporated in order to accommodate unexpected shifts in weather and provide opportunities to detect late-spring and early-summer breeding species as the later, extended sampling period overlaps the typical breeding phenology for all species excluding American bullfrogs (Fogell 2010).

The first call survey each night began at one half hour after sunset, the time at which most species initiate calling, and end by 0100 h (Dorcas et al. 2010, Oseen and Wassersug 2002, Bridges and Dorcas 2000). This time frame encompasses the peak calling period for most temperate anuran species (Dorcas et al. 2010, Bridges and Dorcas 2000). A single call survey consisted of a five-minute period during which all calling species were recorded for a site. Previous studies have found that a three to five-minute call survey is effective for detecting nearly all species present at a site (Gooch et al. 2006, Shirose et al. 1997), thus five minutes is adequate for species detection. Although not necessary in most cases, volunteers waited one minute after arrival to commence surveys, allowing the anurans time to acclimate to human presence and recommence calling activity (de Solla et al. 2005, Ficetola and de Bernardi 2004); not doing so can reduce the proclivity of calling and thus decrease the probability of detecting species (Sun and Narins 2005). During each call survey, the presence of calling species was recorded as a presence (1) or absence (0).

Detection Covariates

Abiotic factors have been shown to affect the ability of researchers to detect calling anurans and the proclivity of many species to call (Saenz et al. 2006, Oseen and Wassersug 2002). Specifically, wind speed, air temperature, and rain directly impact anuran calling activity (Steelman and Dorcas 2010, Saenz et al. 2006, Oseen and Wassersug 2002). Therefore, surveys were not be conducted on nights with heavy rainfall, wind speeds > 32 km per hour, or temperatures below 0º C (Steelman and Dorcas 2010, Crouch and Patton 2002). Prior to commencing the call survey at each stop, surveyors measured and recorded the average wind speed and air temperature using a Kestrel 3000 pocket anemometer (Kestrel Meters, Birmingham, MI). Both windspeed and air temperature were collected by holding the anemometer overhead parallel with the predominant wind direction for a 30 second period. Precipitation was recorded as a categorical variable (None, Drizzle, Light Rain, and Heavy Rain).

Site-specific Covariates

Several site-specific habitat and landscape covariates were assessed as predictor of amphibian species and community occupancy. While undoubtedly there are local wetland characteristics impacting occupancy, such as percent emergent vegetation and wetland slope (Hellman 2013), such factors do not lend themselves to measurement in roadside-based surveys as permission to directly access sites is not obtained. Given these limitations, site-specific covariates in this study were focused on covariates obtainable using remote sensing techniques and measures of landscape condition. Wetland area (*area*) was estimated using the 'calculate area' tool in ArcGIS 10.6 (ESRI 2018) on polygons of contemporary wetlands obtained from the Rainwater Basin Joint Venture. I estimated wetland buffer (*buffer*) as the product of buffer continuity, measured as the percentage of the wetland with a buffer of at least 5 m, and the mean buffer width up to 100 m. The resulting score was divided by 100, placing the final metric on a scale from 0 – 100. The following four landscape metrics were measured at three spatial scales (300 m, 500 m, and 700 m), representing plausible movement distances for three size classes of anurans (Semlitsch 2000, Rittenhouse and Semlitsch 2007). I calculated all continuous metrics as a mean within the given buffer distance using the 'isectpoly' tool in the Geospatial Modelling Environment v.0.7.4 (Beyer 2015). Landscape resistance (*resistance*) to movement was determined by reclassifying land use with estimated measures of landscape resistance to amphibian movement (Compton et al. 2007). Anthropogenic stress (*stress*) is a surrogate for impacts from land use surrounding wetland sites and was calculated using methods described by Comer and Hak (2012) and Comer and Hak (2017). Wetland loss (*loss*) is a measure and the estimated acreage of historic wetlands lost and was determined using data obtained from the Rainwater Basin Joint Ventures. Wetland count (*count*) is an approximate measure of connectivity and was measured as the count of wetland polygons that intersect the buffers surrounding wetland sites.

Statistical Analyses

I assessed factors that affect both the detection of a species during a survey and species occupancy at a given site. I used each unique site-year combination as an individual site for modeling (e.g. A1_2014, A1_2015, A1_2016, etc.), resulting in a total of 372 site-year combinations. All continuous and numeric variables were standardized prior to analysis. Each model was composed of covariates hypothesized to affect either detection or occupancy.

Detection probability was assessed using a logit modeling technique developed by MacKenzie et al. (2006) in which detection covariates are modeled using presence/absence data and detection covariate data collected during repeated sampling. Potential detection covariates included date (*days* = days since first survey), time (*minutes* = minutes after sunset), windspeed (*wind* = wind in mph), and air temperature (*air* = air temperature [°F]). Both linear and quadratic effects of *air* and *days* were included for some species based upon data visualization and knowledge of calling phenology. To evaluate the effects of these covariates on detection, I used logit models of the form:

$$\begin{aligned}\text{logit}(p_i) = \quad & \alpha_0 + (\alpha_1 \times days_{ij}) + (\alpha_2 \times days_{ij}^2) + (\alpha_3 \times air_{ij}) \\ & + (\alpha_4 \times air_{ij}^2) + (\alpha_5 \times minutes_{ij}) + (\alpha_6 \times wind_{ij})\end{aligned} \quad (1)$$

where p_i is the probability of detection given covariate values at site *i* and visit *j*.

Analagous models for occupancy were also evaluated using site-specific covariates under the assumption that sites were "closed" with respect to within season changes in occupancy (MacKenzi et al. 2006). Potential occupancy covariates included wetland type (type = 1 – Pit; 2 – Private; 3 – WMA; 4 – WPA; 5 – WRP), area (area = total wetland area [ac]), buffer (buff = score of mean buffer width and continuity), count (count = number of wetland within 300 m, 500 m , or 700 m), resistance (resistance = mean resistance within 300 m, 500 m, or 700 m), stress (stress = mean anthropogenic stress within 300 m, 500 m, or 700 m), loss (loss = acres of wetland lost within 300 m, 500 m, or 700 m) (Equation 2). The effect of year (year = 1 – 2014; 2 – 2015; 3 – 2016) was forced into all models to account for potential variation in occupancy at sites among years (Taillie and Moorman 2019). The potential effects of occupancy covariates were assessed using the following logit model:

$$\begin{aligned}\text{logit}(\Psi_i) = \quad & \beta_0 + (\beta_1 \times year_i) + (\beta_2 \times type_i) + (\beta_3 \times area_i) \\ & + (\beta_4 \times buffer_i) + (\beta_5 \times count_i) \\ & + (\beta_6 \times resistance_i) + (\beta_7 \times stress_i) \\ & + (\beta_8 \times loss_i)\end{aligned} \quad (2)$$

where Ψ_I is the probability of occupancy at site *i* given occupancy covariate values at site *i*.

I used single-season, single-species occupancy models to assess occupancy of four individual species and a small, four species community, while accounting for imperfect detection. I modeled the detection and occurrence of each individual species using single-season, single-species occupancy models as described by MacKenzie et al. (2006). Additionally, I used the same techniques to model the co-occurrence of a subset of four species commonly detected during surveys as a surrogate for amphibian communities in the RWB. I accomplished this by collapsing the concurrent presence of four species into presence and absence in which if all species were present during a visit, the community was considered to be present (1), but if one or more of the four species considered were not detected, the community was considered to be absent (0).

My general approach to modeling both detection and occupancy was to fit the global model for all species using the ‘occu’ function in the R package unmarked v. 0.12.0 (Fiske and Chandler 2011). This function allows for the fitting of single-season occupancy models from presence/absence data with repeat visits ad both detection and occupancy covariates. I then used the ‘dredge’ function in the R package MuMIn v 1.42.1 (Barton 2018) to fit all possible combinations of detection and site covariates (Doherty et al. 2012, Taillie and Moorman 2019). This function iteratively fits all possible combinations of detection and occupancy covariates. To assess the resulting models, I used multi-model inference with Akaike’s Information Criterion for corrected for small sample sizes (AICc) and model weights to determine the model of best fit given the data (Burnham and Anderson 2002, Anderson 2008). When there was no clear top model in a model set (e.g. many models in the model set with similar AICc and model weights), I calculated model-averaged parameter estimates using a subset of models with an AICc within 2 of the top-ranked model (Burnham and Anderson 2002, Anderson 2008). I used natural averages for the calculation of standard errors and confidence intervals in order to avoid shrinkage toward zero and the dilution of potentially moderately important predictor variables (Grueber et al. 2011).

Important predictor variables for both detection and occupancy were determined based on 95%, 90%, and 85% confidence intervals derived from the model-averaged parameter estimates (Arnold 2010). If a confidence interval did not overlap 0, the predictor variable was considered potentially important. In the case of the categorical variables, wetland type (*type*) and year (*year*), resulting estimates represent differences from the intercept. For *type* the intercept was “Pit” and for *year* the intercept was “2014”. Meaning that a category was important if it was significantly different from the intercept.

RESULTS

Call Surveys

Due to the draining of one private wetland, it was removed from roadside surveys, resulting in a total of 124 sites during each year. Surveys were conducted at each site an average of 3.91 times per year. Surveys during some sampling periods were not conducted due road conditions or other logistical factors. Naïve occupancy rates varied among years and among species (Table 6.1). The most commonly detected species were Western Chorus Frog (*Pseudacris maculate*; PSMA), Woodhouse’s Toad (*Anaxyrus woodhousii*; ANWO), Gray Treefrog (*Hyla chrysoscelis*; HYCH), and Plains Leopard Frog (*Lithobates blairi*; LIBL). A total of eight species were detected during roadside call surveys; however; detection and occupancy probabilities were modeled for PSMA, ANWO, HYCH, and LIBL. In addition, I assessed detection and occupancy for a small, four-species RWB amphibian community. If PSMA, ANWO, HYCH, and LIBL were all detected during a survey, detection was recorded as a 1, if not detection was recorded as a 0. Due to low numbers of detections for ANCO, ACCR, LICA, and SPBO, I was unable to model detection or occupancy rates for those species. I used multi-model inference to determine the model averaged parameter estimates for each species individually and for the small community.

Table 6.1. Naïve occupancy rates by year for each species calculated as the total number of sites where a species was detected during roadside call surveys divided by the total number of sites surveyed.

Species			Naïve Occupancy Rate		
Common Name	***Scientific Name***	***Code***	***2014***	***2015***	***2016***
Western Chorus Frog	*Pseudacris maculata*	PSMA	0.97	0.95	0.98
Great Plains Toad	*Anaxyrus cognatus*	ANCO	0.11	0.10	0.04
Woodhouse's Toad	*Anaxyrus woodhousii*	ANWO	0.69	0.68	0.66
Northern Cricket Frog	*Acris crepitans*	ACCR	0.07	0.10	0.14
Gray Treefrog	*Hyla chrysoscelis*	HYCH	0.65	0.62	0.84
Plains Leopard Frog	*Lithobates blairi*	LIBL	0.63	0.59	0.77
American Bullfrog	*Lithobate catesbeianus*	LICA	0.04	0.06	0.06
Great Plains Spadefoot Toad	*Spea bombifrons*	SPBO	0.02	0.26	0.00
RWB Amphibian Community	-	COMM	0.34	0.25	0.32

Western Chorus Frog

PSMA were detected at nearly all sites in all years (Table 6.1). Overall, they were detected during 74% of surveys. All models in the confidence set included detection covariates *air* and *days* (Table 6.2). All models in the confidence set included the occupancy covariate *type* (Table 6.2). Model averaged parameter estimates are reported in Table 6.3. At all confidence levels, the detection covariates *air* and *days* were found to be significant. The only significant occupancy covariate was *type*, with "Private" and "WPA" wetlands differing from "Pit", although naïve occupancy rates for all wetland types were high. Lack of difference of "WMA" and "WRP" from the intercept are likely due to a few instances in which PSMA were not detected at a site for an entire season.

Table 6.2. Top occupancy models including both detection and occupancy covariates for Western Chorus Frog (PSMA). Models with a ΔAIC within 2 of the top model were included in the confidence set for model averaging.

Models	***K***	**-logLik**	**AICc**	**ΔAICc**	w_i	**Cumulative** w_i
~ air + days ~ year + type + stress	11	-773.59	1569.92	0.000	0.261	0.261
~ air + days ~ year + type	10	-774.89	1570.38	0.462	0.207	0.468
~ air + days ~ year + type + resistance	11	-774.01	1570.74	0.826	0.173	0.641
~ air + days ~ year + type + resistance + stress	12	-773.12	1571.10	1.183	0.145	0.786
~ air + days ~ year + type + area + stress	12	-773.35	1571.58	1.658	0.114	0.900
~ air + days ~ year + type + loss + stress	12	-773.48	1571.83	1.915	0.100	1.000

Table 6.3. Model averaged parameter estimates for PSMA for parameters included in the confidence set of models within 2 ΔAIC of the top model. Reported are 95% CI, 90% CI, and 85% CI for all parameters. Potentially important covariates at each confidence level are presented in bold.

Covariate	**Estimate**	**SE**	**95% CI**		**90% CI**		**85% CI**		***p***
				Detection					
p(Int)	1.28	0.07	**1.15**	**1.41**	**1.17**	**1.39**	**1.19**	**1.38**	<0.001
p(air)	-0.44	0.08	**-0.61**	**-0.28**	**-0.58**	**-0.30**	**-0.56**	**-0.32**	<0.001
p(days)	0.29	0.08	**0.13**	**0.45**	**0.15**	**0.42**	**0.17**	**0.41**	<0.001
				Occupancy					
psi(Int)	2.13	0.60	**0.95**	**3.30**	**1.15**	**3.11**	**1.27**	**2.99**	<0.001
psi(area)	0.27	0.42	-0.57	1.10	-0.43	0.96	-0.35	0.88	0.531
psi(loss)	0.13	0.30	-0.45	0.72	-0.35	0.62	-0.30	0.56	0.655
psi(resistance)	0.30	0.25	-0.19	0.79	-0.11	0.71	-0.06	0.66	0.228
psi(stress)	0.49	0.37	-0.24	1.23	-0.12	1.11	-0.04	1.03	0.184
psi(typePrivate)	1.49	0.70	**0.12**	**2.87**	**0.34**	**2.65**	**0.48**	**2.51**	0.034
psi(typeWMA)	11.63	110.31	-204.58	227.84	-169.28	192.54	-147.22	170.48	0.916
psi(typeWPA)	2.76	1.24	**0.33**	**5.20**	**0.72**	**4.80**	**0.97**	**4.55**	0.026
psi(typeWRP)	11.89	158.96	-299.67	323.46	-248.81	272.59	-217.01	240.80	0.940
psi(year2015)	-0.52	0.74	-1.97	0.92	-1.73	0.68	-1.58	0.53	0.475
psi(year2016)	-0.58	0.74	-2.03	0.86	-1.79	0.62	-1.64	0.48	0.428

Woodhouse's Toad

ANWO were detected at > 65% of sites in all survey years (Table 6.1). The detection covariate *air* was included in all models in the confidence set in combination with other potential detection covariates (Table 6.4). Overall, they were detected during 30% of surveys. Given that three of the top four models include only *air*, it is unsurprising that *air* was the only significant detection covariate (Table 6.4; Table 6.5). The occupancy covariate *type* was included in all models within the confidence set (Table 6.4). The *type* categories "Private" and "WRP" were significant all confidence levels (Table 6.5). "WMA" was significant at the 85% confidence level. The lack of significance for "WMA" and "WPA" at most confidence levels likely relates instances when ANWO were never detected as a site during a season.

Table 6.4. Top occupancy models including both detection and occupancy covariates for Woodhouse's Toad (ANWO). Models with a ΔAIC within 2 of the top model were included in the confidence set for model averaging.

Models	*K*	-logLik	AICc	ΔAICc	w_i	Cumulative w_i
~ air ~ year + type	9	-845.34	1709.17	0.000	0.121	0.121
~ air + wind ~ year + type	10	-844.47	1709.55	0.375	0.100	0.221
~ air ~ year + type + count	10	-844.72	1710.04	0.870	0.078	0.299
~ air ~ year + type + buffer	10	-844.75	1710.11	0.931	0.076	0.375
~ air + minutes ~ year + type	10	-844.76	1710.13	0.959	0.075	0.450
~ air ~ year + type + area	10	-844.83	1710.26	1.086	0.070	0.520
~ air + minutes + wind ~ year + type	11	-843.83	1710.39	1.213	0.066	0.586
~ air + wind ~ year + type + count	11	-843.92	1710.57	1.392	0.060	0.646
~ air + wind ~ year + type + buffer	11	-843.95	1710.62	1.450	0.059	0.705
~ air + wind ~ year + type + area	11	-843.96	1710.66	1.483	0.058	0.763
~ air ~ year + type + area + count	11	-844.05	1710.83	1.654	0.053	0.816
~ air + minutes ~ year + type + count	11	-844.15	1711.02	1.849	0.048	0.864
~ air + minutes ~ year + type + buffer	11	-844.19	1711.11	1.940	0.046	0.910
~ air + days ~ year + type	10	-845.26	1711.13	1.955	0.046	0.956
~ air ~ year + type + buffer	11	-844.21	1711.16	1.988	0.045	1.000

Table 6.5. Model averaged parameter estimates for ANWO for parameters included in the confidence set of models within 2 ΔAIC of the top model. Reported are 95% CI, 90% CI, and 85% CI for all parameters. Potentially important covariates at each confidence level are presented in bold.

Covariate	**Estimate**	**SE**	**95% CI**		**90% CI**		**85% CI**		***p***
					Detection				
p(Int)	-0.51	0.08	**-0.66**	**-0.35**	**-0.64**	**-0.38**	**-0.62**	**-0.39**	<0.001
p(air)	-0.23	0.07	**-0.37**	**-0.09**	**-0.35**	**-0.11**	**-0.33**	**-0.13**	0.001
p(days)	-0.03	0.09	-0.21	0.14	-0.18	0.11	-0.16	0.09	0.693
p(minutes)	0.06	0.06	-0.05	0.18	-0.03	0.16	-0.02	0.15	0.281
p(wind)	0.08	0.06	-0.04	0.21	-0.02	0.19	-0.01	0.17	0.191
					Occupancy				
psi(Int)	0.35	0.48	-0.59	1.29	-0.44	1.14	-0.34	1.04	0.463
psi(area)	-0.21	0.20	-0.60	0.18	-0.53	0.12	-0.49	0.08	0.297
psi(buff)	0.37	0.37	-0.35	1.09	-0.24	0.97	-0.16	0.90	0.318
psi(count)	0.24	0.23	-0.21	0.69	-0.14	0.61	-0.09	0.57	0.297
psi(typePrivate)	1.24	0.48	**0.30**	**2.19**	**0.45**	**2.04**	**0.55**	**1.94**	0.010
psi(typeWMA)	3.51	2.39	-1.17	8.19	-0.40	7.43	**0.08**	**6.95**	0.141
psi(typeWPA)	6.29	73.78	-138.32	150.89	-114.71	127.28	-99.95	112.53	0.932
psi(typeWRP)	1.17	0.53	**0.12**	**2.21**	**0.29**	**2.04**	**0.40**	**1.93**	0.028
psi(year2015)	-0.56	0.50	-1.54	0.43	-1.38	0.27	-1.28	0.16	0.266
psi(year2016)	-0.47	0.49	-1.44	0.50	-1.28	0.34	-1.18	0.24	0.342

Cope's Gray Treefrog

HYCH were detected at approximately 65% of sites in 2014 and 2015, but nearly 85% of sites in 2016 (Table 6.1). Overall, they were detected during 37% of surveys. Occupancy models for HYCH included linear and quadratic effects of both *air* and *day*. All models in the confidence included both *air* and *day*, while *minutes* was included in most models (Table 6.6). *Air*, *days*, and their quadratics were significant predictors of detection at all confidence levels, while *minutes* was significant at the 90% and 85% confidence levels (Table 6.7). Along with *year*, which was forced into all models, both occupancy covariates *type* and *buffer* were also present in all models in the confidence set (Table 6.6). In addition, *area* was present in seven of the nine models. *Buffer* and *year* were significant at all confidence levels (Table 6.7). For the occupancy covariate year, "2015" was found to differ from the other years. The occupancy covariates *area* and *type* category "WPA" were significant at the 90% and 85% confidence levels.

Table 6.6. Top occupancy models including both detection and occupancy covariates for Gray Treefrog (HYCH). Models with a ΔAIC within 2 of the top model were included in the confidence set for model averaging.

Models	***K***	**-logLik**	**AICc**	**ΔAICc**	**w_i**	**Cumulative w_i**
~ air + air^2 + days + $days^2$ + minutes ~ year + type + area + buffer	15	-825.27	1681.89	0.000	0.206	0.206
~ air + air^2 + days + $days^2$ + minutes + wind ~ year + type + area + buffer	16	-824.61	1682.75	0.861	0.134	0.340
~ air + air^2 + days + $days^2$ + minutes + wind ~ year + type + buffer + loss	15	-825.86	1683.08	1.188	0.114	0.454
~ air + air^2 + days + $days^2$ ~ year + type + area + buffer	14	-826.96	1683.09	1.204	0.113	0.567
~ air + air^2 + days + $days^2$ + minutes ~ year + type + area + buffer + stress	16	-824.96	1683.45	1.560	0.095	0.662
~ air + air^2 + days + $days^2$ + minutes ~ year + type + area + buffer + count	16	-824.97	1683.47	1.580	0.094	0.756
~ air + air^2 + days + $days^2$ + minutes ~ year + type + buffer	14	-827.26	1683.70	1.807	0.084	0.840
~ air + air^2 + days + $days^2$ + wind ~ year + type + area + buffer	15	-826.18	1683.70	1.810	0.083	0.923
~ air + air^2 + days + $days^2$ + minutes ~ year + type + area + buffer + loss	16	-825.16	1683.85	1.966	0.077	1.000

Table 6.7. Model averaged parameter estimates for HYCH for parameters included in the confidence set of models within 2 ΔAIC of the top model. Reported are 95% CI, 90% CI, and 85% CI for all parameters. Potentially important covariates at each confidence level are presented in bold.

Covariate	**Estimate**	**SE**	**95% CI**		**90% CI**		**85% CI**		***p***
					Detection				
p(Int)	0.27	0.12	**0.04**	**0.50**	**0.07**	**0.46**	**0.10**	**0.44**	0.023
p(air)	-0.36	0.09	**-0.54**	**-0.18**	**-0.51**	**-0.21**	**-0.49**	**-0.23**	<0.001
p(air^2)	-0.18	0.06	**-0.30**	**-0.05**	**-0.28**	**-0.07**	**-0.26**	**-0.09**	0.004
p(days)	0.41	0.09	**0.24**	**0.58**	**0.27**	**0.55**	**0.29**	**0.53**	<0.001
p($days^2$)	-0.13	0.06	**-0.26**	**-0.01**	**-0.24**	**-0.03**	**-0.22**	**-0.04**	0.039
p(minutes)	0.12	0.07	-0.02	0.26	**0.00**	**0.24**	**0.02**	**0.22**	0.097
p(wind)	-0.08	0.07	-0.21	0.05	-0.19	0.03	-0.18	0.02	0.229
					Occupancy				
psi(Int)	1.34	0.87	-0.37	3.05	-0.09	2.77	**0.09**	**2.60**	0.124
psi(area)	0.37	0.22	-0.06	0.80	**0.01**	**0.73**	**0.05**	**0.68**	0.093
psi(buff)	1.44	0.59	**0.29**	**2.59**	**0.48**	**2.40**	**0.60**	**2.29**	0.14
psi(count)	-0.14	0.18	-0.49	0.21	-0.43	0.16	-0.40	0.12	0.441
psi(loss)	0.25	0.26	-0.26	0.75	-0.17	0.67	-0.12	0.62	0.334
psi(stress)	-0.15	0.19	-0.53	0.23	-0.47	0.16	-0.43	0.13	0.431
psi(typePrivate)	0.41	0.42	-0.41	1.24	-0.28	1.10	-0.19	1.02	0.324
psi(typeWMA)	1.36	1.04	-0.69	3.40	-0.36	3.07	-0.15	2.86	0.194
psi(typeWPA)	7.37	107.47	-203.26	218.00	-168.87	183.61	-147.38	162.12	0.945
psi(typeWRP)	1.22	0.68	-0.12	2.56	**0.10**	**2.34**	**0.24**	**2.20**	0.074
psi(year2015)	-1.11	0.57	**-2.23**	**0.00**	**-2.04**	**-0.18**	**-1.93**	**-0.30**	0.05
psi(year2016)	-0.11	0.53	-1.14	0.92	-0.98	0.75	-0.87	0.64	0.827

Plains Leopard Frog

LIBL were detected at 59 – 77% of sites depending upon the year (Table 6.1). Overall, they were detected in 32% of call surveys. The detection covariate *air* was included in all models in the confidence set (Table 6.8). While the detection covariate *days* was also included in five of the models in the confidence set, it was a significant covariate at any confidence level (Table 6.9). The occupancy covariates *type* and *resistance* were present in all models in the confidence set. Unsurprisingly, these two covariates were also significant at all confidence levels (Table 6.9). All categories of the covariate *type* were significantly different from the intercept ("Pit").

Table 6.8. Top occupancy models including both detection and occupancy covariates for Plains Leopard Frog (LIBL). Models with a ΔAIC within 2 of the top model were included in the confidence set for model averaging.

Models	***K***	**-logLik**	**AICc**	**ΔAICc**	w_i	**Cumulative** w_i
~ air ~ year + type + resistance	10	-839.72	1700.05	0.000	0.119	0.119
~ air ~ year + type + area + resistance	11	-838.77	1700.26	0.214	0.107	0.226
~ air + days ~ year + type + resistance	12	-837.91	1700.70	0.647	0.086	0.312
~ air + days ~ year + type + area + resistance	11	-838.99	1700.70	0.655	0.086	0.398
~ air + days ~ year + type + resistance	11	-839.12	1700.97	0.918	0.075	0.473
~ air ~ year + type + count + resistance	11	-839.33	1701.40	1.348	0.061	0.534
~ air ~ year + type + area + count + resistance	12	-838.27	1701.40	1.350	0.061	0.595
~ air + wind ~ year + type + resistance	11	-839.37	1701.47	1.416	0.059	0.654
~ air ~ year + type + buffer + resistance	11	-839.41	1701.55	1.498	0.056	0.710
~ air + wind ~ year + type + area + resistance	12	-838.43	1701.72	1.674	0.052	0.762
~ air + days ~ year + type + loss + resistance	12	-838.43	1701.73	1.678	0.051	0.813
~ air + minutes ~ year + type + resistance	11	-839.56	1701.85	1.798	0.048	0.861
~ air + days ~ year + type + area + count + resistance	13	-837.44	1701.89	1.844	0.047	0.908
~ air ~ year + type + area + buffer + resistance	12	-838.54	1701.95	1.897	0.046	0.954
~ air ~ year + type + resistance + stress	11	-839.63	1702.00	1.951	0.045	0.999

Table 6.9. Model averaged parameter estimates for LIBL for parameters included in the confidence set of models within 2 ΔAIC of the top model. Reported are 95% CI, 90% CI, and 85% CI for all parameters. Potentially important covariates at each confidence level are presented in bold.

Covariate	Estimate	SE	95% CI		90% CI		85% CI		*p*
					Detection				
p(Int)	-0.22	0.08	**-0.37**	**-0.06**	**-0.34**	**-0.09**	**-0.33**	**-0.10**	0.006
p(air)	-0.28	0.08	**-0.44**	**-0.12**	**-0.42**	**-0.15**	**-0.40**	**-0.16**	<0.001
p(days)	0.12	0.10	-0.07	0.32	-0.04	0.28	-0.02	0.26	0.219
p(minutes)	0.03	0.06	-0.08	0.14	-0.06	0.12	-0.05	0.11	0.569
p(wind)	0.05	0.06	-0.07	0.18	-0.05	0.16	-0.04	0.15	0.405
					Occupancy				
psi(Int)	-0.48	0.36	-1.20	0.23	-1.08	0.11	-1.01	0.04	0.184
psi(area)	0.26	0.21	-0.14	0.66	-0.08	0.60	-0.04	0.55	0.207
psi(buff)	0.17	0.24	-0.29	0.64	-0.22	0.57	-0.17	0.52	0.464
psi(count)	-0.15	0.16	-0.46	0.16	-0.41	0.11	-0.37	0.08	0.338
psi(loss)	0.17	0.17	-0.15	0.50	-0.10	0.44	-0.07	0.41	0.305
psi(resistance)	0.48	0.16	**0.16**	**0.80**	**0.21**	**0.75**	**0.24**	**0.71**	0.004
psi(stress)	-0.07	0.16	-0.37	0.24	-0.32	0.19	-0.29	0.16	0.675
psi(typePrivate)	1.48	0.44	**0.63**	**2.33**	**0.77**	**2.19**	**0.85**	**2.11**	<0.001
psi(typeWMA)	2.65	0.60	**1.48**	**3.83**	**1.67**	**3.64**	**1.79**	**3.52**	<0.001
psi(typeWPA)	2.10	0.52	**1.08**	**3.11**	**1.24**	**2.95**	**1.35**	**2.84**	<0.001
psi(typeWRP)	1.92	0.48	**0.98**	**2.86**	**1.14**	**2.70**	**1.23**	**2.61**	<0.001
psi(year2015)	-0.34	0.39	-1.11	0.43	-0.99	0.31	-0.91	0.23	0.391
psi(year2016)	0.25	0.42	-0.57	1.07	-0.44	0.94	-0.35	0.85	0.551

Four-species Amphibian Community

I assessed the detection and occupancy of a small, four-species amphibian community comprised of PSMA, ANWO, HYCH, and LIBL. All four species were detected together in at least one survey at approximately 30% of sites in all years (Table 6.1). The amphibian community was detected in 10.5% of surveys. The detection covariate *air* was present in all models in the confidence set (Table 6.10). The covariate *wind* was present in five of the models. *Air* was significant at all confidence levels, while *wind* was significant at only the 85% confidence level (Table 6.11). The occupancy covariate *type* was present in all models in the confidence set (Table 6.10). Additionally, *buffer* was present in half of the models in the confidence set. Three of the wetland *type* categories were significantly different from the intercept ("Pit") at all confidence levels, including "WMA", "WPA", and "WRP". The category "Private" was significant at only the 85% confidence level. Similarly, *buffer* was also only significant at the 85% confidence level, indicating weak support for it importance.

Table 6.10. Top occupancy models including both detection and occupancy covariates for RWB amphibian community (COMM). Models with a ΔAIC within 2 of the top model were included in the confidence set for model averaging.

Models	***K***	**-logLik**	**AICc**	**ΔAICc**	w_i	**Cumulative** w_i
~ air ~ year + type	9	-462.35	943.19	0.000	0.100	0.100
~ air + wind ~ year + type	10	-461.32	943.26	0.062	0.097	0.197
~ air + minutes ~ year + type	10	-461.53	943.67	0.479	0.078	0.275
~ air + minutes ~ year + buffer	7	-464.76	943.84	0.644	0.072	0.347
~ air ~year + buffer	6	-465.84	943.91	0.718	0.070	0.417
~ air + wind ~ year + type + buffer	11	-460.61	943.95	0.755	0.068	0.485
~ air + minutes + wind ~ year + type	11	-460.61	943.95	0.756	0.068	0.553
~ air ~ year + type + buffer	10	-461.71	944.03	0.836	0.066	0.619
~ air + minutes ~ year + buffer	7	-464.98	944.27	1.080	0.058	0.677
~ air + minutes + wind ~ year + buffer	8	-464.00	944.40	1.208	0.055	0.732
~ air + minutes ~ year + type + buffer	11	-460.84	944.41	1.220	0.054	0.786
~ air + minutes + wind ~ year + type + buffer	12	-459.84	944.55	1.362	0.050	0.836
~ air ~ year + type + resistance	10	-462.10	944.81	1.622	0.044	0.880
~ air + wind ~ year + type + resistance	11	-461.05	944.84	1.648	0.044	0.924
~ air ~ year + type + area	10	-462.24	945.10	1.906	0.038	0.962
~ air + wind ~ year + type + area	11	-461.22	945.18	1.987	0.037	0.999

Table 6.11. Model averaged parameter estimates for COMM for parameters included in the confidence set of models within 2 ΔAIC of the top model. Reported are 95% CI, 90% CI, and 85% CI for all parameters. Potentially important covariates at each confidence level are presented in bold.

Covariate	Estimate	SE	95% CI		90% CI		85% CI		*p*
					Detection				
p(Int)	-1.36	0.17	**-1.69**	**-1.04**	**-1.63**	**-1.09**	**-1.60**	**-1.12**	<0.001
p(air)	-0.36	0.11	**-0.59**	**-0.14**	**-0.55**	**-0.18**	**-0.53**	**-0.20**	0.001
p(minutes)	0.08	0.06	-0.04	0.21	-0.02	0.19	-0.01	0.18	0.192
p(wind)	-0.14	0.10	-0.34	0.06	-0.31	0.02	**-0.29**	**0.00**	0.160
					Occupancy				
psi(Int)	-0.74	0.72	-2.15	0.68	-1.92	0.45	-1.78	0.30	0.306
psi(area)	-0.09	0.19	-0.47	0.29	-0.40	0.23	-0.37	0.19	0.646
psi(buff)	0.55	0.35	-0.13	1.24	-0.02	1.12	**0.05**	**1.05**	0.111
psi(resistance)	0.13	0.18	-0.22	0.47	-0.16	0.42	-0.13	0.38	0.472
psi(typePrivate)	0.86	0.54	-0.20	1.93	-0.03	1.75	**0.08**	**1.64**	0.113
psi(typeWMA)	2.06	0.72	**0.65**	**3.47**	**0.88**	**3.24**	**1.02**	**3.09**	0.004
psi(typeWPA)	2.11	0.74	**0.67**	**3.55**	**0.90**	**3.32**	**1.05**	**3.17**	0.004
psi(typeWRP)	1.15	0.59	**0.00**	**2.30**	**0.18**	**2.12**	**0.30**	**2.00**	0.051
psi(year2015)	-0.60	0.44	-1.46	0.26	-1.32	0.12	-1.23	0.03	0.174
psi(year2016)	0.24	0.49	-0.71	1.19	-0.55	1.04	-0.46	0.94	0.620

Discussion

The use of occupancy modeling to assess the efficacy of call surveys and factors that may influence site occupancy now seems common practice. Building upon previous work, I used occupancy modeling to assess detection and site occupancy of wetlands in the Rainwater Basin Region of south-central Nebraska. Due to low detection and naïve occupancy rates for half of the species potentially present in RWB wetlands, I was only able to model four individual species and a small community comprised of these four species (Table 6.1). Covariates affecting detection and occupancy were determined for each species and the small community. Despite the ability to model only a few species and the small community, these results provide insights into future implementation of volunteer call surveys and factors that may influence the distribution and occupancy of anuran species in the Rainwater Basins.

Naïve Occupancy

Naïve occupancy rates for all species and the RWB community were generally consistent across all survey years with few exceptions (Table 6.1). Both the HYCH and LIBL had slightly increased naïve occupancy in 2016 relative to 2014 and 2015. All species seemed to have a slight drop in naïve occupancy in 2015. Variability in naïve occupancy is assumed to relate to factors assessed with occupancy modeling. In contrast to other species detected during the three years of this study, the SPBO had a significant increase in naïve occupancy in 2015. The drastic increase in SPBO naïve occupancy likely relates to chance in that this particular species breeds after severe thunder storms (Ballinger et al. 2010). In 2015, therefore, it seems likely that the timing of surveys occurred in days immediately following thunderstorms. The increase in detections and naïve occupancy is also consistent with the frequent observation of SPBO larvae in 2015 (Smeenk, *pers. obs.*).

It appears likely that the wetland types surveyed impacts the naïve occupancy rates for many RWB anuran species. During 2005, 2006, and 2013 surveys temporary, semi-permanent, and permanent wetlands were surveyed along with such sites as pits and roadside ditches. During extremely wet years, such as 2014, all of these wetland sites may hold water; however, in typical years many will be dry for much of the anuran breeding season (Smeenk, *pers. obs.*). Despite being a relatively wet year, I suspect that many of the wetlands surveyed during 2005 were dry during all or part of the survey period, and in extremely dry years such as 2006 and 2013, many of the wetlands were dry (Smeenk, *pers. obs.*). In order to avoid drastic changes in the number of inundated wetlands among years and facilitate a long-term monitoring effort in likely breeding sites, only wetland sites with ponding in five of the eight years prior to 2014 - 2016 were selected for sampling in addition to 25 agricultural reuse pits, which hold water seasonally to permanently. This change may in part explain the high observed naïve occupancy rates from the 2014 – 2016 surveys. In all likelihood, high precipitation prior to and during surveys in addition to the decreased distance to the wetland edge also aided in the higher observed occupancy rates during 2014 - 2016.

Detection

Detection of amphibians during anuran call surveys has frequently been shown to vary with multiple abiotic factors including wind speed (Steelman and Dorcas 2010), air temperature and water temperature (Pellet and Schmidt 2005, Saenz et al. 2006, Williams et al. 2013, Plenderleith et al. 2017), time of day (Bridges and Dorcas 2002, Oseen and

Wassersug 2002, Steelman and Dorcas 2010, Williams et al. 2013), and date (Hellman 2013, Steen et al. 2013, Williams et al. 2013); however, the strength and directionality of relationships frequently varies by species due to difference in breeding phenology (Saenz et al. 2006, Walpole et al. 2012, Plenderleith et al. 2017). This inherent variability in species response to environmental, time, and seasonal covariates illustrates the importance of incorporating these variables when assessing anuran occupancy, particularly when attempting to do so for multiple species or amphibian communities. While other factors such a water temperature are certainly important, it is not usually not possible to measure these variables when conducting road-based surveys, thus precluding the incorporation of those variables in this study. Instead, I focused in easily measurable abiotic covariates. Specifically, I assessed the effects of air temperature, wind speed, time of day, and date on anuran species detection during roadside surveys.

The distance from a wetland has been shown to impact the ability of observers to detect calling amphibian species (McClintock et al. 2010). During previous survey efforts conducted in 2005, 2006, and 2013, observers may have been up to 400 meters (0.25 miles) from a wetlands site. In some cases, species such as LIBL that call from under water cannot be heard in a wetland from that distance due to the low volume of their call. Additionally, when many species are calling or large choruses of PSMA are present, the calls of some species may be drowned out at such distances. This can lead to omission errors by observers and result in an underestimate of site occupancy (McClintock et al. 2010). To mitigate these issues, the maximum distance from the wetland edge to the nearest road was limited to 125 m during 2014 - 2016 surveys. Distance to wetland edge was not found to have any bearing on detection of the four species or RWB community assessed during this study. This indicates that the limitation of distance from wetland edge to only 125 m was successful in mitigating potential issues with omissions due to surveyors being unable to hear calling anurans.

It is generally hypothesized that abiotic factors such as rainfall, wind speed, and air temperature influence both the proclivity of anurans to call and, in relation to wind and rainfall, ability of surveyors to detect call anurans (Oseen and Wassersug 2002, Saenz et al. 2006, McClintock et al. 2010, Steelman and Dorcas 2010). While I attempted to ameliorate issues with detection related to rainfall, wind speed, and air temperature through survey protocols that placed limitations on environmental conditions during which surveys could be conducted, I hypothesized that both air temperature and wind speed may still influence detection. Wind speed < 32 km/h had no effect on detection of any of the four species analyzed or the RWB community. I assumed a quadratic relationship between detection and air temperature, in which detection increases as temperature increases, but declines at a certain threshold. *Air* was a significant predictor of detection for all species and the community modeled (Figure 6.5). For only HYCH, I observed a quadratic relationship of *air* and detection. In all other instances, I observed a linear decrease in detection probability as air temperature increased. The lack of quadratic shape certainly relates the requirement that air temperatures be at least 32° F for surveys to be conducted. Had surveys been conducted at colder temperatures, a quadratic relationship very likely would have been observed for PSMA, ANWO, LIBL, and COMM. The lack of a significant effect of wind speed suggests that the survey design, which did not permit surveys to be conducted when sustained wind speeds exceeded 32 km/hour, helped in ameliorating potential impacts of wind on observers' ability to detect calling amphibians. Additionally, it supports the conclusion that all species assessed in this study call at wind speed less than the dictated threshold.

Additional non-meteorological variables were also hypothesized to influence detection including the days since the first survey during a season (*days*) and minutes after sunset (*minutes*). For most species, neither *days* nor *minutes* were found to effect detection. I suspect that this is because difference in detection for these species are reflected by a decrease in detection with air temperature. For both PSMA and HYCH, however, *days* had a significant effect on detection probability (Table 6.3; Table 6.7). Detection probability for PSMA slightly increased as *days* increased, meaning that detection of PSMA was higher in at later survey dates than at earlier survey dates. In contrast, I observed a greater increase in detection for HYCH at later dates with probability of detection increasing from < 0.4 to > 0.6 as days since first survey increases. Towards the end of each season, detection of HYCH in relations to *days* appears to decline, resulting in a minimal quadratic relationship. Had surveys continued into the summer, this relationship likely would have become more distinct. I also found a slight increase in HYCH detection as minutes since sunset increased, although this was only significant at the 90% and 85% CI, indicating only moderate support for this relationship. Given the general lack of strong relationship between detection and day since first survey and the fact that most species assessed in this study were readily observed during most survey periods, it appears that the timing of RWB volunteer surveys were effective for monitoring RWB amphibian communities. The increase in detection for HYCH relative to other species is consistent with the differing phenology of this species relative to the early spring breeders; however, the timeframe for volunteer surveys in this study was still sufficient for detecting HYCH in all years. The only species present in the RWB that surveys generally in ineffective for detecting is LICA, a mid- to late-summer breeding species, although LICA were still occasionally detected during surveys.

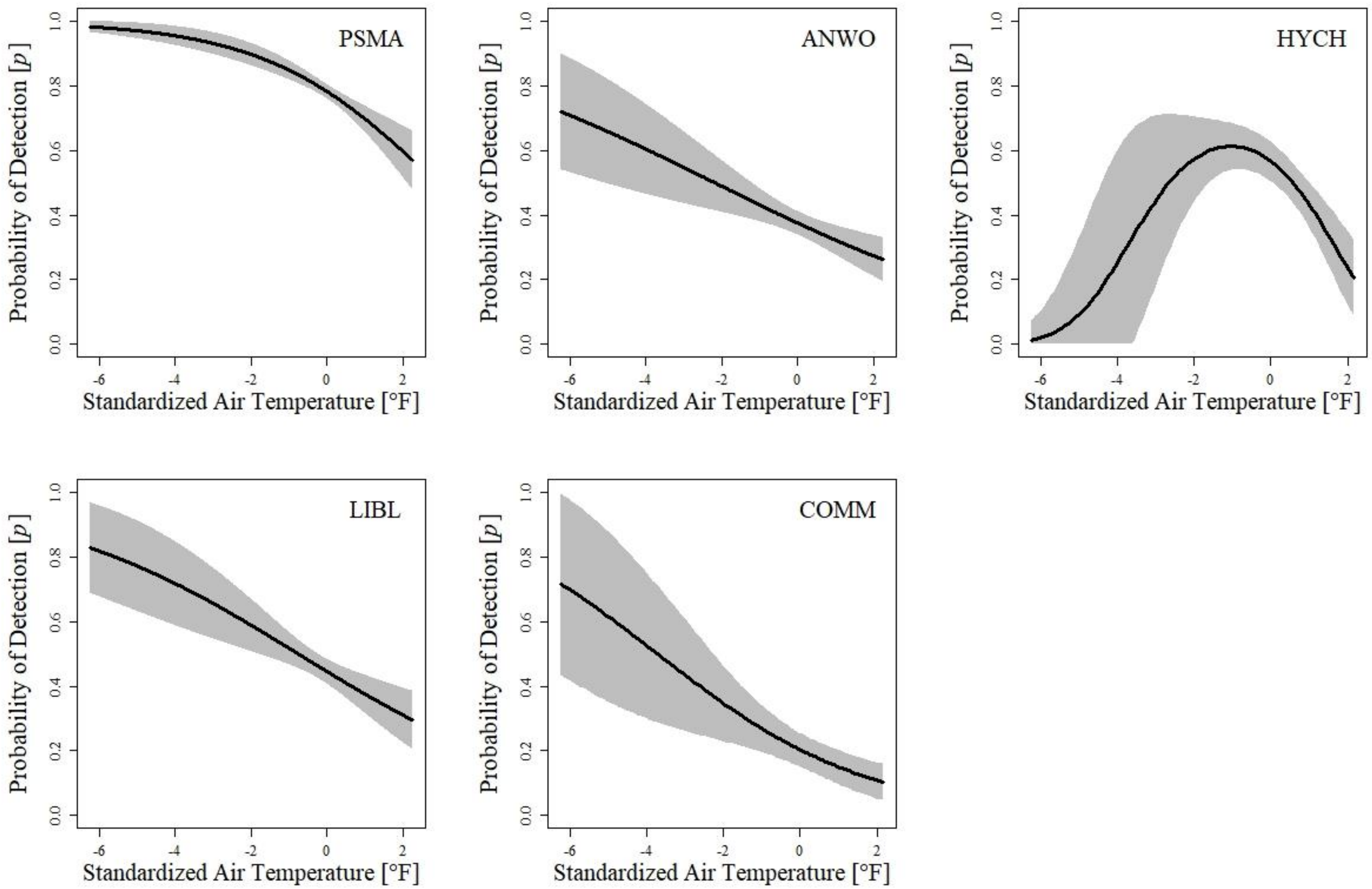

Figure 6.5. Estimated model averaged response curves for air temperature (air) and detection probabilities (p) and four species of anuran (PSMA, ANWO, HYCH, and LIBL) and a small, fours-species RWB anuran community (COMM). The black curve is the model averaged estimate. Gray bands surrounding the model averaged estimates represent 95% CIs.

Occupancy

The ecological condition of habitats directly impacts wildlife communities that occupy sites. Ecological condition can be measured using both local and landscape metrics; however, study design may limit how ecological condition can be assessed due to access and logistical constraints. Volunteer roadside anuran call surveys are unique in that they permit the ability to survey many sites, but do not require direct access. As such, assessing the ecological condition and occupancy of these sites is generally limited to landscape factors assessable using remote sensing and GIS techniques. Both local and landscape factors are known to influence amphibian occupancy of wetland sites, but responses may vary by species (Hellman 2013, VanderHam 2014). I assessed site occupancy of four species and small amphibian community limited local site base factors and measures of landscape condition and stress surrounding wetland sites. In general, I found that local site factors may be more important in determining site occupancy than landscape condition factors in RWB playa wetlands.

Occupancy of five wetland types (*type*) including agricultural reuse pits, private wetlands, wetlands enrolled in WRP, WMAs, and WPAs was assessed for the four species and small community analyzed in this study. For all four species (PSMA, ANWO, HYCH, and LIBL) and the small community, wetland type was important in estimating occupancy probability (Figure 6.6). In general, estimated probability of occupancy was lower for “Pits” than for all other wetland types. Additionally, estimated occupancy probability was nearly always greater in WMA and WPA sites than other wetland types. Although estimated occupancy rates were not always statistically significantly different from “Pits” for all species, it seems that this lack of significance relates to years in which a species was never detected at individual WMA or WPA sites, as was the case for ANWO and HYCH in some years and represents a statistical artifact rather than lack of biological significance. The greater estimated occupancy for managed wetlands (WMA and WPA) and those enrolled in conservation programs (WRP) is consistent with previous studies in which anuran species occupancy and community richness were greater in restored playa wetlands (Beas and Smith 2014) and restored and native wetlands in the Prairie Pothole region (Balas et al. 2012). Although I hypothesized that RWB species may be more likely to occupy larger wetlands, this covariate was not found to be a significant predictor in this study. I assume that this lack of relationship may relate to site selection procedures in which only sites with pooling over many years were included, which may have biased selection towards larger wetlands that consistently hold more water relative to smaller and shallower sites.

Many different types of water features are present on the landscape in the RWB including roadside ditches, pits, and wetlands of various categories and permanence. Although amphibians may use multiple wetland types during their life cycle, for activities such as dispersal, breeding, and over-wintering, the ability of habitats to provide resources for these events will vary due to differences in habitat quality. I assumed that amphibian occupancy rates during the breeding season would vary among wetland categories due to variations in habitat quality related to factors such as management and land use. Although I hypothesized that pits would have lower occupancy rates and species richness, the lack of variation among other wetland categories was surprising given that private, WMA, WPA, and WRP wetlands are managed differently and differ in habitat quality based upon vegetation communities (Smeenk, *pers. obs.*; also see Chapters

2 and 3). Although I expected differences among other wetland types due to assumed differences in habitat quality similar to those described by Micacchion (2002), the lack of difference may be explained by the fact that most of the anuran species found in Nebraska are habitat generalists and will use any wetland given the presence of water and aquatic vegetation. It should be noted, however, that the sites with the highest recorded richness (6 species) were wetlands with known active management including WMA, WPA, and WRP wetland sites. This is not to say that pits are unimportant. In fact, pits and ditches may represent important corridors for dispersal and connectivity among the few remaining wetlands on the landscape (Uden et al. 2014), which could explain the use of pits by some species during at least part of the breeding season. It had also been noted that landscape context is more important for amphibian wetland occupancy than vegetated buffers (Sawatzky et al. 2019).

Generally, occupancy of RWB anuran species appears to be dictated by landscape context and connectivity rather than measures of landscape condition. Both buffer condition (*buff*) and wetland area (*area*) were significant covariates for HYCH occupancy, with estimated occupancy increasing with both buffer condition and area (Table 6.7). Buffer condition was also a potentially important variable for COMM occupancy probability but was only significant at the 85% CI (Table 6.11). I also found a slight increase in occupancy probability relative to landscape resistance (*resist*) (Table 6.9). These relationships appear to be the exception rather than the rule, however, as no other landscape variables were significant for and other species. The lack of importance for nearly all landscape condition variables and most species was somewhat surprising. In highly agricultural landscapes, however, the assumed relationship between wetland occupancy and surrounding landscape may not hold true (Sawatzky et al. 2019). Dirt roads crisscrossing the RWB exist in a gridded pattern with nearly all roads having some sort of ditch alongside. This typically means that no wetland is greater than 0.5 miles from a roadside ditch. While the depth of ditches varies, many ditches in the RWB are very deep and consistently hold water, particularly during wet years (N. Smeenk *pers. obs.*). In some instances, the ditches are present with abundant hydrophytic vegetation and may exist on the landscape as small, functional wetlands. Given the density of roads and associated roadside ditches, abundance of agricultural reuse pits, and general proximity to roads of wetland sites, it seems likely that roadside ditches may mitigate the effects of an agricultural desert in the RWB. Historically, small, temporary wetlands likely served this purpose; however, these wetlands are mre easily drained and altered and thus remain rare on the landscape. Alternatively, anuran species may be responding at scales larger or smaller than were used in this modeling exercise; although the distances used are reasonable given home range sizes and dispersal abilities of species commonly using RWB playa wetlands, agricultural reuse pits, and roadside ditches.

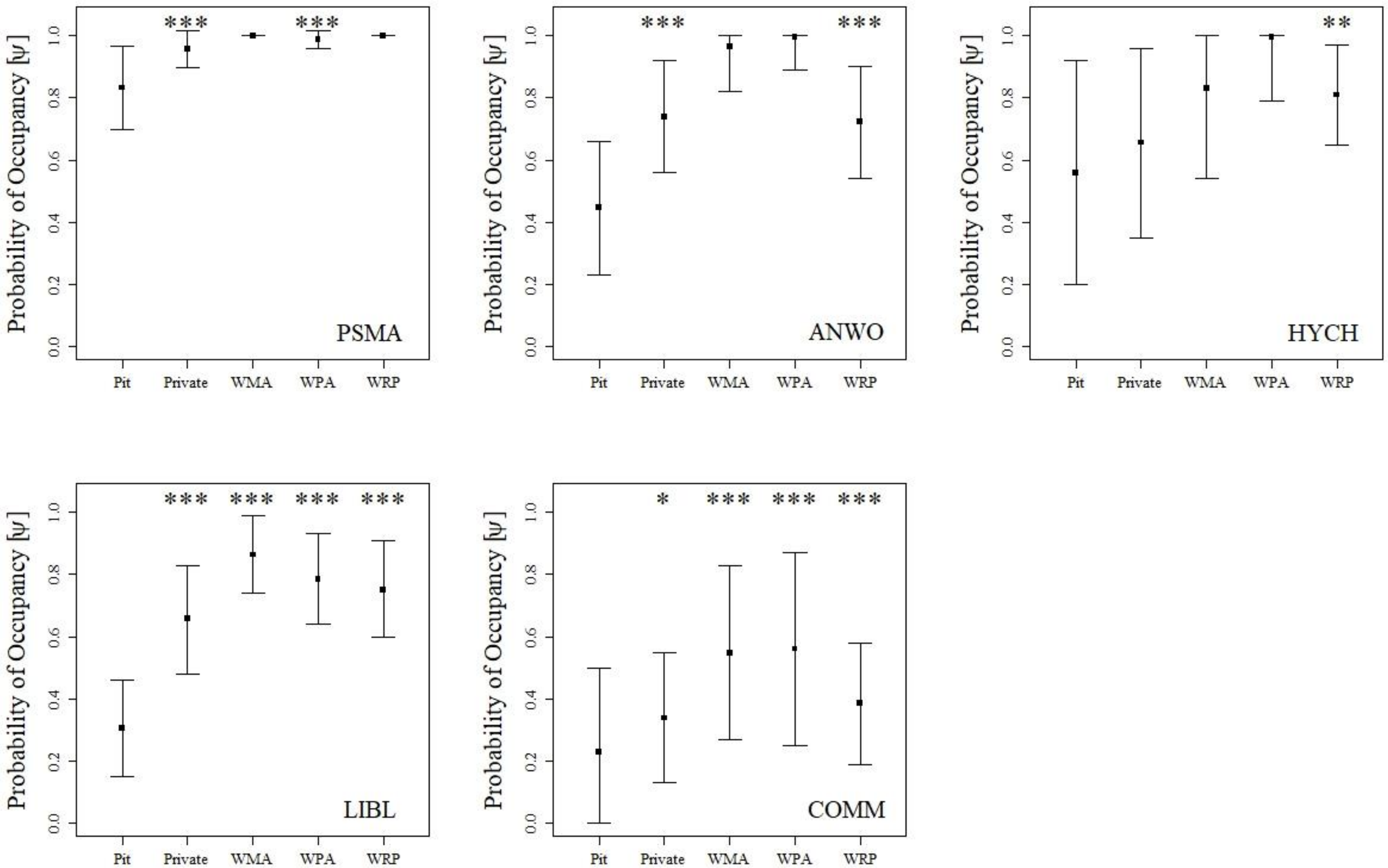

Figure 6.6. Estimated model averaged occupancy rate by wetland type (type) for four species (PSMA, ANWO, HYCH, and LIBL) and a small, four-species RWB anuran community (COMM). Black points are mean model averaged occupancy estimates. Bars on either side of points are 95% CIs. Significance (α) relative to the intercept ("Pit") are indicated as follows: *** = 0.05, ** = 0.10, * = 0.15

Conclusions

Depending on research goals, volunteer based roadside anuran call surveys represent an effective method to survey large areas such as the RWB in central Nebraska. However, such methods do not lend themselves to answer demographic questions. This relates to the fact that a species is detected whether a single individual or 1000 individuals is present. Futher, it also fails to address whether successful reproduction or recruitment occurs at a wetland site. Should concerns about population size or demographics be deemed important, more intensive methods such as drift fences or mark-recapture should be employed. However, if interest lies the simple monitoring of occupancy dynamics, volunteer based roadside anuran call surveys represent a viable montoring technique.

The timing and weather restrictions placed on surveys were effective in mitigating issues related to air temperature, wind speed, and the within night timing of surveys. During surveys from 2014 - 2016, I detected a total of eight species, of which only four species were detected on enough occasions to model. Detections of sporadic breeding species such as ANCO and SPBO and species with limited distributions like ACCR and Northern Leopard Frogs (LIPI) were limited during these surveys. Despite these limitations, roadside call surveys at semi-permanent and permanent wetland sites represent the most cost-effective method for the long-term monitoring of RWB amphibian communities. In addition, power analysis using low estimates of detection (p) and occupancy (Ψ) from this study with 125 sites and four visits indicate an 80 – 99% probability of detection a 33 – 60% decrease in occupancy (Table 6.12; Guillera-Arroita and Lahoz-Monfort 2012). Increasing the number of visits and sites beyond the current study design allows for a slight increase in power to detect smaller changes in occupancy, but only to about a 20% change in occupancy. The ability to detect a smaller change in occupancy rapidly becomes unattainable without substantial increases in detection probability.

With the continued loss of wetlands in the RWB, monitoring of amphibian communities in this region is critical in determining future impacts of agricultural and urban development on wetlands and wetland reliant species. Recent estimates indicate that nearly 90% of RWB playa wetlands have been altered or destroyed (LaGrange 2015). Estimates of current loss found a reduction of 31.0% of Scott and 79.4% of Fillmore hydric soils in the RWB, both of which are typically associated with RWB playas (Tang 2018). Additionally, conservation lands comprise only 11.3% of the total historic wetland footprint yet are estimated to contribute to 40.5% of current wetland function (Tang 2018). Given the apparent importance of conservation lands to function and habitat for native anurans, future work should focus on conserving and restoring semi-permanent RWB playa wetlands. While previous work has illustrated the importance of vegetated buffers for maintaining wetland function and anuran habitat, in agricultural landscapes, these trends may not hold true (Sawatzky et al. 2019). The importance of landscape context and connectivity via vegetated roadside ditches and potentially agricultural reuse pits (Uden et al. 2014) seems apparent given the lack of importance and landscape condition and even vegetative buffers in this study. Due to their sensitivity to environmental degradation, the monitoring of amphibian communities represents a method to assess the future degradation of RWB wetlands. The initiation of volunteer roadside anuran call surveys represents an effective and easy method for long-term monitoring efforts and should continue in the future.

Table 6.12. Estimated power to detect proportional change in occupancy given low end estimates of detection (p) and occupancy (Ψ) from this study and continued efforts to survey 125 sites 4 times per season.

Probability of Detection (*p*)	Probability of Occupancy (*Ψ*)	*α*	Proportional Change in Occupancy	Estimated Power to Detect Proportional Change in Occupancy
0.45	0.6	0.05	0.10	0.13
0.45	0.6	0.05	0.20	0.38
0.45	0.6	0.05	0.30	0.71
0.45	0.6	0.05	0.33	0.80
0.45	0.6	0.05	0.40	0.92
0.45	0.6	0.05	0.50	0.99
0.45	0.6	0.05	0.60	0.99

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CHAPTER 7

THE CHYTRID FUNGUS (*BATRACHOCHYTRIUM DENDROBATIDIS*) IN NATIVE AMPHIBIAN COMMUNITIES OF NEBRASKA

INTRODUCTION

Anecdotal reports at the First World Congress of Herpetology led to concerns about a potential pattern of worldwide amphibian declines beginning in the early 1990's (Collins and Storfer 2003). Since that time, many of those population extinctions, declines, and mass mortality events have been attributed to a fungal infection chytridiomycosis (chytrid), which is caused by the fungal zoospore *Batrachochytrium dendrobatidis* (*Bd*; Skerratt et al. 2007, Stuart et al. 2004, Collins and Storfer 2003). Amphibians affect both ecosystem structure and function and directly contribute to ecosystem services, in some cases representing a significant source of biomass in inhabited areas (Hocking and Babbit 2013, Gibbons et al. 2006, Whiles et al. 2006). Concern over the potential ecological consequences of such rapid and drastic extinctions has led to an increase in effort studying the potential effects of emerging infectious disease on amphibian populations. Furthermore, scientific and technological advances in non-invasive techniques to detect the chytrid fungus have changed the ability of researchers and managers to track the distribution of and measure the population fluctuations and declines related to diseases such as chytrid (Murray et al. 2011, Skerratt et al. 2008, Kriger et al. 2006, Retallick et al. 2006, Boyle et al. 2004).

Apparent concerns and scientific advances in research techniques have led to a worldwide effort to better understand the distribution and factors that affect the distribution of *Bd* in amphibian populations. Researchers have proposed two general hypotheses to explain spread and occurrence of the *Bd* (Venesky et al. 2014, Collins and Crump 2009, Fisher et al. 2009, Rachowicz et al. 2006). The first hypothesis describes *Bd* and subsequent chytrid infections as an epidemic spreading as a wave through naïve regions and populations, resulting in population and species declines, extirpations, or extinctions. This process is well documented from regions of Central America, Australia, and North America (Cheng et al. 2011, Vredenberg et al. 2010, Collins and Crump 2009, James et al. 2009, Lips 1999). The second hypothesis posits that in some regions, *Bd* was introduced decades ago as an epidemic but is now endemic (Richardson et al. 2014, Rosenblum et al. 2013, Ouellet et al. 2005). *Bd* is currently widespread and has been detected on every continent where amphibian populations occur (Olson et al. 2013, Lannoo et al. 2011, Fisher et al. 2009). Similar to worldwide patterns, *Bd* is widespread in the North America (Olson et al. 2013, Oullet et al. 2005) and in the Great Plains (CO, Muths et al. 2003; IA, Sadinski et al. 2010; KS, McTaggart et al. 2014; MO, Lennon et al. 2014; MT, Hossack et al. 2013; NE, Harner et al. 2013; NM, Lannoo et al. 2011; OK, Lannoo et al. 2011; SD, Brown and Kerby 2013; TX, Gaertner et al. 2010; WY, Murphy et al. 2009).

The chytrid fungus is known to occur in Nebraska and has been found in amphibian populations located in Nebraska. Opportunistic sampling through a school-based citizen science effort to sample for the chytrid fungus has detected chytrid in many areas of Nebraska (pers. comm. Jacob Kerby). Sampling on The Crane Trust property located along the Big Bend of the Platte River has also detected chytrid in Woodhouse's Toads (*Anaxyrus woodhousii*), Plains Leopard Frogs (*Lithobates blairi*), and American

Bullfrogs (*Lithobates catesbeianus*) (Harner et al. 2011, Harner et al. 2013). In addition, sampling of American Bullfrogs (*Lithobates catesbeianus*) at the Valentine National Wildlife Refuge in north central Nebraska detected chytrid in 73% of samples collected in June 2012 (Lingenfelter et al. 2014). Although sporadic testing for the chytrid fungus in populations of native amphibians has occurred in Nebraska, widespread surveys have never been conducted. Addressing this lack of knowledge pertaining to the current distribution of chytrid will help the state understand the distribution of the disease, and potentially work to preventing the further spread.

The occurrence and prevalence of *Bd* varies due to multiple biotic and abiotic factors. Detection rates and prevalence differ among species in many instances including both historic and contemporary sampling efforts (Ouellet et al. 2005, Harner et al. 2013, Richards-Hrdlicka et al. 2013). Furthermore, species such as American Bullfrogs and Northern Leopard Frogs have been indicated as potential reservoir species due to perceived immunity and observed high prevalence of *Bd* in sampled specimens (Garner et al. 2006, Woodhams et al. 2008, Schloegel at el. 2009, Harner et al. 2011, Harner et al. 2013). Climate appears to play a large role in the detection and prevalence of *Bd*. Specifically, both maximum summer temperature, precipitation, and seasonality have all been described as good predictors (Berger et al. 2004, Drew et al. 2006, Kriger and Hero 2006, Kriger et al. 2007, Rohr et al. 2011). Lastly, site specific factors such as hydrology and surrounding land use have been shown to be important in predicting *Bd* occurrence and prevalence (Johnson et al. 2007, Kriger and Hero 2007). In most cases, multiple factors, both biotic and abiotic, contribute to the occurrence and prevalence of *Bd* in amphibian communities.

The goal of this study is to assess both the historic and current distribution of the amphibian chytrid fungus in Nebraska. First, I sampled and tested 191 preserved American Bullfrog specimens collected from localities throughout Nebraska. Additionally, I collected disease samples at 53 sites, mostly located in Central and Eastern Nebraska. Using real-time Taqman PCR, I tested historic and contemporary swab samples for the presence of *Bd* zoospores. I compared detection rates among sites and species to determine differences related factors including taxonomy, hydrology, and and seasonality. Lastly, I used a MaxEnt model to predict the current distribution of the amphibian chytrid fungus in aquatic habitats across the state. Results provide a predicted distribution of chytrid in Nebraska and inform on factors that may mediate or inhibit the continued spread of *Bd* throughout the state.

METHODS

Museum specimen sample collection

Genomic studies of *Bd* reveal a complex phylogenetic history of the chytrid fungus, predating the associated amphibian declines (Rosenblum et al. 2013, Velo-Anton et al. 2012, Farrer et al. 2011). Although these studies provide perceived evidence supporting both the novel and endemic pathogen hypotheses (Venesky et al. 2014), it is apparent that in many cases, *Bd* has been present in amphibian populations for longer than previously anticipated. In addition to phylogenetic studies, retrospective sampling from museum collections indicate the presence of *Bd* as early as 1928 in the United States (Huss et al. 2013), 1961 in Canada (Oullet et al. 2005), 1933 in Africa (Reeder et al. 2011), and 1933 in China (Zhu et al. 2013). Furthermore, the broad distribution of *Bd* in non-epidemic amphibian communities may indicate a longstanding history of *Bd* presence and infection in many regions (Richardson et al. 2014, Bai et al. 2012, Goka et al. 2009). In Nebraska, there have been no reports of amphibian population die-offs associated with chytrid; however, *Bd* has been detected in many regions and multiple species (Lingenfelter et al. 2014, Harner et al. 2013, Harner et al. 2011). Based upon these results, it is reasonable to conclude that *Bd* is not epizootic in Nebraska amphibian communities and may have been present in amphibian populations for an extended period of time.

In order to determine the historical extent of *Bd* in Nebraska, I performed retrospective sampling of preserved museum specimens located in the University of Nebraska State Museum Zoology collections. Contemporary studies propose American Bullfrogs as potential hosts and reservoirs for *Bd* (Schloegel et al. 2009, Garner et al. 2006). This evidence in conjunction with high prevalence of *Bd* in American Bullfrogs in Nebraska (Lingenfelter et al. 2014, Harner et al. 2011), advance this species as a potential historic reservoir for *Bd* in the state. Accordingly, I focused retrospective sampling efforts on American Bullfrogs. Museum specimens were stored in jars according to geographic location. Specimens were handled and sampled individually. I swabbed each specimen 30 times with using a dry, polyester tipped Fisherfinest™ transport swab (Fisher Scientific, Waltham, MA): five times across the ventral surface, five time on each inner thigh, five time across the pelvic patch, and five time on each rear foot including interdigital webbing. To avoid cross contamination, I rinsed each specimen thoroughly with non-denatured 70% ETOH and changed gloves in between specimens. Samples were immediately stored in a freezer prior to transfer to the University of South Dakota for PCR testing.

Larval amphibian sample collection

Many previous studies have focused chytrid testing efforts on adult specimens (Muths et al. 2008, Kriger and Hero 2007, Oullet et al. 2005); however, capturing sufficient samples of adults is difficult due to sporadic reproductive behaviors and logistical time constraints. In most frog and toad species, one individual will produce many eggs. This results in an abundance of larval amphibians in the late-spring and early-summer, making it more efficient to capture a sufficient number of individuals for disease sampling. Some research even indicates that tadpoles, particularly in species with extended larval stages (ex. *Lithobates* spp.), may act as reservoirs for *Bd* and that tadpoles may not show clinical signs of infection despite high mortality in post-metamorphic individuals (Rachowicz and Vredenburg 2004, Bradley et al. 2002). Lab experiments indicate that chytrid results in mortality of post-metamorphic amphibians; however, despite apparent infection, does not cause mortality in larval individuals (Berger et al. 1998, Lamirande and Nichols 2002). Based on these findings, it is reasonable to assume that detection rates in post-metamorphic and adult amphibians may actually underestimate true infection rates due to mortality prior to the occurrence of sampling in some species. In order to obtain sufficient samples and mitigate any issues with potential low detection rates in populations I captured and swabbed larval amphibians.

Dip netting

I captured amphibian larvae using a 12” D-frame dip net with a 500 micron mesh bottom or electro-shock dip net with 3/16” mesh. Because the sole purpose of dip netting is to capture tadpoles for disease sampling, I did not employ specific protocols regarding time constraints, number of dip net sweeps, or distance between dip net sweeps. Since many North American species rarely test positive for chytrid, I focused efforts on obtaining samples from individuals of the genera *Lithobates* and *Pseudacris* (Oullet et al. 2005, J. Kerby, pers. comm.) although other species were also opportunistically sampled when captured in sufficient numbers. After capture, I temporarily housed tadpoles in 5-gallon buckets filled with ~4” of local water. To avoid overcrowding and stress, I used multiple buckets. When multiple species were captured, each individual species was housed in a separate bucket.

To prevent spreading chytrid to new populations in Nebraska, I cleaned and disinfected all equipment that touched either site water or larval amphibians, including boots. Based on methods to estimate the potential anthropogenic spread of chytrid among populations, this study was considered low risk (Phillott et al. 2010, St. Hilaire et al. 2009); therefore, I sanitized all equipment by submerging it in a >1% bleach solution for one minute and spraying equipment with a pressure washer filled >1% bleach solution. Equipment was then rinsed with fresh water to remove any remaining bleach residue. Despite the recommendation that equipment only be sanitized between major catchments (Phillott et al. 2010), I sanitized equipment between site visits, increasing the likelihood that this research did not spread chytrid in Nebraska and decreasing the likelihood of “detecting” chytrid at a site due to cross contamination. Because chytrid cannot survive desiccation and bare skin displays a fungicidal effect, hands and skin were not sanitized between sites in order to kill the fungus (Mendez et al. 2008).

Chytrid swabs

Previously, histological slides prepared from skin scrapings or toe clips were used to detect the presence of chytrid (Kriger et al. 2006). More recently, advances in genetic technology, in particular the use of real-time Taqman PCR, have made it possible to detect chytrid from a single zoospore (Kerby et al. 2013, Boyle et al. 2004). These advances have allowed for the development of less invasive sampling methods, including the use of sterile swabs to collect disease samples on post-metamorphic individuals and tadpoles (Retallick et al. 2006).

For this study, each tadpole was taken from the 5-gallon bucket using an aquarium net or bare hand and gently held on its back. Because the chytrid fungus only infects keratinized cells and the only keratin in tadpoles is located in their oral discs (Daszak et al. 1999), I firmly swabbed the mouth of tadpoles 30 times (Adams et al. 2010, Retallick et al. 2006) using a dry, polyester tipped Fisherfinest™ transport swab (Thermo Fisher Scientific, Waltham, MA). I swabbed a total of 64 individuals at each site, which provides an estimated 95% probability of detection given that chytrid is present at a site given an estimated low prevalence (Skerratt et al. 2008). However, because I was attempting to determine presence and not prevalence of chytrid, I batch swabbed eight individuals of the same species with each swab. This provides more potential genetic material on each swab and allows for the specification of not only populations, but species that are infected with chytrid in Nebraska. All swabs were immediately placed on ice and placed in a freezer for longer-term storage (Kriger et al. 2006).

DNA extraction and qPCR testing

In all instances, I used real-time Taqman PCR, which can accurately detect a single chytrid zoospore in a sample, to test for the presence of *Bd* in swab (Kerby et al. 2013, Kriger et al. 2006, Boyle et al. 2004). DNA was extracted from swabs using the DNeasy® spin column kits (Qiagen, Inc., Germantown, Maryland). Each sample was run in triplicate using an Applied Biosystems StepOne Plus quantitative PCR machine (Applied Biosystems, Inc., California) using the protocols described by Kerby et al. (2013). A sample was considered positive if at least two of the three replicates were positive. A subset of samples where a single replicate tested positive were re-run to test for errors in quantitative PCR analysis. In addition, a negative control was placed on each plate. *Bd* standards utilized were from CSIRO laboratories in Australia.

Statistical Analyses

Site and Species Comparisons

Results of qPCR testing allow for the calculation of multiple parameters for measuring infection rates at both sites and species levels. I calculated the detection rate for both sites and species based upon the proportion of positive swabs. Since I collected eight swab samples at each site, I calculated the site-specific detection rate as the number of positive swabs divided by eight. For example, the detection rate at a site with a single positive swab is equal to 1/8 or 0.125. I also calculate species-specific detection rates based upon swabs collected at each site. If all samples at a single site were collected from a single species, then the species detection rate is equal to the site detection rate. Otherwise, I calculated the species detection rate as the number of positive swabs from species *a* at site *b* divided by the total number of sample swabs collected from species *a* at site *b*. For example, if I collected four swabs from chorus frogs at a site and two of those swabs tested positive for *Bd*, the species detection rate is 0.5. Since I swabbed eight individuals with each swab, the minimum prevalence rate can then be calculated as the species detection rate divided by eight.

Due to wide variation in sample size and the non-normality of the data, I used non-parametric tests to compare groups. When comparing fewer than three groups, I analyzed similarities using the Wilcoxon Rank Sum test (Sokal and Rolf 1995), which is similar to a Student's *t*-test. When three or more groups were compared, I used a Kruskal-Wallis test (Sokal and Rolf 1995). I made *post-hoc* pairwise comparisons using Dunn's tests with a Bonferroni correction (Dunn 1964). I compared species specific detection rates among species sampled during this study. In cases where I was unable to capture species at a sufficient number of sites, ecologically and taxonomically similar species were combined for analysis. Additionally, species specific detection rates were used when comparing taxonomic family, reproductive phenology, and species with or without overwintering larvae. I used site-specific detection when comparing rates among the three months when samples were collected as well as the hydrology of wetland sample sites.

Bd Species Distribution Model

Several methods exist for modeling presence-only species data for predicting historic, current, and future geographic distributions in relation to climate and other landscape level factors (Elith et al. 2006). Of these methods, MaxEnt has generally been shown to be a more robust and effective method for presence-only species distribution models (Elith et al. 2006, Phillips et al. 2006). It should be noted, however, that there is no true “best” algorithm for presence-only species distribution modeling (Qiao et al.2015). Although most often applied to wildlife, many researchers have applied climate envelope and ecological distribution models to assess the predicted current and future distributions of diseases (Ron 2005, Puschendorf et al. 2009, Rödder et al. 2010). When applied to wildlife diseases, the development of such models provides a predicted distribution of a disease, which supports informed management and conservation decisions as they relate to inhibiting or mitigating the spread of diseases to new populations and species. Given its relative robustivity for presence-only species distribution models and efficacy relative to alternive methods, I used a maximum entropy modeling method described by Phillips et al. (2006) using the software MaxEnt 3.4.1 (Phillips et al. 2018). MaxEnt is a maximum entropy machine learning program that estimates the probability distribution of a species using presence-only locality data and landscape level environmental constraints (Phillips et al. 2006, 2008). I used MaxEnt to develop a predictive ecological model for the distribution of the amphibian chytrid fungus in Nebraska. MaxEnt requires three types of data: presence-only locations for the species in question, random background points (“pseudo-absences”), and environmental data.

Presence-only Location Data

Ideally, both presence and absence data would be incorporated into models for predicting spatial distributions; however, many times this type of data is not available. For sites sampled during this study, I collected samples from 64 individuals, which allows for the assumption that sites where chytrid is not detected are true absences (Skerratt et al. 2008). Samples collected by citizen science groups are often opportunistic with few samples collected at individual sites, meaning that the non-detection of chytrid cannot be assumed to imply true absence. Therefore, I relied on presence-only samples of positive chytrid results that were obtained from three sources. All positive sites from this study were include resulting in 42 locations from eastern and central Nebraska. An additional 140 positive sample sites were obtained from samples collected as a part of a citizen science program implemented through Omaha's Henry Doorly Zoo. Through this program, classrooms in the Omaha area are provided sampling kits and instructions for proper animal handling and sample collection techniques. Two more positive locations were obtained from BD-maps.net (www.bd-maps.net; accessed 28 October 2018). In all instances, samples were tested for the presence of chytrid at the University of South Dakota. I then randomly selected a subset of the 184 potential observations restricting the distance between points to > 30 m to avoid more than a single point falling within a raster cell, as the resolution of environmental data is 30 x 30 m pixels. Although MaxEnt has the ability to remove spatially duplicated records, doing so manually allows for greater control of the selection process and repeatability of selection procedures.

Background Sample Point Selection

Sampling bias is a recognized issue in the development of species distribution models due to the tendency of records to be spatially biased for many potential reasons (Phillips et al. 2009, Kramer-Schadt et al. 2013). When datasets are large enough to allow for spatial filtering, it is recommended to undertake such an effort; however, with smaller datasets where spatial filtering may result in a dataset with < 100 observations, spatial masking of background points represents a better option (Kramer-Schadt et al. 2013). Spatial masking of background points is accomplished by restricting the area where backgrounds points are randomly selected to the spatial extent of the observation points. Additional masking beyond this may be necessary for habitat specialists or aquatic species to account for known unsuitable habitats. I spatially masked the selection of background points at two extents, the geographic area of observations and potentially occupied habitat. First, I limited the geographic area to the minimum convex polygon surrounding all positive chytrid locations. Since chytrid is a disease of aquatic amphibians, I created a raster layer of all potential aquatic habitats by rasterizing and overlaying wetlands, major stream, lake, and pond maps. The resulting map was clipped using the minimum convex polygon and each raster cell was assigned a point. I then randomly selected 10,000 points while setting the minimum distance at 1 km.

Environmental Data

I used an *a priori* set of nine climate and environmental variables to develop a species distribution model for the amphibian chytrid fungus in Nebraska (Table 7.1). Climate constraints of the chytrid fungus are relatively well understood. The chytrid fungus thrives in moist and moderately warm environments. Complete desiccation, as chytrid can survive for up to fours in minute amounts of water, and temperatures in excess of 32° C for more than 96 hours will kill the chytrid fungus (Johnson et al. 2003). In field and lab settings, both ambient and water temperatures as well as body temperature have strong influences on the presence and pathogenicity of the chytrid fungus (Woodhams et al. 2003, Kriger and Hero 2007, Bustamante et al. 2010, Forrest and Schlaepfer 2011). All climate variables used in the distribution model represent precipitation or ambient temperature and were obtained from WorldClim BioClim v.1.4 dataset (Hijmans et al. 2005; www.worldclim.org). Although 19 potential climate variables are available through the BioClim dataset, I only incorporated five variables representing precipitation and temperature variables assumed to impact the presence of chytrid in amphibian communities.

Table 7.1. Descriptions and codes for environmental and landscape variables used to develop a MaxEnt species distribution model of the distribution of the amphibian fungus chytrid in Nebraska.

Variable	**Code**	**Description**
Annual mean temperature	Bio1	Mean temperature from 1960 – 1990 in °C
Max temperature of warmest month	Bio5	Max temperature of the annual warmest month from 1960 – 1990 in °C
Mean temperature of warmest quarter	Bio10	Mean temperature of the annual warmest quarter from 1960 – 1990 in °C
Annual precipitation	Bio12	Mean annual precipitation from 1960 – 1990 in mm
Precipitation of warmest quarter	Bio18	Mean annual precipitation of the annual warmest quarter from 1960 – 1990 in mm
Human population density	Dasymetric	Mean estimated human population density for a 300 m circular neighborhood
Aquatic habitat type	Habitat	Categorical aquatic habitat type representing wetlands, rivers, ponds, lakes, and agricultural/cattle ponds
Landscape resistance	Resistance	Mean landscape resistance to amphibian movement for a 1000 m circular neighborhood
Anthropogenic stress	Stress	Mean anthropogenic landscape stress for a 300 m circular neighborhood

Landscape surrounding wetland sites is also known to influence the health of aquatic ecosystems and associated amphibian communities. While most SDM research has focused on climatic factors associated with the distribution of chytrid, few have explored additional landscape factors related to population or land use. Interactions between chytrid and run-off including pesticides and fertilizers appear to be complex (Johnson et al. 2007, Gaietto et al. 2014, Hanlon and Parris 2014, Rumschlag et al. 2014, Wise et al. 2014). Additionally, the impacts of urbanization and human populations are confounding with observed effects occurring in both directions (St. Amour et al. 2008, Saenz et al. 2014). I incorporated additional landscape variables representative different aspects of the landscape and habitat surrounding aquatic resources known to influence amphibian communities and chytrid presence and prevalence including human population density, landscape resistance to amphibian movement, and a measure of landscape anthropogenic stress. Both the dasymetric population map and anthropogenic stress measure the impact of surrounding landscape. Anthropogenic stress is a surrogate for effects of agricultural and urban pesticides and fertilizers as increases in both on the landscape surrounding aquatic habitats are strongly correlated with higher levels of both pesticides and eutrophication (Johnson et al. 2007, Heard et al. 2014).

Raster Processing

In order to run properly in MaxEnt, all raster grids must have the same extent and resolution. All environmental raster grid files were processed using the steps outlined by Phillips (2017). I clipped all raster grids to Nebraska state boundaries and masked all output using the dasymetric map raster grid with a cell size of 30 x 30 m. In order to be better representative of true measures of stress at sample points I resampled the landscape raster grids using the ‘focal statistics’ tool. I recalculated both the dasymetric and anthropogenic stress as means for 300 m circular neighborhoods, the approximate home range size for all North American amphibian species (Sermlitsch 2000, Rittenhouse and Semlitsch 2007). Additionally, I recalculated the landscape resistance raster grid as the mean for a 1000 m circular neighborhood to better represent the ability of large-bodied species acting as vectors to move across the landscape (Currie and Bellis 1969, Woodhams et al. 2008, Schloegel et al. 2010).

Assessing Variable Importance and Model Performance

Pillips and Dudik (2008) used a 226 species data set distributed across six broad regions to refine default model parameters. In most instances this resulted in reliable model results. Therefore, I used the default parameters with the exception of setting the number of iterations to 5000 in order to insure convergence during model runs (Phillips 2017). I used 100 bootstrapped replicates using 75% of the data for training and the remaining 25% for testing. Variable importance was calculated using a jackknife approach in which importance is assessed using regularized training gain, test gain, and area under the curve (AUC) for testing data (Tarrant et al. 2013, Phillips 2017). I assessed overall model performance using the AUC statistic and receiver operator characteristic (ROC) plots (Fielding and Bell 1997, Phillips et al. 2006).

RESULTS

Historic Bd Samples

I swabbed 191 preserved bullfrog specimens from the Nebraska Museum of Natural History’s vertebrate collections. Specimens were collected between 1898 and 2011 from 53 of Nebraska’s 93 counties. I was unable to detect chytrid in any of these samples, but this may be related inhibition of pure DNA extraction due to the presence of chemicals such as formalin in the samples. A subset of the samples may be tested again in the future with refined extraction techniques to try and eliminate any potential inhibition issues.

Contemporary Bd Samples

I collected a total of 424 swabs from seven different species at 53 sites located across the eastern half of Nebraska (Figure 7.1). *Bd* was detected at 70% of the sites sampled and detected in at least one site in every general region where samples were collected. The overall detection rate across all sites was 0.226 with a range of 0 – 1. Additionally, *Bd* was detected at least once in each of the seven species tested with detection rates ranging from 0.048 to 1 (Table **7.**2).

Taxonomy

Amphibian species show differing susceptibility to *Bd* infections; therefore, it is reasonable to assume that species specific detection rates may be different when compared among different species or families. I compared species specific detection rates among both species and their associated families. Due to few samples from several species and similarities in species ecology, ACCR and HYCH were combined and LIBL and LIPI were combined for analysis. Species-specific detection rates were significantly different among species ($X^2 = 11.00$, df = 4, p-value < 0.001) with post-hoc tests indicating two groups. Detection rates in bullfrogs were significantly greater than those in all other species, which did not differ (Figure 7.2).

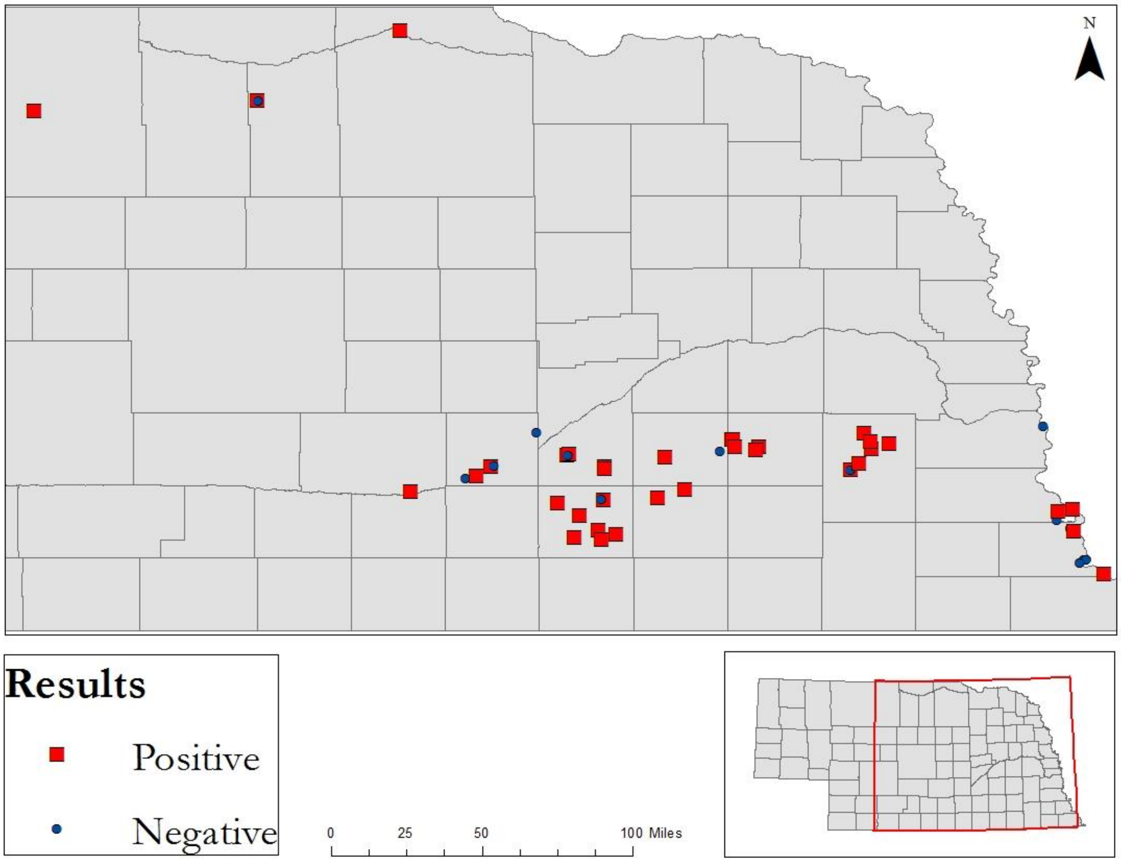

Figure 7.3. Results of Bd sampling at 53 sites in eastern Nebraska. Bd was detected at 70% of sites where sampling occurred. Red squares indicate positive results, while blue circles indicate negative results.

Table 7.2. Species-specific detection rates, standard errors, and estimated minimum prevalence for Bd samples collected from seven species in eastern Nebraska.

Common Name	Scientific Name	Code	Sites	Swabs	Individuals	Mean Detection Rate	SE	Minimum Prevalence
Cricket Frog	*Acris crepitans*	ACCR	2	9	72	0.072	0.072	0.009
Grey Treefrog	*Hyla chrysoscelis*	HYCH	6	20	160	0.048	0.030	0.006
Plains Leopard Frog	*Lithobates blairi*	LIBL	33	178	1424	0.231	0.061	0.029
Bullfrog	*Lithobates catesbeianus*	LICA	3	10	80	1.000	0.000	0.125
Northern Leopard Frog	*Lithobates pipiens*	LIPI	2	8	64	0.333	0.167	0.042
Western Chorus Frog	*Pseudacris maculata*	PSMA	30	171	1368	0.265	0.057	0.033
Plains Spadefoot Toad	*Spea bombifrons*	SPBO	4	27	216	0.156	0.094	0.020

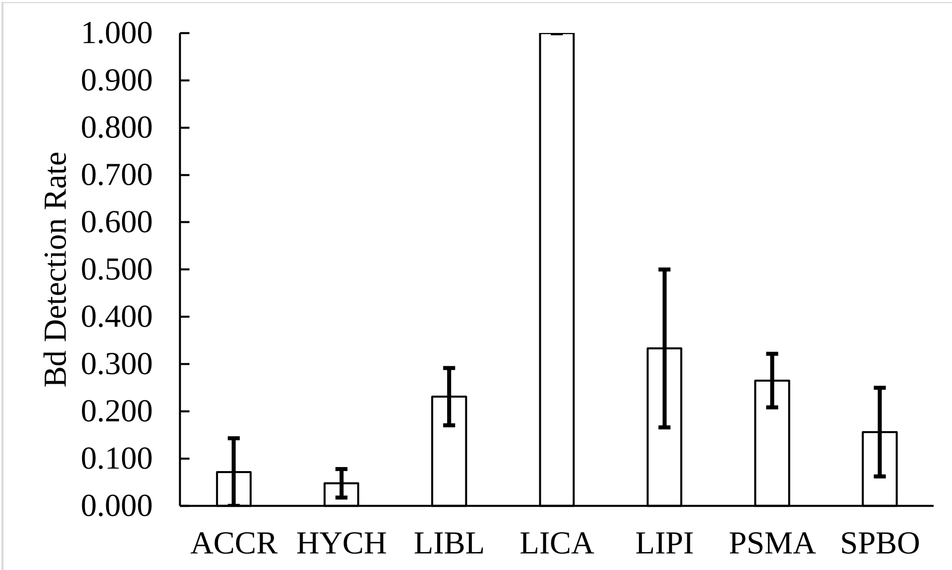

Figure 7.4. Mean species-specific detection rates of Bd for seven amphibian species sampled in eastern Nebraska. The detection rate of bullfrogs was significantly higher than that of all other species, which did not vary among one another. Error bars indicate SE around the mean.

Reproductive Phenology

The timing of when amphibian species are present in wetlands for reproduction may influence the probability that individuals of that species are exposed to *Bd* due to variations in air and water temperatures at a given wetland site. Additionally, species that overwinter, such as bullfrogs and leopard frogs, may have higher detection rates than other species due to susceptibility to infections but immunity to pathogenicity. Because ambient and water temperatures increase throughout the amphibian breeding season, I hypothesized that earlier breeding species would have higher species-specific detection rates than later breeding and sporadically breeding species. I compared spring (PSMA, LIBL, and LIPI), early summer (ACCR and HYCH), late summer (LICA), and sporadic (SPBO) breeding species. Species specific detection rates were significantly different among groups ($X^2 = 10.11$, df = 3, *p*-value < 0.001; Figure 7.3). Late summer breeders had significantly higher detection rates (1 ± 0) than all other reproductive phenologies, followed by spring (0.25 ± 0.041), sporadic (0.125 ± 0.094), and early summer breeders (0.054 ± 0.026), although the latter three were not significantly different.

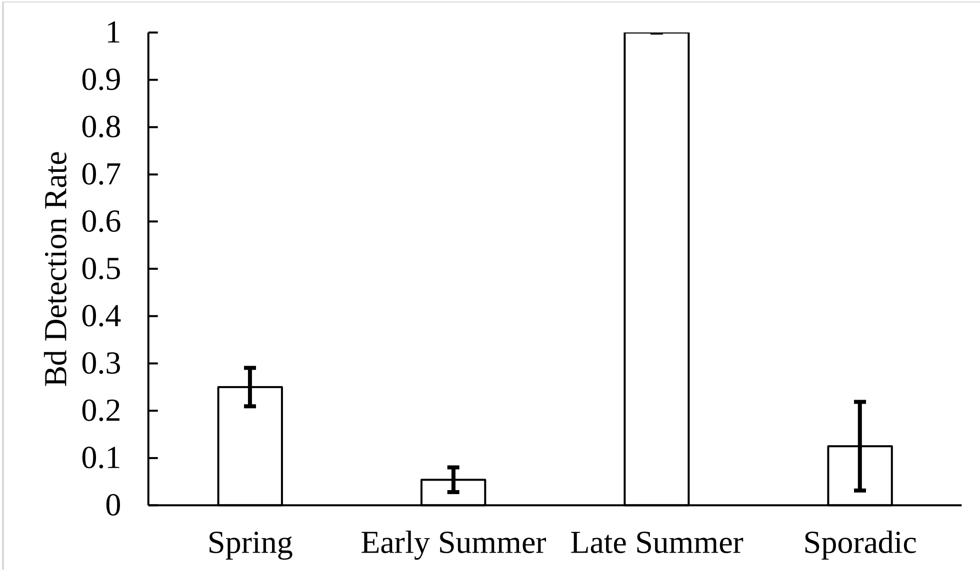

Figure 7.3. Mean species-specific detection rates of Bd for four different reproductive phenologies of amphibian species in eastern Nebraska. Late summer breeding species had significantly higher detection rates than all other reproductive phenologies. Error bars indicate SE around the mean.

Timing of Sampling and Climate

Bd detection rates are known to decrease as environmental temperatures increase due to a phenomenon called the chytrid-temperature paradox. Because both ambient and water temperatures increase throughout the amphibian active season, I hypothesized that detection rates will decrease during the sampling period of May through July. I compared site-specific detection rates among the three months when samples were collected. July had a significantly lower site-specific detection rate that May and June, but there was no significant difference among May and June detection rates ($X^2 = 5.73$, df = 2, p-value < 0.001; Figure 7.4). I then ran logistic regression to test for an effect of Julian day, air temperature, and precipitation on the probability of detecting *Bd* at a site. I found a significant response of detection probability to the day when samples were collected, with the probability of detecting *Bd* decreasing as a function of Julian day (Table 7.3, Table 7.4, and Figure 7.6). Neither temperature nor precipitation were good predictors for the probability of detecting chytrid at a site. However, I did find a significant response of detection rate, measured by the number of positive swabs as a site, and the water temperature at site (Table 7.5, Figure 7.6).

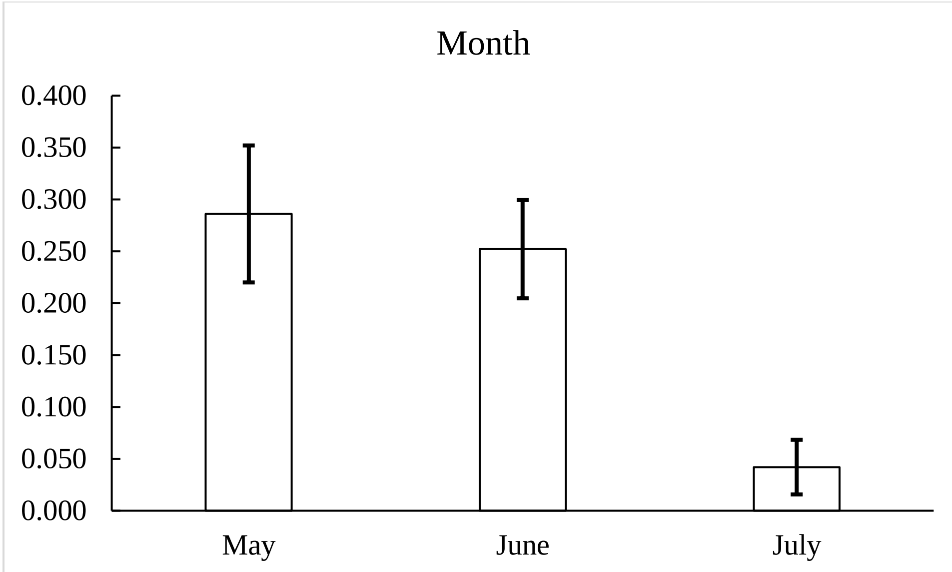

Figure 7.4. Mean site-specific detection rates of Bd for three months when samples were collected. Detection rates in May and June were not different were significantly higher than detection rates than July. Error bars indicate SE around the mean.

Table 7.3. Summary of multi-model inference results from logistic regression analysis of a model set for the probability of detecting chytrid, where AICc = Akaike's Information Criterion, k = the number of parameters, Δ = change in AIC score relative to the top model, and w = model weight. The model including just Julian day had the highest model weight.

Model	**AICc**	***k***	**Δ**	***w***
~ julian day	61.68	3	0.00	0.76
~ julian day + temp + precip	65.25	5	3.57	0.13
~ temp	66.56	3	4.89	0.07
~ temp + precip	68.54	4	6.86	0.02
~ precip	68.91	3	7.23	0.02

Table 7.4. Summary of simple logistic regression analysis with a binomial error distribution for overall effects of Julian Day on the probability of Bd detection at sites sampled in eastern Nebraska.

Coefficients	**Estimate**	**SE**	**z-value**	***p*-value**
Intercept	0.9682	0.3345	2.895	0.004
Julian Day	-0.8922	0.3656	-2.441	0.015

Equation:

Probability of *Bd* Detection = 0.9682 – 0.8622(Julian Day)

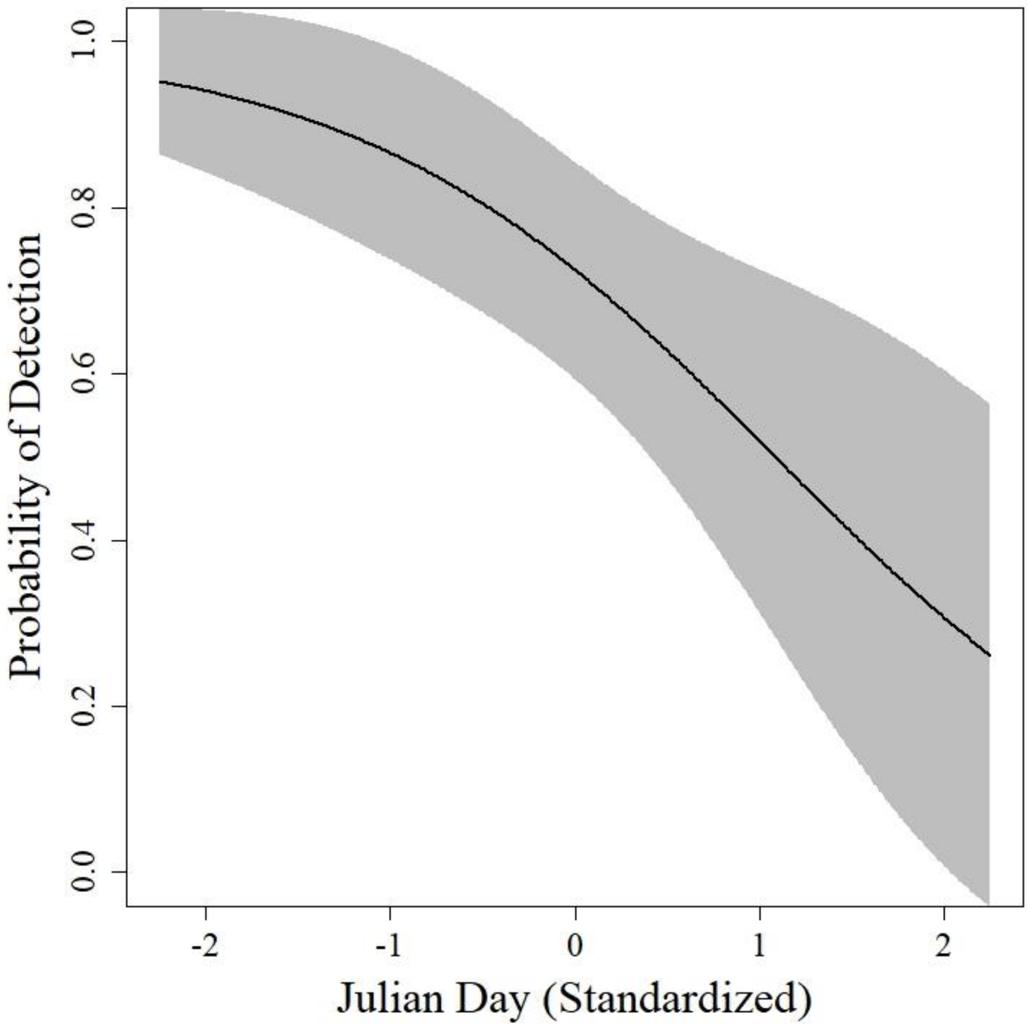

Figure 7.5. Relationship between the Julian Day when a sample was collected at 53 sites in eastern Nebraska and the probability of detecting Bd. The solid black line is the estimated probability of detection, while the light gray band indicates the 95% confidence interval.

Table 7.5. Summary of logistic regression analysis with a poisson error distribution for overall effects of water temperature on the Bd detection rate at sites sampled in eastern Nebraska.

Coefficients	Estimate	SE	z-value	*p*-value
Intercept	0.4902	0.1432	3.422	< 0.001
Water Temperature	-0.2993	0.1280	-2.338	0.019

Equation:

Bd Detection Rate = 0.4902 – 0.2993(Water Temperature)

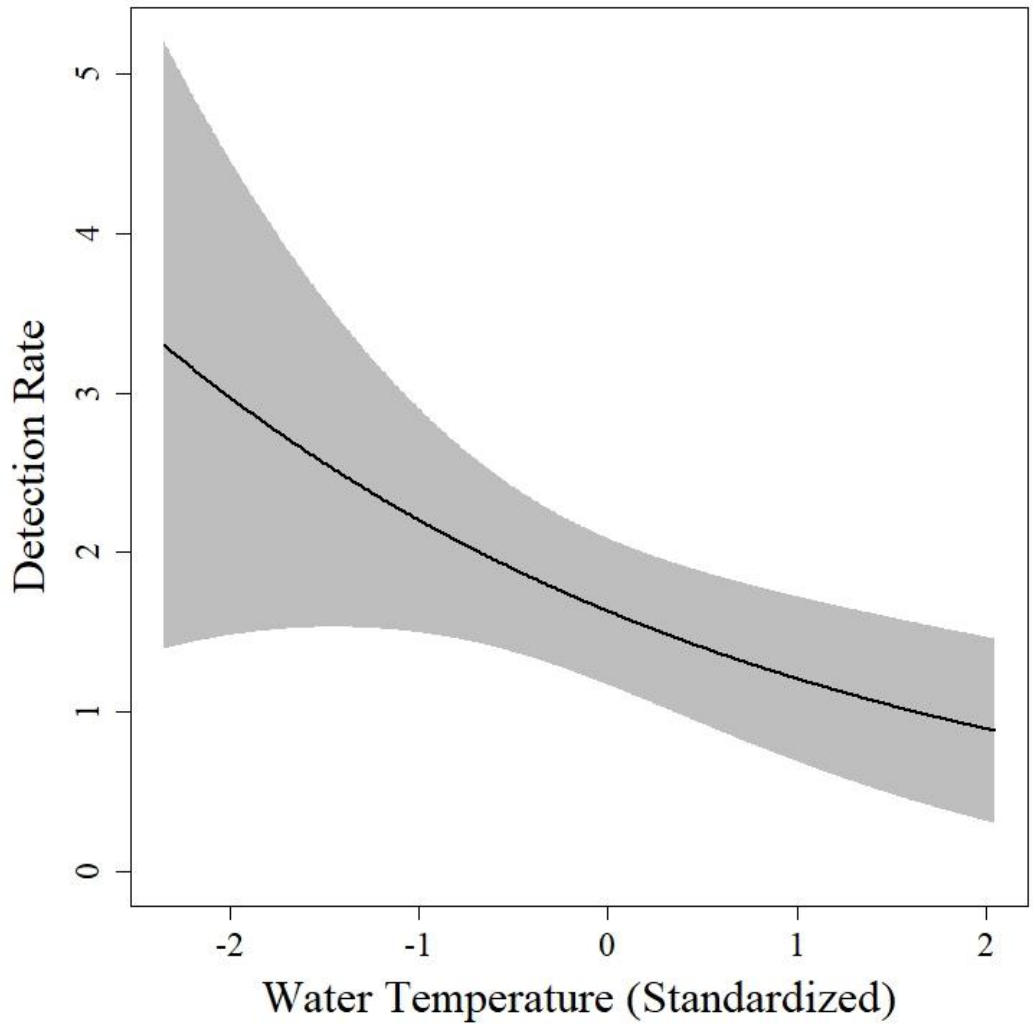

Figure 7.6. The relationship between the water temperature at site and Bd detection rate. Gray points are the number of positive swabs at a site. The solid black line indicates the estimated detection rate as number of swabs, while the light gray band indicates the 95% confidence interval.

Bd Species Distribution Model

A total of 79 *Bd* records were used to model the predicted distribution of the disease in Nebraska. Annual mean temperature, aquatic habitat type, and the human population density contributed the most in defining suitable areas for *Bd* occurrence in Nebraska (Table 7.6). The remaining variables had somewhat limited effect in determining habitat and climate suitability. *Bd* and environmental variable response curves were variable, but the shape and directionality were generally as expected (Figure 7.7). Highest probability of *Bd* presence generally occurs at moderately high annual mean temperature and with higher mean human population density. Additionally, higher probability of presence is predicted in lakes or agricultural ponds (i.e. cattle ponds, reuse pits, etc.) followed by wetlands. Statewide, the highest predicted probabilities of presence of *Bd* were located in the southeast, south central, and panhandle regions of Nebraska (Figure 7.8). In general, this includes counties with large reservoirs and a high density of farm ponds and permanent wetlands (Figure 7.9).

Table 7.6. Analysis of variable contributions reported as the percent contribution and permutation importance. Percent contribution is measured as the mean normalized percent of increase in regularized gain. Permutation importance is measured as the normalized percentage change in AUC resulting from the random permutation of variable values on training and background data points. Both measurements represent averages of 100 bootstrapped replicate runs.

Variable	**% Contribution**	**Permutation Importance**
Bio1	36.2	63.7
Habitat	21.0	5.7
Dasymetric	16.1	3.6
Stress	8.5	2.8
Bio18	6.7	3.1
Bio12	4.3	7.8
Bio10	3.4	6.2
Resistance	2.1	2.5
Bio5	1.7	4.6

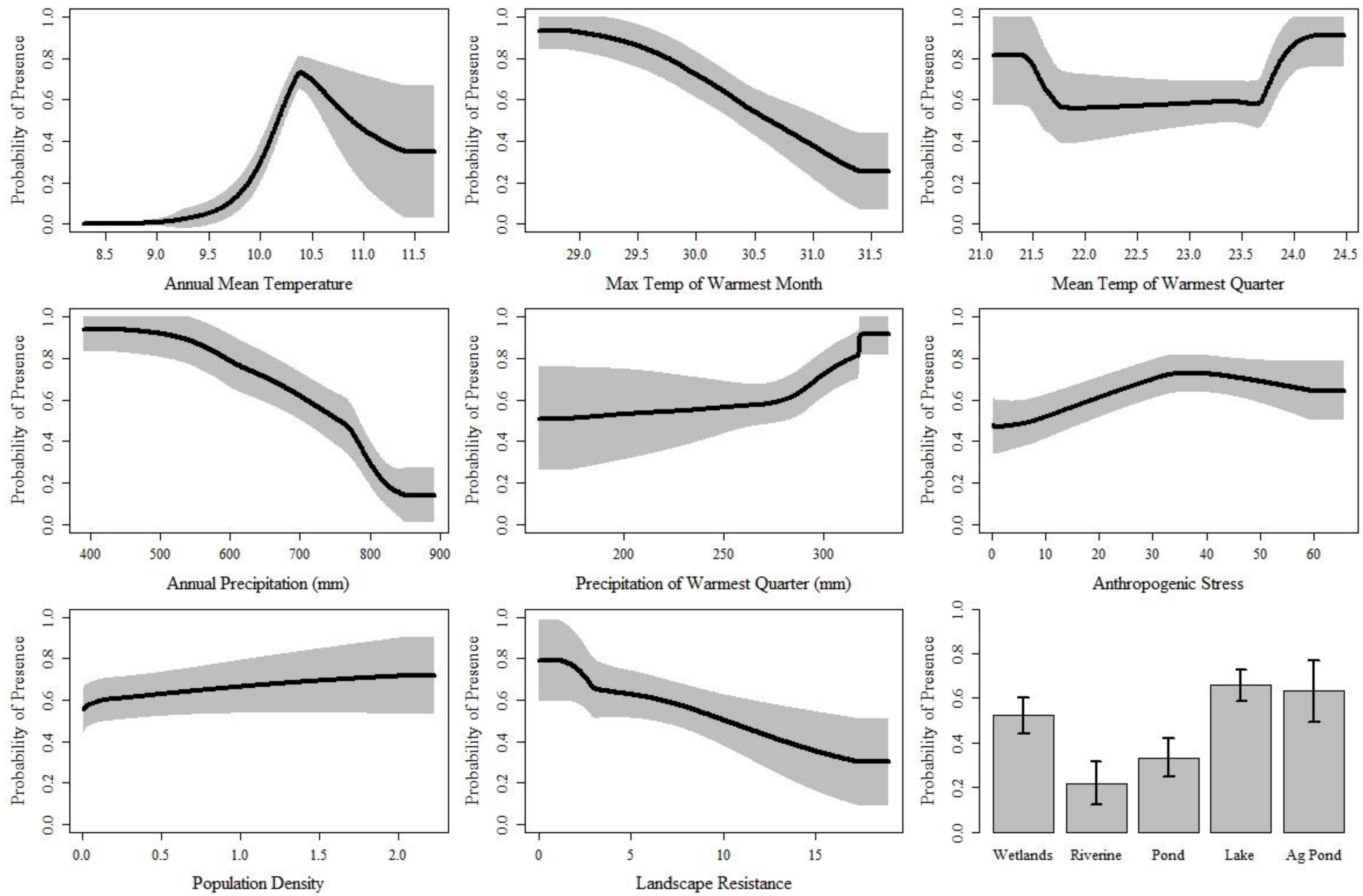

Figure 7.7. Mean variable response curves for 100 bootstrapped replicate runs of the MaxEnt model. Black lines represent the mean response. Gray surrounding curves are ± 1 sd. For the habitat variable (bottom right) grey bars are the mean response, while the black bars are ± 1 sd.

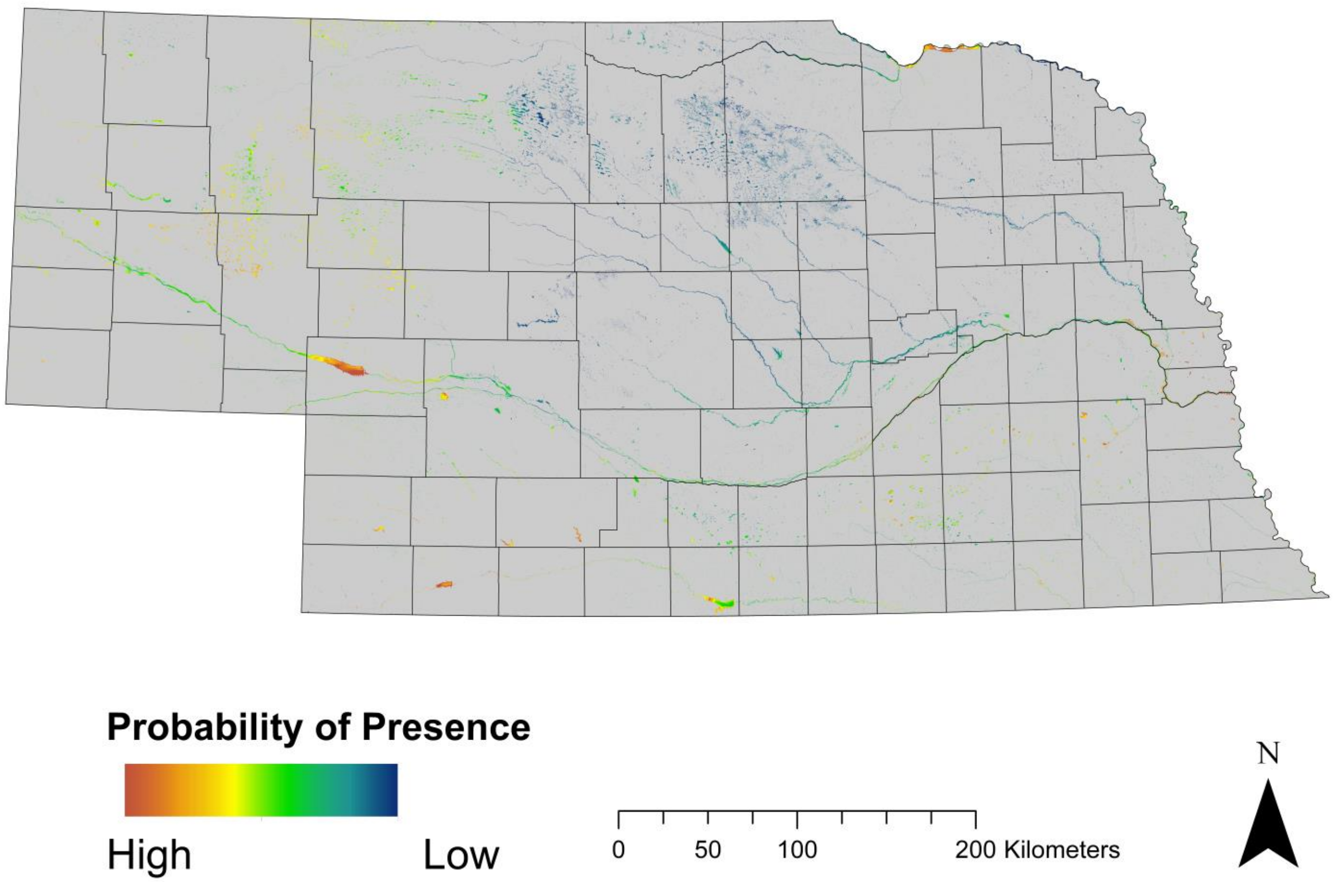

Figure 7.8. Results of the MaxEnt model representing mean variable response. Regions of highest probability of presence include the panhandle, southeast playas, rainwaters basins, and southwest Nebraska.

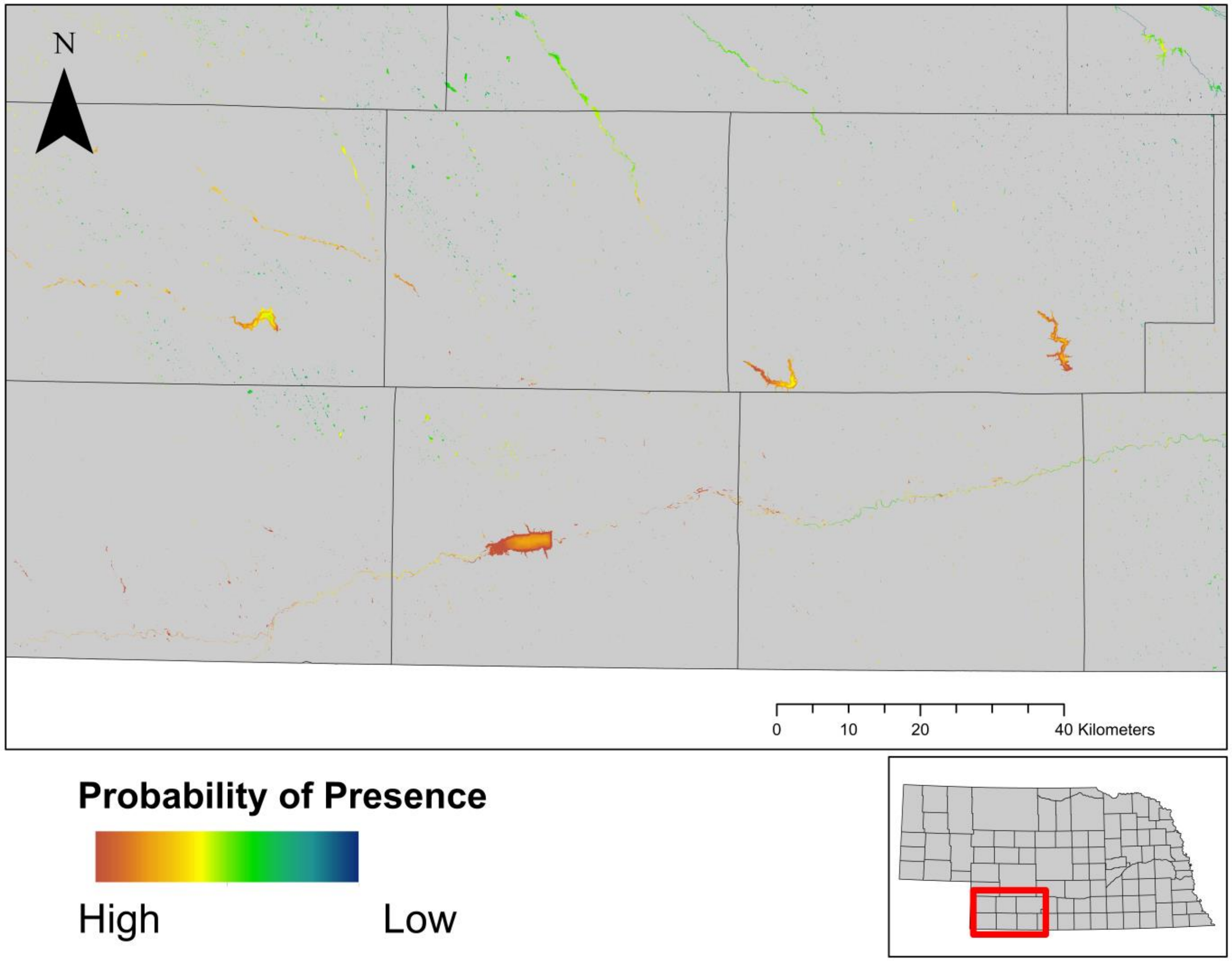

Figure 7.9. Southeastern counties have the highest mean probability of presence largely due to the density of large reservoirs in the region including Enders, Swanson, Red Willow, and Medicine Creek Reservoirs.

DISCUSSION

Historic Distribution of Bd in Nebraska

I did not detect *Bd* in any of the samples collected from 191 preserved bullfrog specimens from the Nebraska State Museum vertebrate collections. The lack of detection is surprising given the sensitivity of qPCR analysis and results from similar studies, although historical sampling of preserved specimens in Thailand (McLeod et al. 2008), the Appalachian region (Muletz et al. 2014), and Central America (Richards-Hrdlicka 2013) also resulted in non-detection so is not without precedent. *Bd* has previously been detected in preserved specimens of 12 species from North America, including the American bullfrog, although histological and ultrastructural rather than qPCR were used for diagnostics (Oulett et al. 2005). More recently, however, qPCR was successfully used to detect *Bd* from 120 archived American bullfrog specimens from California, with detections occurring in specimens collected as early as 1926 (Huss et al. 2013). A similar study from Illinois was also able to detect *Bd* from archived specimens collected between 1900 and 1910, although similar to these results, no American bullfrog specimens tested positive (Talley et al. 2015). There are three potential reasons for the non-detection of *Bd* in Nebraska bullfrog specimens. Similar to the study from Talley et al. (2015), *Bd* may not have been present in the state or *Bd* positive individuals were never collected and preserved. Alternatively, the qPCR process may have been inhibited due to the presence of preservation chemicals, such as formalin and alcohol, resulting in negative detection results (J. Kerby, pers. comm., Richards-Hrdlicka 2012). Based upon the number of specimens sampled, the estimated prevalence of *Bd* from contemporary bullfrog populations in Nebraska, and results from similar studies of bullfrogs elsewhere, it seems likely that qPCR was inhibited by the presence of contaminants, leading to inconclusive results.

Current Distribution of Bd in Nebraska

The chytrid fungus was widespread and prevalent in Nebraska's amphibian communities. I detected *Bd* at 70% of the 53 sites where samples were collected; however, *Bd* was not always detected at all wetlands on a single property. I collected samples from multiple wetlands located on the same property on five occasions, and in all instances *Bd* was not detected at all wetland sites. In fact, on a single occasion samples were collected from the same two species at two wetlands divided only by a man-made dike, yet one tested positive and the other negative. On one occasion, a single site tested positive for *Bd* in multiple years. The distribution of *Bd* is variable and relates to multiple biotic and abiotic factors. I compared detection rates using taxonomic, reproductive phenology, and climatic variables. Other landscape factors including population density (Adams et al. 2010, Murray et al. 2011, Rohr et al. 2011) and surrounding land use (Johnson et al. 2007) have also been found to be important predictors of *Bd* detection and merit further investigation in the future.

I found that American bullfrogs displayed higher infection rates than all other species, yet did not find a significant differences among the six other species sampled. Despite no statistical differences, these results indicate higher detection rates in leopard frogs and chorus frogs compared to other species and are consistent with other studies. Additionally, I report the first detection of *Bd* from plains spadefoot toads. Historic sampling shows varying infection rates among species in North American amphibian communities, with leopard frogs, American bullfrogs, and chorus frogs having high detection rates relative to other conspecifics (Oulett et al. 2005). Amphibian species show varying degrees of susceptibility to *Bd* infections due to many factors including microbial skin communities (Conlon 2011), behavioral adaptations (Collins and Crump 2009, Richards-Zawacki 2009), and natural or acquired immunity (Briggs et al. 2010, Rosenblum et al. 2012). For example, American bullfrogs are typically found with extremely high fungal loads, yet do not display symptoms or effects of *Bd* infection (Garner et al. 2006, Schloegel et al. 2009). Due to their ability to migrate great distances and overwintering tadpoles, American bullfrogs may be both a vector and reservoir for *Bd* (Schloegel et al. 2009). As such, bullfrogs are suspected of spreading *Bd* into new areas, although no clear link has been found between the spread or introduction of bullfrogs and emergence of *Bd* (Garner et al. 2006).

Seasonality has been noted as a primary factor in the detection rate and prevalence of chytrid in amphibian communities. I tested for effects of seasonality through multiple means using breeding phenology, month, Julian day, and climate factors as variables. Although there appears to be a trend in detection rate due to breeding phenology, with spring and late summer breeders having higher detection rates than early summer and sporadic breeders, I only found a significant difference in late summer breeders (American bullfrogs) relative to other breeding phenologies. Similarly, months coinciding with early and late spring had higher detection rates than summer months, with detection rates decreasing from May to June to July. Lingenfelter et al. (2014) found similar trends in adult American bullfrogs in north central Nebraska where prevalence decreased from 73% in early June to 6% in late June and early July. Detection and prevalence rates showed a similar trend from multiple studies along the

Central Platte River (Harner et al. 2011, Harner et al. 2013). Taken together, these results support the climate-chytrid paradox hypothesis, wherein prevalence rates of *Bd* decrease due to increase of environmental temperatures outside of the thermal optimum (Pounds et al. 2006).

Previously, significant trends observed in detection rates relative seasonality were found to coincide with both an increase in temperature and decrease in precipitation (Woodhams et al. 2003, Muths et al. 2008, Bustamante et al. 2010). The similar trends in detection rates among both larval (this study) and adult amphibians in Nebraska (Harner et al. 2011, Harner et al. 2013, Lingenfelter et al. 2014) suggest that similar mechanisms mitigate prevalence and detection regardless of life-stage. Therefore, it is likely that environmental variables, such as temperature and rainfall may also be important in predicting detection rates. I failed to find a relationship among either ambient air temperature or precipitation and the detection rate of *Bd* in larval amphibian communities. However, I did find higher detection rates at sites with lower water temperatures than those with higher water temperatures. Previous studies have focused on adult amphibians. Unlike adults, larval amphibians cannot mediate body temperature relative to ambient air temperature but depend upon water temperature for this function. Similar to air temperature, however, high water temperatures decrease *Bd* infection rates in larval amphibians (Forrest and Schlaepfer 2011, Geiger et al. 2011). Because water has a high specific heat resulting in slower temperature changes than air, larval amphibians may show a slower response in regard to decreased infection rates as air temperature rises relative to their adult conspecifics.

***Bd* Species Distribution Model**

I used MaxEnt to model climate and landscape variable impacts on the probability of *Bd* presence in aquatic habitats. The climate variables incorporated into the model represented both mean ambient air temperature and mean precipitation from 1960 – 1990 during all or portions of the year. The most climate variable from this study was annual mean temperature, with the highest probability of *Bd* peaking at moderate temperatures and nearly no probability of presence at mean annual temperatures below 9.0 °C. Probability of presence then tapers as mean annual temperatures increase beyond about 10.5 °C. A similar decrease in probability of presence was observed in relation to the mean maximum temperature of the warmest month. These results were not surprising and are consistent with the chytrid-temperature paradox hypothesis (Pound et al. 2006). These results are also consistent with similar analyses from Costa Rica (Puschendorf et al. 2009) and a worldwide assessment (Rödder et al. 2010) in which annual mean temperature were good predictors of current and future *Bd* distributions. Surprisingly, precipitation was a relatively insignificant predictor of *Bd* distribution in Nebraska with all precipitation variables having mean contributions <10%. This is in contrast to studies from other regions in which precipitation was a very important predictor (Puschendorf et al. 2009, Tarrant et al. 2013).

Many modeling efforts for *Bd* focus solely on climate as a predictor, while ignoring other potentially important landscape factors. As such, most studies ignore habitat when modeling at least at a landscape scale. Habitat was an important variable in this study with predictive *Bd* presence highest in lentic systems with permanent water. Incorporating only aquatic habitats in the model provides more precise predicted distribution as demonstrated by the high variable contribution and overall high AUC for the model relative to other studies. Also incorporated in the model assessed in this study were various measures of landscape stress including human population density and estimated anthropogenic stress, both assumed to be surrogates for factors related to habitat quality such as water quality and the presence of high levels of pesticides or nutrients. Both were seemingly more important predictors than nearly all climate variables. These results are consistent with studies that have linked increased *Bd* infection rates and pathogenicity to local anthropogenic stress (St-Amour et al. 2008), aquatic eutrophication (Johnson et al. 2007), and pesticides (Gaietto et al. 2014, Hanlon and Parris 2014, Wise et al. 2014, Smalling et al. 2015). The exact mechanisms resulting in increased infection are complicated and likely linked. Recently, however, local microfauna abundance and diversity have been linked to the prevalence of *Bd* spores in this system (Strauss and Smith 2013, Schmeller et al. 2014) suggesting that both stress to the system and organism work synergistically to ameliorate or increase *Bd* infection and pathogenicity in aquatic systems, both of which are strongly linked to the surrounding landscape.

CONCLUSIONS

The chytrid fungus is prevalent and predicted to be widespread in Nebraska. In addition, all of the species I sampled tested positive for *Bd* during these surveys. I found both detection rates and detection probabilities to be related to seasonality and environmental temperature. If *Bd* prevalence were tracked over a longer period of time, it seems probable that fluctuations in both detection and prevalence would be observed due to variable environmental conditions such as water temperature. Although results of historical samples were inconclusive, I suspect that *Bd* has been present in Nebraska for an extended period of time. Despite the apparent prevalence of *Bd* in Nebraska amphibian communities, no population die offs or declines have been noted prior to or during these surveys. While die offs may have occurred during the initial introduction of the chytrid fungus into Nebraska, no direct mortalities can currently be attributed to the disease, supporting the notion that non-epidemic amphibian communities persist and even thrive despite the presence of *Bd.*

As noted, I detected chytrid within the same site during different years despite the wetland completely drying up in the intervening timeframe. *Bd* does have the ability to persist in the environment for a duration of time so long as sufficient environmental conditions are present, but this does not seem like a probable source of *Bd* re-emergence due to extremely hot and dry intervening years during which many wetlands completely dried up. Rather, *Bd* may have been dispersed via two source vectors, waterfowl or bullfrogs, both of which have been noted as reservoirs for the fungus (Schloegel et al. 2012, Garmyn et al. 2012). Few management options exist to prevent this type of biological spread although an extended American bullfrog harvest season could be considered, particularly in areas outside of southeastern Nebraska where the species is thought to be native. Alternatively, *Bd* may have been spread via humans, particularly in areas such as the Rainwater Basins, where hunters may move gear among wetlands without proper sanitization. In this sense, *Bd* should be treated like other aquatic invasive species and may merit suggested cleaning programs similar to those implemented to prevent the spread of aquatic invasive species like zebra and quagga mussels.

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CHAPTER 8

SYNOPSIS - THE IMPORTANCE OF SPATIAL AND LANSCAPE CONTEXT FOR THE CONSERVATION AND MANAGEMENT OF NEBRASKA'S WETLAND RESOURCES

Diverse wetlands across the landscape provide variable and diverse ecosystem services. The ability of wetlands to provide these ecosystem services is dependent upon the maintenance of the ecological condition of of wetland resources across the landscape. Nebraska's wetland resources are diverse and complex; as such, conservation and management in most instances must strive to match this diversity and complexity. In order to effectively manage these wetland resources conservation and management efforts must effectively match the time scale, spatial scale, and landscape context applicable to a given function or taxa.

In many instances, management and conservation decisions for many ecosystems is reliant upon the response of avifauna to the ecological condition sites. While birds are an important component of many ecosystems, they are also one of the few taxa that temporarily occupy wetlands and surrounding habitats and have the ability to readily move between suitable and unsuitable habitat patches. In some respects, this reliance on birds to support conservation and management goals in merited; however, it is also a result of concerted effort by groups such as Ducks Unlimited and the Audobon Society. When conservation and management planning is largely predicated upon the requirements of a migratory taxa, we often ignore other components of the local community and ecosystem when making management decisions. In order to further facilitate the incorporation of additional taxa into conservation and management planning for wetlands in Nebraska, methodologies to assess the ecological condition must first be developed and assessed. Resulting methodologies can then be used to assess the relationship between the ecological condition of wetland sites and additional taxa. Further, it can help to elucidate patterns of landscape scale and context that may influence the ecological condition of wetlands and associated taxa.

I used two taxa to help inform on factors that influence the ecological condition and function of wetlands in Nebraska, plant and anuran communities. The first step in measuring the ecological condition of wetlands is determining methods that best describe condition. Vegetative communities can provide multiple descriptive metrics against which to measure methods for determining the ecoloigical condition of wetland sites. In Chapter 2, I describe native vegetative communities in 11 wetland complexes using multiple vegetative metrics. These metrics provide and general measure of wetland plant communities and provide a baseline against which to measure future monitoring efforts. In chapter 3, I focus on the use of the Floristic Quality Assessment Index to measure wetland condition. Because FQAI scores are generally not comparable among differing wetland communities, I present a novel approach in which random subsets of diagnostic and common species from a reference standard sites are used to calculate an expected mean and standard deviation for each wetland vegetative community. These values can then be used to calculate a z-score and then departure of the vegetative community at a given site from reference standard and logical condition categories.

Florisitic Quality Assessment scores and some additional vegetative community metrics were then used to test alternative measures of ecological condition including a new rapid assessment method and multiple landscape methods. In chapter 4, I describe the development, implementation, and assessment of the Nebraska Wetland Rapid Assessment Method. This method incorporates both site level and landscape factors to measure the ecological condition of wetlands. While some components of the method are effective, this method still needs some changes prior to wide acceptance and implementation. In chapter 5, I assessed multiple landscape level methods including buffer width and condition, proportion of natural landcover, and two more complex landscape methods, the Landscape Development Intensity Index (Brown and Vivas 2005) and the NatureServe Lanscape Condition Model (Comer and Hak 2016). In general, results indicated a stronger relationship between vegetative community metrics and measures of landscape condition at 100 m. This supports the conclusion that high-quality vegetative buffers genereally mitigate issues with other surrounding land uses.

Amphibians are another wetland reliant taxa often used as a surrogate when considering the ecological condition of sites due to their biphasic life-cycle in which wetlands and surrounding uplands are used during portions of the year. This can result in anuran community sensitivity to both site-level and landscape-level factors. I assessed detetion and occupancy of anurans at 124 wetland sites in the Rainwater Basins using volunteer roadside call surveys. For most species, buffer and landscape condition had little effect on the occupancy by anurans in the region. Only for HYCH and a small, four-species community was buffer width and condition found to be important. More important was the type of wetland, with actively managed wetlands being more likely to occupied by all species than pits and private wetlands. Inclusion of site-specific characteristics may help in elucidating factors related to this relationship but may also be difficult to ascertain due to most sites being privately owned. A similar pattern was observed for the amphibian fungal disease *Bd*, in which aquatic habitat type was the second most important predictor following mean annual temperature for predicting presence. Population density and anthropogenic stress on the surrounding landscape were found to have a moderate effect. These observations support the idea that site-specific characteristics and spatial context may be more important for anurnas than landscape factors.

Maintaining natural buffers surrounding aquatic resources including streams and wetlands is imperative for the maintenance of the ecological condition and natural function of these ecosystems. Generally, it is agreed that a 100 m vegetated buffer is sufficient in protecting the function of these resources (Castelle et al. 1994); however, recent studies indicate that factors such as conservation plantings may actually alter function dependent upon the vegetative community present in the buffer (Bartuszevige et al. 2012, Cariveau et al. 2011, Gleason et al. 2011). Results of analysis of both vegetative and anuran communities from this study generally support the importance of maintaining high quality vegetative buffers around sites. This relationship is certainly stronger for plants, but also present for at least some species of anurans in Nebraska. The importance of buffers for plants was expected given previous work, but the lack of importance for other landscape factors was somewhat surprising. I also anticipated a stronger relationship between amphibian occupancy and buffer and landscape factors.

These results support a few general conclusions. First, vegetative buffers are an important component in maintaining the ecological condition and function of wetlands in Nebraska for multiple taxa. It appears as though the maintenance of a minimal 100 m vegetative buffer is sufficient in mitigating the effects of surrounding land use, even in highly agricultural landscapes. The general lack of measureable landscape effects may also relate to the fact that much of Nebraska is still dominated by native grasslands and managed for use as cattle grazing lands using techniques amenable to the maintenance of wetland and grassland condtion and function. Interestingly, this is not the case for amphibians in the Rainwater Basins. Rather, it seems that the landscape context plays a large role in the occupancy probability of anurans in this region. Despite the lack of wide vegetative buffers at many sites, anurans seem to be thriving at managed and conservation program wetlands. The Rainwater Basins is a region criss-crossed with dirt roads with associated vegetated ditches, many of which are deep. It appears that these ditches act as migration corridors between wetlands, with agricultural resuse pits functioning as potential stop-over points between wetland sites (Uden et al. 2014). Historically, thousands of temporary wetlands were present across the RWB region that served this purpose. Current conservation efforts are attempting restore many of these wetlands, but their presence on prime agricultural land presents issues with this approach.

Given these observations, it seems imperative that any management or conservation effort for wetands in Nebraska should include the maintenance or restoration of vegetated buffers. As little as a 100 m vegetated buffer may be enough to maintain the vegetative community and ecological function of many wetland types. Further, managers must consider the spatial context of wetlands. Given the value of agricultural land in Nebraska, acquisition of large properties may not be possible, but targeting wetlands for purchase or restoration near deep roadside ditches may offer managers the ability to succesfully maintain function for amphibians with much less buffer than the generally accepted 100 m. It all stresses the importance of understanding how anthropogenic habitats may function as important corridors in highly modified agricultural regions as anurans were regularly observed using both agricultural reuse pits and roadside ditches during this study.

Future Research

During this study, I tested multiple methods for assessing the ecological condition of wetlands in Nebraska. I was unable to identify landscape measures that provide a good measure of the condition of wetlands, possibly related to distinct differences in landscape among regions, but also related to buffer condition and extent. While I found a moderate relationship between vegetative communities and the Nebraska Wetland Rapid Assessment Method, this method can be improved through the implementation of best professional judgement and continuous rather than categorical measures of variable condition. The method can then be tested at additional sites across the state to insure reproducibility and effective implementation for use by regulatory agencies.

Efforts to monitor anuran communities should continue in the Rainwater Basins using volunteer roadside anuran call surveys. In its current form, I estimate that the current protocol can detect a 30 -40% decline in anuran occupancy. Future efforts should focus on determining site-specific factors that influence occupancy. Additionally, increasing our understanding of the importance of anthropogenic habitats for functional connectivity, in particular roadside ditches, may be imperative for future wetland and conservation planning in highly agricultural landscapes.

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APPENDIX A: REFERENCE STANDARD PLANT COMMUNITIES

Tables below provide lists of diagnostic and common species for plant communities found in the wetland complexes assessed during this study. Diagnostic species are bolded and highlighted in green.

Table A.1. Reference standard plant community for the CP wetland complex.

Northern Cordgrass Wet Prairie	
Species Name (synonymy)	**Common Name**
Calamagrostis stricta	**northern reedgrass**
Spartina pectinata	**prairie cordgrass**
Carex emoryi	Emory’s sedge
Carex pellita	woolly sedge
Equisetum laevigatum	smooth scouringrush
Panicum virgatum	switchgrass
Persicaria coccinea (Polygonum coccineum)	swamp smartweed

Table A.2. Reference standard plant community for the CTP wetland complex.

Wheatgrass Playa Grassland	
Species Name (synonymy)	**Common Name**
Buchloë dactyloides	**buffalograss**
Pascopyrum smithii	**western wheatgrass**
Phyla cuneifolia	**wedgeleaf fog-fruit**
Oenothera canescens	**spotted evening-primrose**
Vernonia fasciculata	**prairie ironweed**
Agrostis hyemalis	ticklegrass
Ambrosia artemisiifolia	annual ragweed
Ambrosia grayi	bur ragweed
Carex brevior	shortbeak sedge
Eleocharis macrostachya	largespike spikerush
Hordeum jubatum	foxtail barley
Juncus interior	inland rush
POA PRATENSIS	Kentucky bluegrass

Table A.3. Reference standard plant community for the CCWM wetland complex.

Sandhills Wet Meadow	
Species Name (synonymy)	**Common Name**
Calamagrostis canadensis	**bluejoint**
Calamagrostis stricta	**northern reedgrass**
Carex sartwellii	**Sartwell's sedge**
Carex nebrascensis	Nebraska sedge
Carex pellita	woolly sedge
Carex praegracilis	clustered field sedge
Carex scoparia	pointed broom sedge
Eleocharis compressa	flat-stem spikerush
Juncus arcticus var. balticus	Baltic rush
Juncus nodosus	knotted rush
Juncus torreyi	Torrey's rush
Persicaria coccinea (Polygonum coccineum)	swamp smartweed
PHALARIS ARUNDINACEA	REED CANARYGRASS
Stachys pilosa var. pilosa	common hedge-nettle

Table A.4. Reference standard plant community for the EHW wetland complex.

Sandhills Hardstem Bulrush Marsh	
Species Name (synonymy)	**Common Name**
Schoenoplectus acutus	**hardstem bulrush**
Sagittaria latifolia	**common arrowhead**
Typha latifolia	**broadleaf cattail**
Carex lacustris	ripgut sedge
Ceratophyllum demersum	coontail
Eleocharis erythropoda	bald spikerush
Lemna spp.	duckweeds
Lemna trisulca	star duckweed
Persicaria amphibia	water smartweed
Phragmites australis	common reed
Potamogeton spp.	pondweeds
Sparganium eurycarpum	large-fruit bur-reed
Wolffia spp.	watermeal
Zannichellia palustris	horned pondweed

Table A.5. Reference standard plant communities for the MR wetland complex.

Eastern Riparian Forest	
Species Name (synonymy)	**Common Name**
Acer saccharinum	**silver maple**
Cornus drummondii	**roughleaf dogwood**
Fraxinus pennsylvanica	**green ash**
Populus deltoides	**plains cottonwood**
Ulmus americana	**American elm**
Acer negundo	box-elder
Ageratina altissima	white snakeroot
Carex spp.	sedges
Celtis occidentalis	hackberry
Cornus drummondii	roughleaf dogwood
Elymus virginicus	Virginia wildrye
Festuca subverticillata	nodding fescue
Galium aparine	annual bedstraw
Galium triflorum	sweet-scented bedstraw
Geum canadense	white avens
Gleditsia triacanthos	honey-locust
Laportea canadensis	wood nettle
Leersia virginica	whitegrass
Maianthemum stellatum	starry false Solomon's seal
MORUS ALBA	WHITE MULBERRY
Morus rubra	red mulberry
Muhlenbergia spp.	muhlys
Osmorhiza longistylis	aniseroot
Parthenocissus quinquefolia	Virginia creeper
Ribes missouriense	Missouri gooseberry
Rudbeckia laciniata	goldenglow
Sanicula canadensis	Canada sanicle
Sanicula odorata	clustered sanicle
Solidago spp.	goldenrods
Symphoricarpos orbiculatus	coralberry
Toxicodendron radicans	eastern poison ivy
Ulmus americana	American elm
Ulmus rubra	slippery elm
Urtica dioica	stinging nettle
Viola spp.	violets
Vitis riparia	riverbank grape

Eastern Cottonwood-Dogwood Riparian Woodland	
Species Name (synonymy)	**Common Name**
Cornus drummondii	**roughleaf dogwood**
Equisetum hyemale	**common scouringrush**
Populus deltoides	**Plains cottonwood**
Ageratina altissima	white snakeroot
Galium triflorum	sweet-scented bedstraw
Parthenocissus quinquefolia	Virginia creeper
Toxicodendron radicans	eastern poison ivy
Urtica dioica	stinging nettle

Table A.6. Reference standard plant community for the NR wetland complex.

Eastern Sedge Wet Meadow	
Species Name (synonymy)	**Common Name**
Carex cristatella	**crested sedge**
Carex vulpinoidea	**fox sedge**
Scirpus atrovirens	**dark-green bulrush**
Scirpus pallidus	**pale bulrush**
AGROSTIS GIGANTEA	REDTOP
Carex pellita	woolly sedge
Carex stipata	saw-beak sedge
Hordeum jubatum	foxtail barley
Verbena hastata	blue vervain

Table A.7. Reference standard plant community for the RWB wetland complex.

Cattail Shallow Marsh	
Species Name (synonymy)	**Common Name**
Bolboschoenus fluviatilis	**river bulrush**
Schoenoplectus heterochaetus	**slender bulrush**
Typha latifolia	**broadleaf cattail**
Eleocharis macrostyachya	largespike spikerush
Leersia oryzoides	rice cutgrass
Lemna aequinoctialis	lesser duckweed
Lemna turionifera	turion duckweed
Persicaria coccinea (Polygonum coccineum)	swamp smartweed
Sagittaria brevirostra	short-beak arrowhead
Sagittaria cuneata	duck-potato arrowhead
Sparganium eurycarpum	large-fruit burreed
TYPHA ANGUSTIFOLIA	NARROWLEAF CATTAIL

Table A.8. Reference standard plant community for the SAL wetland complex.

Eastern Saline Meadow	
Species Name (synonymy)	**Common Name**
Atriplex dioica	**salt-marsh spearscale**
Distichlis spicata	**inland saltgrass**
Poa arida	**plains bluegrass**
Salicornia rubra	**saltwort**
Sporobolus texanus	**Texas dropseed**
Suaeda calceoliformis	**seablite**
Hordeum jubatum	foxtail barley
Iva annua	annual marsh-elder
Spartina pectinata	prairie cordgrass

Table A.9. Reference standard plant community for the SALK wetland complex.

Western Alkaline Marsh	
Species Name (synonymy)	**Common Name**
Amphiscirpus nevadensis	**Nevada bulrush**
Schoenoplectus pungens	**three-square bulrush**
Bolboschoenus maritimus	salt-marsh bulrush
Hordeum jubatum	foxtail barley
Puccinellia nuttalliana	Nuttall’s alkali grass

Table A.10. Reference standard plant community for the SWP wetland complex.

Playa Wetland	
Species Name (synonymy)	**Common Name**
Coreopsis tinctoria	**plains coreopsis**
Echinochloa muricata	**rough barnyard grass**
Limosella aquatica	**mudwort**
Plagiobothrys scouleri	**popcorn flower**
Bacopa rotundifolia	water-hyssop
Cyperus acuminatus	shortpoint flatsedge
Echinochloa spp.	barnyard grass
Elatine rubella	common waterwort
Eleocharis obtusa	blunt spikerush
Heteranthera limosa	mud-plantains
Heteranthera rotundifolia	mud-plantains
Lindernia dubia	false pimpernel
Mollugo verticillata	carpetweed
Persicaria bicornis (Polygonum bicorne)	pink smartweed
Persicaria lapathifolia (Polygonum lapathifolium)	nodding smartweed
RUMEX STENOPHYLLUS	NARROWLEAF DOCK
Sagittaria calycina	hooded arrowhead

Table A.11. Reference standard plant community for the NPR wetland complex.

Western Alkaline Meadow	
Species Name (synonymy)	**Common Name**
Amphiscirpus nevadensis	**Nevada bulrush**
Atriplex dioica	**salt-marsh spearscale**
Cleomella angustifolia	**eastern cleomella**
Distichlis spicata	**inland saltgrass**
Plantago eriopoda	**alkali plantain**
Primula pauciflora	**northern shooting-star**
Sporobolus airoides	**alkali sacaton**
Thelypodium integrifolium	**thelypody**
Carex praegracilis	clustered field sedge
Elymus trachycaulus	slender wheatgrass
Hordeum jubatum	foxtail barley
Muhlenbergia asperifolia	scratchgrass
Poa arida	meadow bluegrass
Suaeda calceoliformis	seablite
Triglochin maritima	alkali arrowgrass

APPENDIX B: WETLAND SITE PLANT COMMUNITY DATA

The following tables provide plant species lists and estimated cover of each plant species for sites assessed from 2011 - 2013. Absolute cover percent is the estimated mean cover or each of the five assessment plots. Relative cover percent is calculated as the absolute percent cover of and individual species divided by the sum of absolute percent cover for all species at a site. The column *Invasive* indicates if a species is a non-native invasive species where 1 = invasive species and 0 = native species. *CC* is the coefficient of conservatism for a plant species from the Nebraska Natural Heritage database (NNHP 2011). *Weighted CC* is the *CC* multiplied by the *Relative % Cover* for each species. Both *CC* and *Weighted CC* can be used for different calculations of Floristic Quality Assessment Indices. *Wetness* and *C of W* are wetness values assigned for the purposes of wetland delineation and can be used in the calculation of the “Dominance Test” and “Prevalence Index”.

CPREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agalinus tenuifolia	0	2	0	0	0	0.40	0.21	0	5	1.05	FACW	2
Alisma triviale	0	0	0	0	4	0.80	0.42	0	4	1.69	OBL	1
Ambrosia psilotachya	0.1	0.1	2	0.1	0	0.46	0.24	0	1	0.24	FAC	3
Apocynum cannabinum	2	0	5	0.1	0	1.42	0.75	0	2	1.50	FAC	3
Asclepias incarnata	0.1	0.1	0	0	0	0.04	0.02	0	4	0.08	OBL	1
Aster falcatus	0.1	1	10	5	0	3.22	1.70	0	4	6.79	FAC	3
Aster lanceolatus	0.1	1	0.1	0.1	0	0.26	0.14	0	2	0.27	FACW	2
Bouteloua curtipendula	1	0	1	0	0	0.40	0.21	0	5	1.05	UPL	5
Bromus inermis	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Calamagrostis stricta	15	20	5	1	0	8.20	4.32	0	6	25.94	FACW	2
Carex crawei	10	2	5	2	0	3.80	2.00	0	6	12.02	FACW	2
Carex emoryi	1	15	10	10	0	7.20	3.80	0	5	18.98	OBL	1
Carex granularis	5	2	5	1	0	2.60	1.37	0	6	8.22	FACW	2
Carex pellita	15	0	10	2	0	5.40	2.85	0	4	11.39	OBL	1
Carex praegracilis	20	2	5	2	0	5.80	3.06	0	4	12.23	FACW	2
Carex scoparia	1	0	2	0	0	0.60	0.32	0	5	1.58	FACW	2
Carex tetanica	2	2	1	2	0	1.40	0.74	0	7	5.17	FACW	2
Carex vulpinoidea	0.1	1	1	0.1	0	0.44	0.23	0	4	0.93	OBL	1
Cicuta maculata	0.1	0	0.1	0.1	0	0.06	0.03	0	5	0.16	OBL	1
Crepis runcinata	0.1	0	0	0.1	0	0.04	0.02	0	5	0.11	FAC	3
Desmanthus illinoiense	1	0.1	0	0.1	0	0.24	0.13	0	5	0.63	FACU	4
Digitaria cognata	0.1	0	0	0	0	0.02	0.01	0	4	0.04	UPL	5
Eleocharis acicularis	0	0	0	0	0.1	0.02	0.01	0	4	0.04	OBL	1
Eleocharis compressa	2	10	0	10	0	4.40	2.32	0	6	13.92	FACW	2
Eleocharis palustris	50	30	20	20	30	30.00	15.82	0	4	63.26	OBL	1

Equisetum arvense	0	1	2	0.1	0	0.62	0.33	0	4	1.31	FAC	3
Equisetum laevigatum	0.1	0.1	0.1	0.1	0	0.08	0.04	0	4	0.17	FACW	2
Erigeron strigosus	0	0.1	0.1	0	0	0.04	0.02	0	2	0.04	FAC	3
Eupatorium altissimum	2	1	10	2	0	3.00	1.58	0	3	4.74	FACU	4
Eupatorium perfoliatum	0.1	0.1	0.1	0.1	0	0.08	0.04	0	5	0.21	OBL	1
Euthamia gymnospermoides	1	0.1	0	0	0	0.22	0.12	0	4	0.46	FACW	2
Glyceria striata	1	1	0.1	0	0	0.42	0.22	0	5	1.11	OBL	1
Helenium autumnale	4	10	1	2	0	3.40	1.79	0	6	10.75	FACW	2
Helianthus maximiliani	0.1	20	5	15	0	8.02	4.23	0	4	16.91	UPL	5
Hypoxis hirsuta	0.1	0.1	0	0.1	0	0.06	0.03	0	7	0.22	FACW	2
Juncus dudleyi	5	15	10	15	0	9.00	4.74	0	5	23.72	FACW	2
Juncus torreyi	0.1	0	0	0	0	0.02	0.01	0	4	0.04	FACW	2
Lippia lanceolata	0.1	0	0.1	0.1	0	0.06	0.03	0	3	0.09	OBL	1
Ludwigia palustris	0	0	0	0	1	0.20	0.11	0	5	0.53	OBL	1
Lycopus americanus	2	0.1	4	0	0	1.22	0.64	0	4	2.57	OBL	1
Lysimachia thrysiflora	0.1	0.1	0.1	0	0	0.06	0.03	0	7	0.22	OBL	1
Lythrum salicaria	0	0.1	0.1	0.1	0	0.06	0.03	1	0	0.00	OBL	1
Mentha arvensis	0.1	0	0.1	0.1	0	0.06	0.03	0	4	0.13	FACW	2
Panicum acuminatum	0	0.1	0	0	0	0.02	0.01	0	6	0.06	FACW	2
Panicum virgatum	25	25	20	30	0	20.00	10.54	0	4	42.18	FAC	3
Poa pratensis	0.1	0	1	2	0	0.62	0.33	1	0	0.00	FACU	4
Polygonum coccineum	0	0	0.1	0.1	25	5.04	2.66	0	2	5.31	FACW	2
Polygonum persicaria	0	0	0	0	1	0.20	0.11	1	0	0.00	OBL	1
Rudbeckia hirta	0.1	0	0.1	0	0	0.04	0.02	0	4	0.08	FACU	4
Schoenoplectus pungens	20	50	15	10	25	24.00	12.65	0	4	50.61	OBL	1
Schoenoplectus tabernaemontana	0	0.1	0	0	0	0.02	0.01	0	5	0.05	OBL	1
Sisyrinchium montanum	0	0.1	0.1	0.1	0	0.06	0.03	0	5	0.16	FAC	3
Solidago gigantea	0.1	0.1	0	0.1	0	0.06	0.03	0	3	0.09	FACW	2

Sorghastrum nutans	0	0	2	1	0	0.60	0.32	0	5	1.58	FACU	4
Sparganium eurycarpum	0	0	0	0	75	15.00	7.91	0	5	39.54	OBL	1
Spartina pectinata	25	20	30	15	0	18.00	9.49	0	5	47.45	FACW	2
Taraxacum officianale	0	0.1	0.1	0.1	0	0.06	0.03	1	0	0.00	FACU	4
Triglochin maritima	0.1	0.1	0	0	0	0.04	0.02	0	5	0.11	OBL	1
Verbena hastata	0.1	0.1	1	1	0	0.44	0.23	0	4	0.93	FACW	2
Vernonia fasciculata	4	1	2	1	0	1.60	0.84	0	4	3.37	FAC	3
Viola sororia	0	0	0	0.1	0	0.02	0.01	0	3	0.03	FAC	3

CP1

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Allium canadense var. canadense	0	0.1	0.1	0.1	1	0.26	0.11	0	3	0.33	FACU	4
Andopogon gerardii	2	15	0	5	1	4.60	1.94	0	5	9.72	FAC	3
Apocynum cannabinum	1	0.1	1	1	0.1	0.64	0.27	0	2	0.54	FAC	3
Asclepias syriaca	1	0	0.1	0	0	0.22	0.09	0	1	0.09	FAC	3
Asclepias verticillata	0.1	0.1	0	0.1	0	0.06	0.03	0	3	0.08	FACU	4
Asparagus officianalis	0	0	0	0.1	0	0.02	0.01	1	0	0.00	FACU	4
Aster ericoides	5	0.1	0	2	0.1	1.44	0.61	0	3	1.82	FACU	4
Bouteloua curtipendula	2	17	0	5	0	4.80	2.03	0	5	10.14	UPL	5
Bromus inermis	50	80	90	65	95	76.00	32.10	1	0	0.00	FACU	4
Callirhoe alcaeoides	2	0.1	0.1	1	0.1	0.66	0.28	0	5	1.39	UPL	5
Callirhoe involucrata	5	0	2	1	0.1	1.62	0.68	0	2	1.37	UPL	5
Carex brevior	0	0.1	0	0.1	0.1	0.06	0.03	0	4	0.10	FAC	3
Carex pellita	0	0.1	0	0	0	0.02	0.01	0	4	0.03	OBL	1
Cirsium floodmanii	0	0	0.1	0	0	0.02	0.01	0	4	0.03	FAC	3
Dalea purpurea	0.1	0	0	0	0	0.02	0.01	0	6	0.05	UPL	5
Desmanthus illinoense	0	0	0	0	0.1	0.02	0.01	0	5	0.04	FACU	4

Eleocharis compresse	1	0.1	0	1	0.1	0.44	0.19	0	6	1.12	FACW	2
Equisetum hyenale	0.1	0.1	0.1	0.1	0	0.08	0.03	0	4	0.14	FACW	2
Erigeron strigosus	0	0.1	0	0	0	0.02	0.01	0	2	0.02	FAC	3
Euthamia gymnospermoides	1	0	0	0.1	0	0.22	0.09	0	4	0.37	FACW	2
Galium aparine	0	0	0	0.1	0	0.02	0.01	0	0	0.00	FACU	4
Hesperostipa spartea	2	0	0	0	0	0.40	0.17	0	6	1.01	UPL	5
Hypoxis hirsuta	0	0.1	0	0	0	0.02	0.01	0	7	0.06	FACW	2
Koeleria macrantha	1	0	0	1	0	0.40	0.17	0	6	1.01	UPL	5
Lithospermum incisum	0.1	0	0	1	0	0.22	0.09	0	5	0.46	UPL	5
Medicago sativa	75	80	80	20	60	63.00	26.61	1	0	0.00	UPL	5
Melilotus officinalis	2	0	1	1	0	0.80	0.34	1	0	0.00	FACU	4
Oxalis stricta	0	0	0	0	0.1	0.02	0.01	0	0	0.00	FACU	4
Panicum oligosanthes	0	0	0	1	0	0.20	0.08	0	4	0.34	FACU	4
Panicum virgatum	0	0.1	0	0	0	0.02	0.01	0	4	0.03	FAC	3
Phleum pratense	0	0	0	1	0	0.20	0.08	1	0	0.00	FACU	4
Physalis virginiana	5	0.1	0.1	1	0	1.24	0.52	0	6	3.14	UPL	5
Poa compressa	0	0	0	0	0.1	0.02	0.01	1	0	0.00	FACU	4
Poa pratensis	40	70	75	50	75	62.00	26.19	1	0	0.00	FACU	4
Potentilla recta	0.1	0.1	0.1	0.1	0	0.08	0.03	1	0	0.00	UPL	5
Ratibida columnifera	0.1	0	0	0	0	0.02	0.01	0	4	0.03	UPL	5
Rudbeckia hirta	0	0.1	0	0	0	0.02	0.01	0	4	0.03	FACU	4
Rumex crispus	0	0	0	1	0	0.20	0.08	1	0	0.00	FACW	2
Schizachyrium scoparium	2	0	0	10	0	2.40	1.01	0	4	4.06	FACU	4
Silene antirrhina	0	0	0	0	0.1	0.02	0.01	0	2	0.02	UPL	5
Sisyrynchium campestre	0	0	0.1	0.1	0	0.04	0.02	0	5	0.08	UPL	5
Solanum ptychanthum	0	0	0	0.1	0.1	0.04	0.02	0	0	0.00	FACU	4
Sorghastrum nutans	30	0	0	10	0	8.00	3.38	0	5	16.90	FACU	4
Spartina pectinata	15	1	2	0.1	0	3.62	1.53	0	5	7.65	FACW	2

Sporobalus compositus	1	0	0	0.1	0	0.22	0.09	0	3	0.28	FACU	4
Thalictrum dasycarpum	0.1	0	1	5	0	1.22	0.52	0	4	2.06	FACW	2
Toxicodendron radicans	0	0	0	0	2	0.40	0.17	0	2	0.34	FAC	3
Tragopogon dubius	1	0.1	0.1	1	0.1	0.46	0.19	1	0	0.00	FACU	4
Trifolium pratense	0	0	0	0	1	0.20	0.08	1	0	0.00	FACU	4
Viola pratincola	0	0	0	0	0.1	0.02	0.01	0	1	0.01	FAC	3

CP2

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis gigantea	0	0	0	0	2	0.40	0.21	1	0	0.00	FACW	2
Ambrosia psilotachya	0	0	0.1	0.1	0	0.04	0.02	0	1	0.02	FAC	3
Andropogon gerardii	0	0	1	4	0	1.00	0.53	0	5	2.65	FAC	3
Apocynum cannabinum	1	0	0.1	0.1	0.1	0.26	0.14	0	2	0.28	FAC	3
Asclepias syriaca	0	0	0	0	0.1	0.02	0.01	0	1	0.01	FAC	3
Aster falcatus	0	0	0	0.1	0	0.02	0.01	0	4	0.04	FAC	3
Bolboschoenus fluviatilus	0	0	0	0	1	0.20	0.11	0	3	0.32	OBL	1
Bouteloua curtipendula	0	0	2	10	0.1	2.42	1.28	0	5	6.42	UPL	5
Bromus inermis	0	0	2	15	0	3.40	1.80	1	0	0.00	FACU	4
Carex emoryi	50	60	1	0	0	22.20	11.78	0	5	58.89	OBL	1
Carex meadii	0	0	0	0	1	0.20	0.11	0	6	0.64	FAC	3
Carex molesta	0	1	0	0	0.1	0.22	0.12	0	3	0.35	FAC	3
Carex pellita	30	25	4	2	60	24.20	12.84	0	4	51.35	OBL	1
Carex praegracilis	1	1	0.1	0	1	0.62	0.33	0	4	1.32	FACW	2
Carex vulpinoidea	0	1	0	0	0.1	0.22	0.12	0	4	0.47	OBL	1
Desmanthus illinoensis	0	0	0.1	0.1	0.1	0.06	0.03	0	5	0.16	FACU	4
Digitaria cognata	0	0	0	1	0.1	0.22	0.12	0	4	0.47	UPL	5
Eleocharis compressa	0	0	40	20	0	12.00	6.37	0	6	38.20	FACW	2

Eleocharis erythropoda	10	15	0	0	40	13.00	6.90	0	5	34.48	OBL	1
Equisetum laevigatum	0.1	0.1	0.1	0.1	0	0.08	0.04	0	4	0.17	FACW	2
Erirgeron strigosus	0	0	0.1	0.1	0	0.04	0.02	0	2	0.04	FAC	3
Hordeum jubatum	0.1	1	0	0	1	0.42	0.22	0	1	0.22	FACW	2
Juncus dudleyi	25	10	1	0	50	17.20	9.12	0	5	45.62	FACW	2
Leersia oryzoides	0.1	0	0	0	0.1	0.04	0.02	0	4	0.08	OBL	1
Lemna minor	0.1	0	0	0	0.1	0.04	0.02	0	5	0.11	OBL	1
Lippia lanceolata	5	1	0	0	1	1.40	0.74	0	3	2.23	OBL	1
Lolium arundinaceum	0.1	0	4	50	0.1	10.84	5.75	1	0	0.00	FACU	4
Lycopus americanus	0.1	0	0	0	0	0.02	0.01	0	4	0.04	OBL	1
Lythrum salicaria	1	1	0	0	2	0.80	0.42	1	0	0.00	OBL	1
Mentha arvensis	0.1	0	0	0	0	0.02	0.01	0	4	0.04	FACW	2
Panicum acuminatum	0	0	1	0.1	0.1	0.24	0.13	0	6	0.76	FACW	2
Panicum virgatum	10	0	10	4	0.1	4.82	2.56	0	4	10.23	FAC	3
Pascopyrum smithii	0	0	30	40	0	14.00	7.43	0	3	22.28	FACU	4
Phalaris arundinacea	0.1	0	0	0	2	0.42	0.22	1	0	0.00	FACW	2
Phleum pratense	5	50	0	0	0	11.00	5.84	1	0	0.00	FACU	4
Phragmites australis	0.1	0	0	0	1	0.22	0.12	1	0	0.00	FACW	2
Poa compressa	0	10	1	0	0.1	2.22	1.18	1	0	0.00	FACU	4
Poa pratensis	30	30	1	10	40	22.20	11.78	1	0	0.00	FACU	4
Rumex crispus	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACW	2
Schoenoplectus pungens	1	1	4	0.1	10	3.22	1.71	0	4	6.83	OBL	1
Sisyrynchium montanum	0	0	0.1	1	0	0.22	0.12	0	5	0.58	FAC	3
Solanum ptycanthum	0	0	0	0.1	0	0.02	0.01	0	0	0.00	FACU	4
Sorghastrum nutans	0	0	4	1	0	1.00	0.53	0	5	2.65	FACU	4
Sparganium eurycarpum	0.1	0	0	0	0	0.02	0.01	0	5	0.05	OBL	1
Spartina pectinata	15	1	25	2	25	13.60	7.21	0	5	36.07	FACW	2
Sporobalus compositus	0	0	2	15	0	3.40	1.80	0	3	5.41	FACU	4

Taraxacum officianale	0	0	0	0.1	0	0.02	0.01	1	0	0.00	FACU	4
Trifolim repens	0.1	0.1	0	0	1	0.24	0.13	1	0	0.00	FACU	4
Vernonia fasciculata	0.1	0	0	0	0	0.02	0.01	0	4	0.04	FAC	3

CP3

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Allium canadense var. canadense	1	0.1	0	0	0.1	0.24	0.11	0	3	0.34	FACU	4
Allium canadense var. lavendulare	0	0	0.1	0.1	0	0.04	0.02	0	7	0.13	FACU	4
Ambrosia artemisifolia	0	0.1	0	0	0	0.02	0.01	0	0	0.00	FACU	4
Amorpha fruticosa	0	1	0	0.1	0.1	0.24	0.11	0	5	0.56	OBL	1
Andropogon gerardii	0	0.1	0	0	0	0.02	0.01	0	5	0.05	FAC	3
Apocynum cannabinum	0.1	0	1	4	0	1.02	0.48	0	2	0.95	FAC	3
Bromus inermis	2	15	0	0.1	1	3.62	1.69	1	0	0.00	FACU	4
Carex brevior	80	20	40	50	0	38.00	17.76	0	4	71.02	FAC	3
Carex crawei	0	0.1	0	2	15	3.42	1.60	0	6	9.59	FACW	2
Carex molesta	1	10	2	30	30	14.60	6.82	0	3	20.47	FAC	3
Carex pellita	2	2	50	30	15	19.80	9.25	0	4	37.01	OBL	1
Carex praegracilis	0.1	0	0	0.1	0	0.04	0.02	0	4	0.07	FACW	2
Carex scoparia	0	0	0	0.1	0	0.02	0.01	0	5	0.05	FACW	2
Carex tetanica	0	1	0	1	0	0.40	0.19	0	7	1.31	FACW	2
Carex vulpinoidea	0.1	0	2	0	0.1	0.44	0.21	0	4	0.82	OBL	1
Eleocharis compressa	0.1	0.1	0	0	0	0.04	0.02	0	6	0.11	FACW	2
Eleocharis palustris	0	0	0	0.1	0	0.02	0.01	0	4	0.04	OBL	1
Elymus trachycaulus	0.1	0.1	0	0	0	0.04	0.02	0	5	0.09	FACU	4
Equisetum laevigatum	0.1	10	0	0.1	0.1	2.06	0.96	0	4	3.85	FACW	2
Eupatorium altissimum	0	0.1	0	0	0	0.02	0.01	0	3	0.03	FACU	4
Galium obtusum	15	0.1	20	20	15	14.02	6.55	0	6	39.30	FACW	2

Glychirriza lepidota	10	5	10	0	0	5.00	2.34	0	4	9.34	FACU	4
Hordeum jubatum	0	0	2	1	0.1	0.62	0.29	0	1	0.29	FACW	2
Lotus corniculata	30	5	40	30	20	25.00	11.68	1	0	0.00	FACU	4
Panicum oligosanthes	0	0.1	0	0	0	0.02	0.01	0	4	0.04	FACU	4
Panicum virgatum	0.1	0	0	0	0	0.02	0.01	0	4	0.04	FAC	3
Pascopyrum smithii	0.1	0.1	0	0	0	0.04	0.02	0	3	0.06	FAC	3
Phalaris arundinacea	0.1	25	20	0	30	15.02	7.02	1	0	0.00	FACW	2
Phleum pratense	45	0	3	3	1	10.40	4.86	1	0	0.00	FACU	4
Phyla lanceolata	0	0	0	0.1	1	0.22	0.10	0	3	0.31	OBL	1
Poa compressa	15	25	0	1	10	10.20	4.77	1	0	0.00	FACU	4
Poa pratensis	1	20	15	30	30	19.20	8.97	1	0	0.00	FACU	4
Polygonum coccineum	0	0	0	0.1	0	0.02	0.01	0	2	0.02	FACW	2
Rumex crispus	0.1	1	0.1	1	1	0.64	0.30	1	0	0.00	FACW	2
Schoenoplectus pungens	0	0	0	7	0	1.40	0.65	0	4	2.62	OBL	1
Solidago gigantea	0	0.1	0	0	0	0.02	0.01	0	3	0.03	FACW	2
Spatina pectinata	10	10	30	50	25	25.00	11.68	0	5	58.41	FACW	2
Thlaspi arvense	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Trifolium pratense	0	0	0	0.1	0.1	0.04	0.02	1	0	0.00	FACU	4
Verbena hastata	0	0.1	0	0	0	0.02	0.01	0	4	0.04	FACW	2
Vernonia fasciculata	1	1	10	1	1	2.80	1.31	0	4	5.23	FAC	3
Viola sororia	0	1	0	0	0	0.20	0.09	0	3	0.28	FACW	2

CP4

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agalinis tenuifolia	1	0	0.1	0	0.1	0.24	0.13	0	5	0.67	FACW	2
Ambrosia psilotachya	1	0	0.1	0.1	1	0.44	0.25	0	1	0.25	FAC	3
Apocynum cannabinum	0.1	0	0.1	0	0	0.04	0.02	0	2	0.04	FAC	3

Asclepias incarnata	0	0	0	0.1	0.1	0.04	0.02	0	4	0.09	OBL	1
Asclepias syriaca	0	0	0.1	0	0	0.02	0.01	0	1	0.01	FAC	3
Aster falcutus	4	0	5	2	2	2.60	1.46	0	4	5.84	FAC	3
Aster lanceolatus	0.1	0.1	0.1	0.1	0.1	0.10	0.06	0	2	0.11	FACW	2
Aster praeltus	0.1	0	0.1	0.1	0.1	0.08	0.04	0	5	0.22	FACW	2
Bouteloua curtipedula	2	0	10	1	2	3.00	1.68	0	5	8.42	UPL	5
Calamagrostis stricta	5	35	1	20	15	15.20	8.53	0	6	51.18	FACW	2
Carex crawei	5	0	2	2	2	2.20	1.23	0	6	7.41	FACW	2
Carex emoryi	1	60	10	4	4	15.80	8.87	0	5	44.33	OBL	1
Carex granularis	4	0	5	1	2	2.40	1.35	0	6	8.08	FACW	2
Carex pellita	5	20	10	25	10	14.00	7.86	0	4	31.43	OBL	1
Carex praegracilis	20	0	5	1	2	5.60	3.14	0	4	12.57	FACW	2
Carex scoparia	0	10	0	0	0	2.00	1.12	0	5	5.61	FACW	2
Carex tetanica	10	0	4	1	2	3.40	1.91	0	7	13.36	FACW	2
Cicuta maculata	0	1	0	0	0	0.20	0.11	0	5	0.56	OBL	1
Crepis runcinata	0.1	0	0.1	0	0	0.04	0.02	0	5	0.11	FAC	3
Digitarium cognata	0	0	15	0	1	3.20	1.80	0	4	7.18	UPL	5
Eleocharis compressa	30	0	25	10	50	23.00	12.91	0	6	77.44	FACW	2
Eleocharis erythropoda	20	10	1	20	2	10.60	5.95	0	5	29.74	OBL	1
Elymus trachycaulus	0.1	0	10	2	2	2.82	1.58	0	5	7.91	FACU	4
Equisetum arvense	0.1	1	0	0	0	0.22	0.12	0	4	0.49	FAC	3
Equisetum laevigatum	0.1	0	0.1	0.1	0	0.06	0.03	0	4	0.13	FACW	2
Erigeron philidelphicus	0.1	0	0.1	0	0	0.04	0.02	0	3	0.07	FAC	3
Eupatorium altissumum	2	0	1	2	1	1.20	0.67	0	3	2.02	FACU	4
Eupatorium perfoliatum	0.1	1	0.1	0.1	0	0.26	0.15	0	5	0.73	OBL	1
Euthamia gymnospermoides	10	0	0.1	0	0	2.02	1.13	0	4	4.53	FACW	2
Galium tinctorum	0	0.1	0	0	0	0.02	0.01	0	7	0.08	FACW	2
Glychyrrhiza lepidota	0.1	0	0	1	0	0.22	0.12	0	4	0.49	FACU	4

Helenium autumnale	1	0.1	0.1	1	2	0.84	0.47	0	6	2.83	FACW	2
Helianthus maximiliani	2	0	15	2	0.1	3.82	2.14	0	4	8.57	UPL	5
Hypoxis hirsuta	0.1	0	0.1	0.1	0.1	0.08	0.04	0	7	0.31	FACW	2
Juncus balticus	1	0	0	0	2	0.60	0.34	0	6	2.02	OBL	1
Juncus dudleyi	1	0.1	1	2	2	1.22	0.68	0	5	3.42	FACW	2
Juncus nodosus	0	0	0	1	2	0.60	0.34	0	6	2.02	OBL	1
Juncus torreyi	10	0	1	1	1	2.60	1.46	0	4	5.84	FACW	2
Leersia oryzoides	0	2	0	0	0	0.40	0.22	0	4	0.90	OBL	1
Lippia lanceolata	1	1	0.1	0	0.1	0.44	0.25	0	3	0.74	OBL	1
Ludwigia palustris	0	1	0	0	0	0.20	0.11	0	5	0.56	OBL	1
Lycopus americanus	0.1	0.1	0.1	1	0.1	0.28	0.16	0	4	0.63	OBL	1
Lysimachia thyrsiflora	0.1	1	0	0	0	0.22	0.12	0	7	0.86	OBL	1
Lythrum alatum	0.1	0	0.1	0	0	0.04	0.02	0	6	0.13	OBL	1
Lythrum salicaria	2	0	0.1	0	0	0.42	0.24	1	0	0.00	OBL	1
Mentha arvensis	0	0.1	0	0	0	0.02	0.01	0	4	0.04	FACW	2
Panicum acuminatum	0.1	0	0.1	0	0.1	0.06	0.03	0	6	0.20	FACW	2
Panicum virgatum	30	0	15	30	30	21.00	11.78	0	4	47.14	FAC	3
Phleum pratense	0	0	0.1	0	0	0.02	0.01	1	0	0.00	FACU	4
Polygonum coccineum	0	30	0	0	0	6.00	3.37	0	2	6.73	FACW	2
Polygonum persicaria	0	0.1	0	0	0	0.02	0.01	1	0	0.00	OBL	1
Prunella vulgaris	0.1	0	0	0	0	0.02	0.01	1	0	0.00	FACW	2
Ranunculus cymbalaria	1	0	4	0.1	1	1.22	0.68	0	3	2.05	OBL	1
Schoenoplectus pungens	30	30	2	5	30	19.40	10.89	0	4	43.55	OBL	1
Schoenoplectus tabernaemontana	0	0.1	0	0	0	0.02	0.01	0	5	0.06	OBL	1
Scutellaria galericulata	0	0.1	0	0	0	0.02	0.01	0	6	0.07	OBL	1
Sisyrinchium montanum	0.1	0	0.1	0.1	0.1	0.08	0.04	0	5	0.22	FAC	3
Solidago gigantea	1	0	1	0.1	0	0.42	0.24	0	3	0.71	FACW	2
Sorghastrum nutans	0	0	2	1	0	0.60	0.34	0	5	1.68	FACU	4

Sparganium eurycarpum	0	1	0	0	0	0.20	0.11	0	5	0.56	OBL	1
Spartina pectinata	0	10	10	1	5	5.20	2.92	0	5	14.59	FACW	2
Taraxicum officianale	0.1	0	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Triglochin maritima	1	0	1	1	2	1.00	0.56	0	5	2.81	OBL	1
Verbena hastata	0.1	0.1	0.1	0	0	0.06	0.03	0	4	0.13	FACW	2
Vernonia fasciculata	1	0	0.1	0.1	0.1	0.26	0.15	0	4	0.58	FAC	3

CP5

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Alisma triviale	0	1	1	0.1	0	0.42	0.32	0	4	1.30	OBL	1
Ambrosia trifida	0	0	0	0.1	0	0.02	0.02	0	0	0.00	FACW	2
Apocynum cannabinum	0.1	0	0	0	0	0.02	0.02	0	2	0.03	FAC	3
Asclepias incarnata	0.1	0.1	0.1	0.1	0	0.08	0.06	0	4	0.25	OBL	1
Aster lanceolatus	0.1	0	0.1	0.1	0	0.06	0.05	0	2	0.09	FACW	2
Bidens frondosa	0	0	0	0.1	0	0.02	0.02	0	1	0.02	FACW	2
Boehmeria cylindrica	0.1	0	0.1	0.1	0.1	0.08	0.06	0	6	0.37	OBL	1
Calamagrostis stricta	0	0.1	0.1	0.1	0	0.06	0.05	0	6	0.28	FACW	2
Carex emoryi	50	40	5	10	50	31.00	23.96	0	5	119.80	OBL	1
Carex pellita	15	15	5	10	20	13.00	10.05	0	4	40.19	OBL	1
Carex stipata	0.1	0	0	2	0	0.42	0.32	0	5	1.62	OBL	1
Cicuta maculata	0.1	0	0	0.1	0	0.04	0.03	0	5	0.15	OBL	1
Eleocharis erythropoda	0.1	0.1	0.1	10	1	2.26	1.75	0	5	8.73	OBL	1
Eleocharis palustris	0	0	0.1	0.1	0	0.04	0.03	0	4	0.12	OBL	1
Equisetum arvense	0.1	0	0	0	0	0.02	0.02	0	4	0.06	FAC	3
Eupatorium altissimum	0.1	0	0	0.1	0	0.04	0.03	0	3	0.09	FACU	4
Eupatorium perfoliatum	0.1	0	0	0	0	0.02	0.02	0	5	0.08	OBL	1
Galium obtusum	0	0	0	0.1	0	0.02	0.02	0	6	0.09	FACW	2

Glyceria striata	0.1	0	0	0	0.1	0.04	0.03	0	5	0.15	OBL	1
Helenium autumnale	0	0	0	0.1	0	0.02	0.02	0	6	0.09	FACW	2
Hordeum jubatum	0	0	0.1	0.1	0	0.04	0.03	0	1	0.03	FACW	2
Iva annua	0.1	0	0	0	0	0.02	0.02	0	1	0.02	FAC	3
Juncus dudleyi	0.1	0	0	0	0	0.02	0.02	0	5	0.08	FACW	2
Leersia oryzoides	10	10	10	20	10	12.00	9.28	0	4	37.10	OBL	1
Lippia lanceolata	0.1	2	1	5	0	1.62	1.25	0	3	3.76	OBL	1
Ludwigia palustris	0.1	1	1	0.1	1	0.64	0.49	0	5	2.47	OBL	1
Lycopus americanus	0.1	0	0.1	0.1	0.1	0.08	0.06	0	4	0.25	OBL	1
Lysimachia thrysiflora	2	0	0.1	0.1	1	0.64	0.49	0	7	3.46	OBL	1
Lythrum alatum	0.1	0	0	0	0	0.02	0.02	0	6	0.09	OBL	1
Lythrum salicaria	0.1	0.1	0.1	0.1	0	0.08	0.06	1	0	0.00	OBL	1
Mentha arvensis	1	0.1	1	1	1	0.82	0.63	0	4	2.54	FACW	2
Mimulus ringens	0	0	1	0	0.1	0.22	0.17	0	6	1.02	OBL	1
Penthorum sedoides	0	0	1	0.1	0	0.22	0.17	0	4	0.68	OBL	1
Phalaris arundinacea	1	10	10	5	10	7.20	5.57	1	0	0.00	FACW	2
Polygonum presicaria	0.1	0.1	0.1	0	0.1	0.08	0.06	1	0	0.00	OBL	1
Ranunculus scelaratus	1	0.1	2	0.1	1	0.84	0.65	1	0	0.00	OBL	1
Rorippa palustris	0.1	0.1	1	0.1	0.1	0.28	0.22	0	4	0.87	OBL	1
Rumex crispus	0	0	0	0.1	0	0.02	0.02	1	0	0.00	FACW	2
Schoenoplectus pungens	10	1	5	5	12	6.60	5.10	0	4	20.41	OBL	1
Schoenoplectus tabernaemontana	0	10	0	0	0	2.00	1.55	0	5	7.73	OBL	1
Scuttelaria galericulata	0.1	0	0.1	0	0	0.04	0.03	0	6	0.19	OBL	1
Sium suave	0.1	0.1	0.1	0	0	0.06	0.05	0	7	0.32	OBL	1
Solidago gigantea	0.1	0.1	0	0.1	0	0.06	0.05	0	3	0.14	FACW	2
Sparganium eurycarpum	30	50	60	40	40	44.00	34.01	0	5	170.04	OBL	1
Spartina pectinata	1	2	0	2	5	2.00	1.55	0	5	7.73	FACW	2
Teucrium canadense	0.1	0	0	0.1	0	0.04	0.03	0	4	0.12	FACW	2

Thelypteris palustris	0.1	0	0	0	0	0.02	0.02	0	7	0.11	FACW	2
Ulmus americana	0	10	0	0	0	2.00	1.55	0	3	4.64	FAC	3
Vernonia fasciculata	0	0	0	0	0.1	0.02	0.02	0	4	0.06	FAC	3
Viola sororia	0	0	0	0.1	0	0.02	0.02	0	3	0.05	FACW	2

CP6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alopecurus carolinianus	0	0	0	1	0	0.20	0.06	0	1	0.06	FACW	2
Aster lanceolatus	0.1	1	1	0.1	0.1	0.46	0.15	0	2	0.30	FACW	2
Calamagrostis stricta	45	70	70	60	30	55.00	17.75	0	6	106.49	FACW	2
Carex emoryi	80	75	50	30	60	59.00	19.04	0	5	95.20	OBL	1
Carex interior	0	0	10	0	0	2.00	0.65	0	7	4.52	OBL	1
Carex pellita	15	10	5	5	5	8.00	2.58	0	4	10.33	OBL	1
Carex praegracilis	1	0	10	2	1	2.80	0.90	0	4	3.61	FACW	2
Carex scoparia	30	15	20	10	1	15.20	4.91	0	5	24.53	FACW	2
Carex stipata	10	10	10	1	1	6.40	2.07	0	5	10.33	OBL	1
Carex tetanica	0	1	2	1	1	1.00	0.32	0	7	2.26	FACW	2
Carex vulpinoidea	0	0	2	0	1	0.60	0.19	0	4	0.77	OBL	1
Cornus drummondii	0	0	0	0.1	0	0.02	0.01	0	3	0.02	FAC	3
Eleocharis palustris	90	40	40	80	80	66.00	21.30	0	4	85.19	OBL	1
Elymus trachycaulus	0	0	1	0	0	0.20	0.06	0	5	0.32	FACU	4
Equisetum arvense	0.1	0.1	1	0.1	0.1	0.28	0.09	0	4	0.36	FAC	3
Eupatorium perfoliatum	2	4	0.1	0.1	0	1.24	0.40	0	5	2.00	OBL	1
Euthamia gymnospermoides	0	1	0	0	0	0.20	0.06	0	4	0.26	FACW	2
Fraxinus pennsylvanica	0	0.1	0	0	0	0.02	0.01	0	2	0.01	FACW	2
Glyceria striata	2	20	30	5	10	13.40	4.32	0	5	21.62	OBL	1
Helenium autumnale	1	1	0.1	0.1	0.1	0.46	0.15	0	6	0.89	FACW	2

Hordeum jubatum	5	0	0.1	1	0.1	1.24	0.40	0	1	0.40	FACW	2
Juncus brachyphyllus	0	0	0	0	0.1	0.02	0.01	0	6	0.04	FACU	4
Juncus dudleyi	5	5	10	1	1	4.40	1.42	0	5	7.10	FACW	2
Leersia oryzoides	0	0	0.1	10	1	2.22	0.72	0	4	2.87	OBL	1
Lippia lanceolata	4	1	4	1	10	4.00	1.29	0	3	3.87	OBL	1
Lycopus americanus	5	10	6	1	1	4.60	1.48	0	4	5.94	OBL	1
Lysimachia ciliata	0	0	0	0.1	0	0.02	0.01	0	5	0.03	FACW	2
Lysimachia thrysiflora	10	4	2	0.1	0.1	3.24	1.05	0	7	7.32	OBL	1
Lythrum solicaria	2	10	1	0	0.1	2.62	0.85	1	0	0.00	OBL	1
Mentha arvensis	4	2	1	0.1	0.1	1.44	0.46	0	4	1.86	FACW	2
Panicum virgatum	0	0	0.1	0	0	0.02	0.01	0	4	0.03	FAC	3
Phalaris arundinacea	10	15	2	5	2	6.80	2.19	1	0	0.00	FACW	2
Poa compressa	0	0	0.1	0.1	0	0.04	0.01	1	0	0.00	FACU	4
Poa pratensis	10	10	10	1	1	6.40	2.07	1	0	0.00	FACU	4
Ranunculus sceleratus	0	0	0	3	0	0.60	0.19	1	0	0.00	OBL	1
Schoenoplectus pungens	40	40	50	20	1	30.20	9.75	0	4	38.98	OBL	1
Schoenoplectus tabernaemontana	0	0	0	1	0	0.20	0.06	0	5	0.32	OBL	1
Scuttelaria galericulata	0.1	1	0.1	0	0	0.24	0.08	0	6	0.46	OBL	1
Solidago gigantea	0	0.1	1	0	0	0.22	0.07	0	3	0.21	FACW	2
Sparganium eurycarpum	0	0	0	0.1	0	0.02	0.01	0	5	0.03	OBL	1
Spartina pectinata	0	5	20	0	10	7.00	2.26	0	5	11.29	FACW	2
Verbena hastata	0.1	0	2	0	0	0.42	0.14	0	4	0.54	FACW	2
Vernonia fasciculata	2	4	1	0.1	0.1	1.44	0.46	0	4	1.86	FAC	3

CP7

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia psilotachya	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	1	0.08	FAC	3

Aster lanceolatus	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	2	0.15	FACW	2
Bromus inermis	1	1	0	0	0	0.40	0.30	1	0	0.00	FACU	4
Calamagrostis stricta	0.1	1	1	0.1	0	0.44	0.33	0	6	2.00	FACW	2
Carex emoryi	15	2	10	25	20	14.40	10.89	0	5	54.45	OBL	1
Carex pellita	10	4	10	20	10	10.80	8.17	0	4	32.67	OBL	1
Carex praegracilis	0	10	2	5	0	3.40	2.57	0	4	10.29	FACW	2
Carex vulpinoidea	2	0	1	0	0.1	0.62	0.47	0	4	1.88	OBL	1
Cirsium vulgare	0.1	0.1	0.1	0	0	0.06	0.05	1	0	0.00	UPL	5
Conyza canadensis	0.1	0	0	0.1	0	0.04	0.03	0	0	0.00	FACU	4
Dactylus glomerata	0.1	0	0	0	0	0.02	0.02	1	0	0.00	FACU	4
Eleocharis palustris	50	30	25	30	20	31.00	23.45	0	4	93.78	OBL	1
Equisetum laevigitum	0	0.1	0	0	0	0.02	0.02	0	4	0.06	FACW	2
Erigeron philidelphicus	0.1	0	0	0	0	0.02	0.02	0	3	0.05	FAC	3
Festuca rubra	0	0.1	0	0	0	0.02	0.02	1	0	0.00	FAC	3
Helenium autumnale	0	0.1	0.1	0	0	0.04	0.03	0	6	0.18	FACW	2
Hordeum jubatum	2	0.1	1	1	1	1.02	0.77	0	1	0.77	FACW	2
Iva annua	0.1	0.1	0.1	1	1	0.46	0.35	0	1	0.35	FAC	3
Juncus dudleyi	1	10	1	0	0	2.40	1.82	0	5	9.08	FACW	2
Lactuca serriola	0.1	0	0	0.1	0	0.04	0.03	1	0	0.00	FAC	3
Leersia oryzoides	1	0	0.1	0	0.1	0.24	0.18	0	4	0.73	OBL	1
Lippia lanceolata	40	15	25	40	40	32.00	24.20	0	3	72.61	OBL	1
Lolium arundinaceum	0	0.1	0	0	0	0.02	0.02	1	0	0.00	FACU	4
Lotus corniculata	0	0.1	0	0	0	0.02	0.02	1	0	0.00	FACU	4
Lycopus americanus	0.1	0.1	0.1	0.1	0	0.08	0.06	0	4	0.24	OBL	1
Lysimachia ciliata	0	0	0	0	0.1	0.02	0.02	0	5	0.08	FACW	2
Lythrum salicaria	0.1	0.1	0.1	0	0	0.06	0.05	1	0	0.00	OBL	1
Mentha arvensis	0.1	0	1	1	0	0.42	0.32	0	4	1.27	FACW	2
Mimulus ringens	0	0	0	0.1	0	0.02	0.02	0	6	0.09	OBL	1

Panicum virgatum	0	15	2	0	2	3.80	2.87	0	4	11.50	FAC	3
Pascopyrum smithii	0	2	0	0.1	1	0.62	0.47	0	3	1.41	FAC	3
Phalaris arundinacea	1	0.1	0	0	0	0.22	0.17	1	0	0.00	FACW	2
Poa pratensis	10	25	25	10	25	19.00	14.37	1	0	0.00	FACU	4
Polygonum amphibium	0	0	0	0.1	1	0.22	0.17	0	6	1.00	OBL	1
Polygonum coccineum	0	0	0	0	0.1	0.02	0.02	0	2	0.03	FACW	2
Ranunculus sceleratus	0.1	0.1	0.1	0.1	0	0.08	0.06	1	0	0.00	OBL	1
Rosa multiflora	0.1	3	0	0	0	0.62	0.47	1	0	0.00	UPL	5
Rosa woodsii	0	1	0	0	0	0.20	0.15	0	4	0.61	FACU	4
Rumex crispus	0.1	0.1	0.1	0.1	0.1	0.10	0.08	1	0	0.00	FACW	2
Schoenoplectus pungens	10	3	2	0.1	2	3.42	2.59	0	4	10.35	OBL	1
Scutellaria galericulata	1	0	0.1	1	0.1	0.44	0.33	0	6	2.00	OBL	1
Solidago gigantea	0	0	0.1	0	0	0.02	0.02	0	3	0.05	FACW	2
Sparganium eurycarpum	0.1	0	0.1	0.1	0	0.06	0.05	0	5	0.23	OBL	1
Spartina pectinata	1	1	1	1	0.1	0.82	0.62	0	5	3.10	FACW	2
Taraxacum officianale	0.1	0.1	0	0	0.1	0.06	0.05	1	0	0.00	FACU	4
Teucrium canadense	0	0	0.1	0	0.1	0.04	0.03	0	4	0.12	FACW	2
Trifolium repens	0.1	20	0	0	0	4.02	3.04	1	0	0.00	FACU	4
Verbena hastata	0.1	0	0	0	0	0.02	0.02	0	4	0.06	FACW	2
Vernonia fasciculata	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	4	0.30	FAC	3
Veronica arvensis	0.1	0	0	0.1	0	0.04	0.03	1	0	0.00	FACU	4
Viola sororia	0.1	0	0	0	0	0.02	0.02	0	3	0.05	FACW	2

CP8

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis gigantea	0	1	0	0	0	0.20	0.09	1	0	0.00	FACW	2
Ambrosia psilotachya	0.1	1	0	0.1	0	0.24	0.10	0	1	0.10	FAC	3

Aster falcatus	0	0.1	0	0	0	0.02	0.01	0	4	0.03	FAC	3
Aster lanceolatus	0.1	1	1	1	0.1	0.64	0.28	0	2	0.56	FACW	2
Bouteloua curtipendula	0	0	0	0.1	0	0.02	0.01	0	5	0.04	UPL	5
Carex crawei	0	15	0	4	0	3.80	1.65	0	6	9.91	FACW	2
Carex emoryi	50	1	50	2	50	30.60	13.30	0	5	66.51	OBL	1
Carex granularis	0	2	0	2	0	0.80	0.35	0	6	2.09	FACW	2
Carex pellita	30	20	15	15	30	22.00	9.56	0	4	38.25	OBL	1
Carex praegracilis	4	4	2	10	10	6.00	2.61	0	4	10.43	FACW	2
Carex tetanica	1	6	0	4		2.20	0.96	0	7	6.69	FACW	2
Carex vulpinoidea	2	0.1	15	0	2	3.82	1.66	0	4	6.64	OBL	1
Cicuta maculata	0.1	0	0	0	0	0.02	0.01	0	5	0.04	OBL	1
Cornus drummondii	0.1	0.1	0	0	0	0.04	0.02	0	3	0.05	FAC	3
Digitaria cognata	0	0.1	0	0	0	0.02	0.01	0	4	0.03	UPL	5
Eleocharis compressa	2	20	0	20	0	8.40	3.65	0	6	21.91	FACW	2
Eleocharis palustris	10	0	1	0	2	2.60	1.13	0	4	4.52	OBL	1
Elymus trachycaulus	0	15	0	10	0	5.00	2.17	0	5	10.87	FACU	4
Equisetum laevigatum	0.1	1	1	0.1	0	0.44	0.19	0	4	0.77	FACW	2
Eupatoria altissimum	0	0.1	0	0	0	0.02	0.01	0	3	0.03	OBL	1
Hordeum jubatum	0.1	0	0	0.1	5	1.04	0.45	0	1	0.45	FACW	2
Iva annua	5	40	15	40	2	20.40	8.87	0	1	8.87	FAC	3
Juncus balticus	0	0	0	12	0	2.40	1.04	0	6	6.26	OBL	1
Juncus dudleyi	0	1	0	0	0	0.20	0.09	0	5	0.43	FACW	2
Juniperus virginiana	0	1	0	0	0	0.20	0.09	0	1	0.09	FACU	4
Lippia lanceolata	50	10	40	0	10	22.00	9.56	0	3	28.69	OBL	1
Lycopus americanus	0.1	0.1	0	0	0.1	0.06	0.03	0	4	0.10	OBL	1
Lythrum salicaria	0	0	0	0.1	0	0.02	0.01	1	0	0.00	OBL	1
Mentha arvensis	0.1	0	0.1	0	0	0.04	0.02	0	4	0.07	FACW	2
Panicum acuminatum	0	0.1	0	0	0	0.02	0.01	0	6	0.05	FACW	2

Panicum virgatum	0	15	0	4	0	3.80	1.65	0	4	6.61	FAC	3
Phalaris arundinacea	70	10	60	10	65	43.00	18.69	1	0	0.00	FACW	2
Phleum pratensis	2	0.1	0.1	0	0	0.44	0.19	1	0	0.00	FACU	4
Poa compressa	0	2	0	4	0	1.20	0.52	1	0	0.00	FACU	4
Poa pratensis	10	15	10	30	10	15.00	6.52	1	0	0.00	FACU	4
Rumex crispus	0.1	0	0	0	0	0.02	0.01	1	0	0.00	FACW	2
Schoenoplectus pungens	2	2	6	4	5	3.80	1.65	0	4	6.61	OBL	1
Sisyrinchium montanum	0	0.1	0	0	0	0.02	0.01	0	5	0.04	FAC	3
Solidago gigantea	0	0.1	0	0	0	0.02	0.01	0	3	0.03	FACW	2
Spartina pectinata	35	10	60	20	15	28.00	12.17	0	5	60.86	FACW	2
Taraxacum officianale	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Trifolium repens	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Vernonia fasciculata	0.1	2	4	1	0.1	1.44	0.63	0	4	2.50	FAC	3

CP9

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alisma triviale	0	2	0.1	0	0	0.42	0.24	0	4	0.97	OBL	1
Alopecurus carolinianus	0	4	15	10	0	5.80	3.36	0	1	3.36	FACW	2
Ambrosia psilotachya	0.1	0	0	0.1	0.1	0.06	0.03	0	1	0.03	FAC	3
Apocynum cannabinum	0.1	0	0	0	0	0.02	0.01	0	2	0.02	FAC	3
Asclepias incarnata	0	0	0	1	1	0.40	0.23	0	4	0.93	OBL	1
Aster lanceolatus	0.1	0.1	0.1	2	2	0.86	0.50	0	2	1.00	FACW	2
Bidens cernua	0	0.1	4	2	0	1.22	0.71	0	3	2.12	OBL	1
Bidens frondosa	0.1	0	0	0	0	0.02	0.01	0	1	0.01	FACW	2
Bromus japonicus	0	0	0	0	0.1	0.02	0.01	1	0	0.00	FACU	4
Carduus nutans	0.1	0	0	0	0	0.02	0.01	1	0	0.00	UPL	5
Carex emoryi	60	25	5	25	60	35.00	20.25	0	5	101.26	OBL	1

Carex molesta	0	0.1	0	0	0	0.02	0.01	0	3	0.03	FAC	3
Carex pellita	25	5	5	20	30	17.00	9.84	0	4	39.35	OBL	1
Carex scoparia	6	0.1	0	2	5	2.62	1.52	0	5	7.58	FACW	2
Carex stipata	10	25	0	10	25	14.00	8.10	0	5	40.50	OBL	1
Carex vulpinoidea	0	0	0	1	1	0.40	0.23	0	4	0.93	OBL	1
Conyza canadensis	0.1	0	0	0	0	0.02	0.01	0	0	0.00	FACU	4
Cornus drummondii	0	0	0	0.1	0	0.02	0.01	0	3	0.03	FAC	3
Eleocharis acicularis	0	0	0	0.1	0	0.02	0.01	0	4	0.05	OBL	1
Eleocharis erythropoda	0	50	15	10	0	15.00	8.68	0	5	43.40	OBL	1
Eleocharis palustris	8	0	0	0	4	2.40	1.39	0	4	5.55	OBL	1
Fraxinus pennsylvanica	0	0.1	0	0	0	0.02	0.01	0	2	0.02	FACW	2
Galium aparine	0.1	0.1	0	0.1	1	0.26	0.15	0	0	0.00	FACU	4
Galium obtusum	0	30	5	6	0.1	8.22	4.76	0	6	28.54	FACW	2
Helianthus grossesseratus	0	0	0	0.1	0	0.02	0.01	0	4	0.05	FACW	2
Hordeum jubatum	6	4	0.1	5	2	3.42	1.98	0	1	1.98	FACW	2
Iva annua	0	2	2	2	0	1.20	0.69	0	1	0.69	FAC	3
Juncus dudleyi	0	0	0.1	1	1	0.42	0.24	0	5	1.22	FACW	2
Lactuca serriola	0.1	0	0	0.1	0.1	0.06	0.03	1	0	0.00	FAC	3
Leersia oryzoides	1	20	4	5	2	6.40	3.70	0	4	14.81	OBL	1
Lolium pratense	1	0	0	0	0	0.20	0.12	1	0	0.00	FAC	3
Ludwigia palustris	0	0.1	1	0	0	0.22	0.13	0	5	0.64	OBL	1
Lycopus americanus	0.1	0.1	0	1	0.1	0.26	0.15	0	4	0.60	OBL	1
Lysimachia ciliata	0	0.1	0	0.1	0	0.04	0.02	0	5	0.12	FACW	2
Mentha arvensis	0	1	3	10	6	4.00	2.31	0	4	9.26	FACW	2
Mimulus ringens	0	0.1	0	0	0.1	0.04	0.02	0	6	0.14	OBL	1
Penthorum sedoides	0	0.1	0.1	0.1	0.1	0.08	0.05	0	4	0.19	OBL	1
Phalaris arundinacea	10	10	3	10	15	9.60	5.55	1	0	0.00	FACW	2
Phleum pratense	0	0	0	0.1	0	0.02	0.01	1	0	0.00	FACU	4

Poa pratensis	30	2	0	25	25	16.40	9.49	1	0	0.00	FACU	4
Polygonum amphibium	6	2	0	25	25	11.60	6.71	0	6	40.27	OBL	1
Polygonum persicaria	6	6	0	0	2	2.80	1.62	1	0	0.00	OBL	1
Polygonum punctatum	0	3	10	1	2	3.20	1.85	0	4	7.41	OBL	1
Potomageton pectinatus	0	0.1	0.1	0	0	0.04	0.02	0	6	0.14	OBL	1
Ranunculus cymbalaria	0	0.1	0	0	0	0.02	0.01	0	3	0.03	OBL	1
Ranunculus sceleratus	0.1	0.1	2	0	0	0.44	0.25	1	0	0.00	OBL	1
Rorippa palustris var. glabra	0.1	0.1	0.1	3	0.1	0.68	0.39	0	4	1.57	OBL	1
Rumex crispus	0.1	0.1	0.1	1	1	0.46	0.27	1	0	0.00	FACW	2
Salix amigdaloides	0	0	0.1	0	0	0.02	0.01	0	4	0.05	FACW	2
Schoenoplectus pungens	0	0.1	0	4	4	1.62	0.94	0	4	3.75	OBL	1
Schoenoplectus tabernaemontana	0	0.1	1	0	0	0.22	0.13	0	5	0.64	OBL	1
Scirpus pallidus	0.1	1	0.1	4	2	1.44	0.83	0	5	4.17	OBL	1
Scutellaria galericulata	0.1	1	0	0.1	0	0.24	0.14	0	6	0.83	OBL	1
Sium suave	0	1	2	0.1	0	0.62	0.36	0	7	2.51	OBL	1
Sparganium eurycarpum	0	10	0.1	0	0	2.02	1.17	0	5	5.84	OBL	1
Spartina pectinata	2	0	0	0	0	0.40	0.23	0	5	1.16	FACW	2
Taraxacum officianale	0	0	0	0.1	0	0.02	0.01	1	0	0.00	FACU	4
Thlaspi arvensis	0	0	0	0	0.1	0.02	0.01	1	0	0.00	FACU	4
Trifolium repens	0	0	0	0.1	0	0.02	0.01	1	0	0.00	FACU	4
Tuecrium canadense	0	0	0	0	0.1	0.02	0.01	0	4	0.05	FACW	2
Verbena hastata	0.1	0	0	0.1	0.1	0.06	0.03	0	4	0.14	FACW	2
Vernonia fasciculata	0	0	0	2	1	0.60	0.35	0	4	1.39	FAC	3
Veronica peregrina	0	0	0	0.1	0	0.02	0.01	0	1	0.01	OBL	1
Viola sororia	0.1	0	0	0	0	0.02	0.01	0	3	0.03	FACW	2

CTPREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Ambrosia artemisifolia	0	0	0.1	0	0	0.02	0.02	0	0	0.00	FACU	4
Artemisia ludoviciana	0.1	0.1	0.1	0.1	0	0.08	0.10	0	4	0.39	FACU	4
Carex brevior	0.1	0.1	1	1	0.1	0.46	0.56	0	4	2.24	FAC	3
Chenopodium album	0.1	0.1	0.1	0.1	0	0.08	0.10	1	0	0.00	FAC	3
Circium vulgare	0.1	0.1	0.1	0	0	0.06	0.07	1	0	0.00	UPL	5
Coreopsis tinctoria	0.1	0.1	0.1	0	0	0.06	0.07	0	1	0.07	FAC	3
Eleocharis palustris	0.1	0.1	0.1	0.1	0.1	0.10	0.12	0	4	0.49	OBL	1
Hordeum jubatum	18	5	3	0.1	0.1	5.24	6.38	0	1	6.38	FACW	2
Kochia scoparia	0	0	0.1	0.1	0	0.04	0.05	1	0	0.00	FACU	4
Marsilia vestita	0	0	0.1	0	0	0.02	0.02	0	3	0.07	OBL	1
Pascopyrum smithii	1	5	3	5	5	3.80	4.63	0	3	13.88	FACU	4
Poa pratensis	20	70	90	90	90	72.00	87.63	1	0	0.00	FACU	4
Polygonum arviculare	0.1	0.1	0.1	0.1	0.1	0.10	0.12	1	0	0.00	FACW	2
Polygonum bicorne	0.1	0	0	0	0	0.02	0.02	0	0	0.00	FACW	2
Rumex stenophyllus	0.1	0	0.1	0	0	0.04	0.05	1	0	0.00	FACW	2
Verbena bracteata	0.1	0	0.1	0	0	0.04	0.05	0	0	0.00	FACU	4

CTP1

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alopecuris carolinianus	0.1	0.1	0.1	10	0	2.06	1.30	0	1	1.30	FACW	2
Ambrosia artemisifolia	12	7	6	6	65	19.20	12.14	0	0	0.00	FACU	4
Callirhoe involucrata	0	0	0	0.1	0	0.02	0.01	0	2	0.03	UPL	5
Carex brevior	0	0	0	0.1	0	0.02	0.01	0	4	0.05	FAC	3
Chenopodium album	0.1	0.1	0.1	0.1	1	0.28	0.18	1	0	0.00	FAC	3
Cirsium vulgare	0.1	0.1	0	0	0.1	0.06	0.04	1	0	0.00	UPL	5

Conyza canadensis	0.1	0.1	0.1	0.1	0	0.08	0.05	0	0	0.00	FACU	4
Coreopsis tinctoria	45	20	65	18	12	32.00	20.24	0	2	40.47	FAC	3
Echinocloa muricata	25	45	70	65	15	44.00	27.82	0	0	0.00	OBL	1
Eleocharis palustris	0.1	0.1	0.1	0	0.1	0.08	0.05	0	4	0.20	OBL	1
Helianthus annuus	0.1	0.1	0.1	0.1	0.1	0.10	0.06	0	0	0.00	FACU	4
Hordeum jubatum	7	5	0	2	0	2.80	1.77	0	1	1.77	FACW	2
Lactuca serriola	0.1	0.1	0	0.1	0.1	0.08	0.05	1	0	0.00	FAC	3
Lotus purshianus	0	0.1	0	0	0	0.02	0.01	0	3	0.04	FAC	3
Panicum dichotomiflorum	0	0	0.1	0	0	0.02	0.01	0	0	0.00	FAC	3
Polygonum aviculare	5	1	1	1	1	1.80	1.14	1	0	0.00	FACW	2
Polygonum bicorne	0.1	1	0.1	0.1	0.1	0.28	0.18	0	0	0.00	FACW	2
Polygonum coccineum	30	1	0.1	0.1	0.1	6.26	3.96	0	2	7.92	FACW	2
Polygonum lapathifolium	55	55	40	55	15	44.00	27.82	0	2	55.65	OBL	1
Polygonum ramosissimum	0	0	0	0.1	0.1	0.04	0.03	0	3	0.08	FAC	3
Potentilla norvegica	0.1	0.1	0.1	0.1	0.1	0.10	0.06	0	2	0.13	FAC	3
Rumex altissimus	0.1	0.1	0	3	0.1	0.66	0.42	0	0	0.00	FAC	3
Schoenoplectus tabernaemontani	0	0.1	0.1	0.1	0.1	0.08	0.05	0	5	0.25	OBL	1
Taraxacum officianale	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Typha angustifolia	0	0	0.1	0.1	20	4.04	2.55	1	0	0.00	OBL	1
Verbena bracteata	0	0	0	0	0.1	0.02	0.01	0	0	0.00	FACU	4
Veronica peregrina	0	0	0	0	0.1	0.02	0.01	0	1	0.01	OBL	1

CTP2

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Phalaris arundinacea	80	85	85	85	85	84.00	99.17	1	0	0.00	FACW	2
Eleocharis palustris	0.1	1	1	0.1	0.1	0.46	0.54	0	4	2.17	OBL	1
Chenopodium album	0	0	0	0.1	0	0.02	0.02	1	0	0.00	FAC	3
Phleum pratense	0	0	0	0.1	1	0.22	0.26	1	0	0.00	FACU	4

CTP3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

CTP4

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

CTP5

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Ambrosia artemisifolia	0.1	0.1	1	15	6	4.44	4.56	0	0	0.00	FACU	4
Carex brevior	0.1	0	0	0	1	0.22	0.23	0	4	0.90	FAC	3
Carex gravida	2	0.1	2	7	2	2.62	2.69	0	4	10.77	FACU	4
Chenopodium album	2	0.1	0.1	0.1	0.1	0.48	0.49	1	0	0.00	FAC	3
Conyza canadensis	0	0	0	0	0.1	0.02	0.02	0	0	0.00	FACU	4
Echinocloa muricata	0.1	0.1	0.1	0.1	0.1	0.10	0.10	0	0	0.00	OBL	1
Eleocharis palustris	0.1	0	1	1	0.1	0.44	0.45	0	4	1.81	OBL	1
Helianthus annuus	0.1	0	0.1	1	0.1	0.26	0.27	0	0	0.00	FACU	4

Hordeum jubatum	1	0.1	1	80	85	33.42	34.33	0	1	34.33	FACW	2
Lotus purshianus	0	0	0	0.1	0.1	0.04	0.04	0	3	0.12	FAC	3
Pascopyrum smithii	0	0	0	0	1	0.20	0.21	0	3	0.62	FAC	3
Polygonum aviculare	2	0.1	2	0.1	0.1	0.86	0.88	1	0	0.00	FACW	2
Polygonum bicorne	90	85	90	1	1	53.40	54.86	0	0	0.00	FACW	2
Polygonum ramosissimum	0.1	0.1	0.1	2	1	0.66	0.68	0	3	2.03	FAC	3
Rumex crispus	0.1	0.1	0.1	0.1	0.1	0.10	0.10	1	0	0.00	FACW	2
Verbena bracteata	0.1	0.1	0	0.1	0.1	0.08	0.08	0	0	0.00	FACU	4

CTP6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Amaranthus blitoides	0.1	0.1	0	0	0	0.04	0.08	0	0	0.00	FACW	2
Ambrosia artemisifolia	0	0	0	0.1	0	0.02	0.04	0	0	0.00	FACU	4
Coreopsis tinctoria	40	25	50	50	40	41.00	84.29	0	1	84.29	FAC	3
Echinocloa muricata	1	1	1	1	1	1.00	2.06	0	0	0.00	OBL	1
Eleocharis palustris	0.1	1	4	3	1	1.82	3.74	0	4	14.97	OBL	1
Hordeum jubatum	0	0	0	0	0.1	0.02	0.04	0	1	0.04	FACW	2
Marsilia vestita	3	3	1	1	0.1	1.62	3.33	0	3	9.99	OBL	1
Polygonum aviculare	1	0.1	1	1	2	1.02	2.10	1	0	0.00	FACW	2
Polygonum bicorne	3	2	1	1	1	1.60	3.29	1	0	0.00	FACW	2
Populus deltoides	0.1	0	0.1	0	0	0.04	0.08	0	3	0.25	FAC	3
Rorippa palustris	0.1	0.1	0.1	0.1	0.1	0.10	0.21	0	4	0.82	OBL	1
Solanum rostratum	0.1	0.1	0.1	0.1	1	0.28	0.58	0	0	0.00	UPL	5
Verbena bracteata	0	0.1	0	0.1	0	0.04	0.08	0	0	0.00	FACU	4
Xanthium strumarium	0	0.1	0.1	0	0	0.04	0.08	0	1	0.08	FAC	3

CTP7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Cirsium vulgare	0	0.1	0	0	0	0.02	0.02	1	0	0.00	UPL	5
Phalaris arundinacea	85	85	85	85	85	85.00	87.23	1	0	0.00	FACW	2
Polygonum coccineum	10	10	10	15	17	12.40	12.73	0	2	25.45	FACW	2
Rumex stenophylla	0	0	0	0.1	0	0.02	0.02	1	0	0.00	FACW	2

CTP8

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bolboschoenus fluviatilis	70	0	90	20	0	36.00	39.90	0	3	119.71	OBL	1
Chenopodium album	1	0	0	0.1	15	3.22	3.57	1	0	0.00	FAC	3
Cuscuta campestris	0	0	0	1	0	0.20	0.22	0	0	0.00	FACU	4
Echinocloa muricata	3	7	0.1	10	0.1	4.04	4.48	0	0	0.00	OBL	1
Polygonum bicorne	7	4	2	10	1	4.80	5.32	1	0	0.00	FACW	2
Polygonum lapathifolium	10	70	12	35	80	41.40	45.89	0	2	91.78	OBL	1
Potentilla norvegica	0.1	0	0	0	0	0.02	0.02	0	2	0.04	FAC	3
Rorippa palustris	2	0.1	0.1	0.1	0.1	0.48	0.53	0	4	2.13	OBL	1
Salsola collina	0.1	0	0	0.1	0	0.04	0.04	1	0	0.00	FACU	4
Solanum interius	0.1	0	0	0	0	0.02	0.02	0	1	0.02	FACU	4

CTP9

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

CCWMREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrostis hyemalis	10	10	10	10	0	8.00	2.36	0	4	9.45	FACU	4
Agrostis stolonifera	15	25	10	25	25	20.00	5.90	1	0	0.00	FAC	3
Alopecurus aequalis	20	15	20	15	15	17.00	5.02	0	6	30.11	OBL	1
Apocynum cannibinum	0	0	5	3	0	1.60	0.47	0	2	0.94	FAC	3
Bidens frondosa	3	3	0	3	3	2.40	0.71	0	1	0.71	FACW	2
Calamagrostis canadensis	10	10	10	10	10	10.00	2.95	0	6	17.71	FACW	2
Carex brevior	1	1	3	0	1	1.20	0.35	0	4	1.42	FAC	3
Carex granularis	1	0	0	0	0	0.20	0.06	0	6	0.35	FACW	2
Carex interior	0	45	0	0	0	9.00	2.66	0	7	18.60	OBL	1
Carex nebrascensis	30	25	25	30	35	29.00	8.56	0	5	42.80	OBL	1
Carex pellita	10	5	15	25	25	16.00	4.72	0	4	18.89	OBL	1
Carex praegracilis	10	10	0	5	5	6.00	1.77	0	4	7.08	FACW	2
Carex sartwellii	30	25	0	25	30	22.00	6.49	0	6	38.96	OBL	1
Carex scoparia	75	50	30	65	50	54.00	15.94	0	5	79.69	FACW	2
Carex tetanica	35	20	20	5	5	17.00	5.02	0	7	35.12	FACW	2
Carex vulpinoidea	0	0	5	0	0	1.00	0.30	0	4	1.18	OBL	1
Cicuta maculata	10	5	3	1	3	4.40	1.30	0	5	6.49	OBL	1
Eleocharis compressa	15	10	10	10	5	10.00	2.95	0	6	17.71	FACW	2
Eleocharis wolfii	0	5	5	0	3	2.60	0.77	0	7	5.37	OBL	1
Equisetum hyemale	0	1	1	1	1	0.80	0.24	0	4	0.94	FACW	2
Euthamia gymnospermoides	3	3	0	3	3	2.40	0.71	0	4	2.83	FACW	2
Galium tinctorium	1	0	0	0	0	0.20	0.06	0	7	0.41	FACW	2
Helianthus nuttallii	0	1	1	0	0	0.40	0.12	0	6	0.71	FAC	3
Hordeum jubatum	0	0	0	15	3	3.60	1.06	0	1	1.06	FACW	2
Juncus balticus	10	10	3	0	0	4.60	1.36	0	6	8.15	OBL	1

Juncus dudleyi	10	10	20	10	10	12.00	3.54	0	5	17.71	FACW	2
Juncus longistylis	10	10	0	0	1	4.20	1.24	0	7	8.68	FACW	2
Juncus tenuis	0	1	0	0	0	0.20	0.06	0	3	0.18	FAC	3
Lysimachia thrysiflora	1	0	0	0	1	0.40	0.12	0	7	0.83	OBL	1
Poa pratensis	5	0	5	0	0	2.00	0.59	1	0	0.00	FACU	4
Polygonum amphibium	0	1	5	0	0	1.20	0.35	0	6	2.13	OBL	1
Salix petiolaris	0	3	0	0	0	0.60	0.18	0	9	1.59	OBL	1
Saprtina pectinata	45	45	60	80	65	59.00	17.41	0	5	87.07	FACW	2
Scutellaria parvula	1	3	0	0	0	0.80	0.24	0	6	1.42	FACU	4
Trifolium hybridum	15	15	15	10	20	15.00	4.43	1	0	0.00	FACU	4

CCWM1

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Alisma triviale	0	0	15	0	0	3.00	1.08	0	4	4.32	OBL	1
Alyssum alyssoides	0	5	0	0	0	1.00	0.36	1	0	0.00	UPL	5
Ambrosia psilotachya	5	10	0	0	5	4.00	1.44	0	1	1.44	FAC	3
Argemone polyanthemos	0	5	0	0	0	1.00	0.36	0	1	0.36	UPL	5
Artemisia ludoviciana	0	5	0	0	0	1.00	0.36	0	4	1.44	FACU	4
Carex pellita	55	0	20	75	45	39.00	14.03	0	4	56.12	OBL	1
Carex praegracilis	0	35	0	30	10	15.00	5.40	0	4	21.58	FACW	2
Carex sartwellii	25	0	0	10	0	7.00	2.52	0	6	15.11	OBL	1
Carex tetanica	15	0	0	25	10	10.00	3.60	0	7	25.18	FACW	2
Dicanthelium acuminatum	5	15	0	0	5	5.00	1.80	0	6	10.79	FACW	2
Eleocharis acicularis	10	0	0	5	5	4.00	1.44	0	4	5.76	OBL	1
Eleocharis compressa	30	10	0	10	5	11.00	3.96	0	6	23.74	FACW	2
Eleocharis erythropoda	5	0	5	5	0	3.00	1.08	0	5	5.40	OBL	1
Eleocharis palustris	0	0	10	0	0	2.00	0.72	0	4	2.88	OBL	1

Elymus canadensis	5	0	0	0	0	1.00	0.36	0	5	1.80	FACU	4
Equisetum laevigatum	10	5	0	5	5	5.00	1.80	0	4	7.19	FACW	2
Glycherrhiza lepidota	0	5	0	5	5	3.00	1.08	0	4	4.32	FACU	4
Helianthus petiolaris	0	5	0	0	0	1.00	0.36	0	1	0.36	UPL	5
Hordeum jubatum	0	0	0	0	5	1.00	0.36	0	1	0.36	FACW	2
Juncus balticus	20	25	0	40	25	22.00	7.91	0	6	47.48	OBL	1
Koelaria macrantha	0	5	0	0	0	1.00	0.36	0	6	2.16	UPL	5
Lemna minor	0	0	10	0	0	2.00	0.72	0	5	3.60	OBL	1
Lotus purshianus	0	5	0	0	0	1.00	0.36	0	3	1.08	FAC	3
Lycopus uniflorus	0	0	0	5	0	1.00	0.36	0	6	2.16	OBL	1
Mentha arvensis	0	0	0	0	5	1.00	0.36	0	4	1.44	FACW	2
Mentzelia nuda	0	5	0	0	0	1.00	0.36	0	4	1.44	UPL	5
Panicum virgatum	30	15	0	15	5	13.00	4.68	0	4	18.71	FAC	3
Pascopyrum smithii	10	15	0	0	10	7.00	2.52	0	3	7.55	FACU	4
Phalaris arundinacea	5	0	0	0	5	2.00	0.72	1	0	0.00	FACW	2
Poa pratensis	40	50	0	45	85	44.00	15.83	1	0	0.00	FACU	4
Poa secunda	0	20	0	0	0	4.00	1.44	0	6	8.63	FACU	4
Polygonum amphibium	0	0	10	0	0	2.00	0.72	0	6	4.32	OBL	1
Polygonum coccinieum	0	0	10	0	0	2.00	0.72	0	2	1.44	FACW	2
Rosa arkansana	0	5	0	5	5	3.00	1.08	0	4	4.32	FACU	4
Schizachyrium scoparium	5	25	0	0	0	6.00	2.16	0	4	8.63	FACU	4
Schoenoplectus acutus	0	0	25	0	0	5.00	1.80	0	5	8.99	OBL	1
Schoenoplectus pungens	10	0	10	5	5	6.00	2.16	0	4	8.63	OBL	1
Solidago canadensis	5	5	0	5	5	4.00	1.44	0	2	2.88	FACU	4
Spartina pectinata	25	0	0	45	25	19.00	6.83	0	5	34.17	FACW	2
Stipa comata	0	10	0	0	0	2.00	0.72	0	6	4.32	UPL	5
Toxicodendron rydbergii	5	0	0	5	0	2.00	0.72	0	1	0.72	FAC	3
Typha angustifolia	0	0	50	0	0	10.00	3.60	1	0	0.00	OBL	1

Utricularia macrorhiza	0	0	5	0	0	1.00	0.36	0	6	2.16	OBL	1

CCWM2

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute% Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis stolonifera	25	30	0	0	10	13.00	3.37	1	0	0.00	FAC	3
Alopecuris arundinacea	5	0	0	0	0	1.00	0.26	1	0	0.00	OBL	1
Andropogon gerardii	10	25	15	0	20	14.00	3.63	0	5	18.13	FAC	3
Aster praealtus	5	0	0	0	0	1.00	0.26	0	5	1.30	FACW	2
Carex emoryi	15	30	40	40	10	27.00	6.99	0	5	34.97	OBL	1
Carex laeviconica	0	0	0	35	0	7.00	1.81	0	4	7.25	OBL	1
Carex pellita	75	60	50	55	25	53.00	13.73	0	4	54.92	OBL	1
Carex praegracilis	45	40	0	0	35	24.00	6.22	0	4	24.87	FACW	2
Carex sartwellii	20	5	20	20	10	15.00	3.89	0	6	23.31	OBL	1
Carex scoparia	30	35	0	15	5	17.00	4.40	0	5	22.02	FACW	2
Carex stipata	20	0	70	75	45	42.00	10.88	0	5	54.40	OBL	1
Carex tetanica	35	50	25	0	15	25.00	6.48	0	7	45.33	FACW	2
Carex vulpinoidea	10	20	0	0	10	8.00	2.07	0	4	8.29	OBL	1
Crepis runcinata	0	0.1	0	0	0	0.02	0.01	0	5	0.03	FAC	3
Eleocharis compressa	60	60	40	40	65	53.00	13.73	0	6	82.38	FACW	2
Eleocharis erythropoda	25	0	0	0	0	5.00	1.30	0	5	6.48	OBL	1
Equisetum hyemale	0.1	0.1	0	0	10	2.04	0.53	0	4	2.11	FACW	2
Hypoxis hirsuta	0.1	0.1	0	0	0.1	0.06	0.02	0	7	0.11	FACW	2
Juncus alpinoarticulatus	20	20	0	0	15	11.00	2.85	0	7	19.95	OBL	1
Juncus balticus	20	25	0	0	15	12.00	3.11	0	6	18.65	OBL	1
Juncus interior	10	0	0	0	0	2.00	0.52	0	4	2.07	FAC	3
Lycopus americanus	0	0	0	0.1	0	0.02	0.01	0	4	0.02	OBL	1
Mentha arvensis	0.1	0.1	0.1	0.1	0.1	0.10	0.03	0	4	0.10	FACW	2

Phalaris arundinacea	5	0	25	15	10	11.00	2.85	1	0	0.00	FACW	2
Poa pratensis	30	40	30	25	10	27.00	6.99	1	0	0.00	FACU	4
Polygonum amphibium	0.1	0.1	0	0	0	0.04	0.01	0	6	0.06	OBL	1
Polygonum coccineum	5	5	0	0	0	2.00	0.52	0	2	1.04	FACW	2
Polygonum lapathifolium	0	0	0	25	25	10.00	2.59	0	2	5.18	OBL	1
Pycanthemum virginianum	0.1	0.1	0	0	0.1	0.06	0.02	0	6	0.09	FAC	3
Sagittaria latifolia	0	0	10	0.1	0	2.02	0.52	0	5	2.62	OBL	1
Spirodela polyrhiza	0	0	0	0.1	0	0.02	0.01	0	6	0.03	OBL	1
Trifolium hybridum	2	1	1	2	2	1.60	0.41	1	0	0.00	FACU	4
Typha latifolia	0	0	0.1	0.1	0	0.04	0.01	0	1	0.01	OBL	1

CCWM3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Achillea millefolium	0	10	0	0	0.1	2.02	0.92	0	2	1.84	FACU	4
Artemisia ludoviciana	0	0.1	0	0	0	0.02	0.01	0	4	0.04	FACU	4
Bidens cernua	0	1	0	1	0	0.40	0.18	0	3	0.55	OBL	1
Bidens connata	1	0	1	0	0	0.40	0.18	0	3	0.55	OBL	1
Boehmaria cylindrica	0	1	1	1	1	0.80	0.36	0	6	2.19	OBL	1
Calamagrostis canadensis	0	10	10	10	15	9.00	4.10	0	6	24.59	OBL	1
Carex aurea	0	0.1	0	0	0.1	0.04	0.02	0	7	0.13	FACW	2
Carex pellita	0	50	0	30	35	23.00	10.47	0	4	41.89	OBL	1
Carex praegracilis	0	25	0	30	25	16.00	7.29	0	4	29.14	FACW	2
Carex sartwellii	0	0	5	0	0	1.00	0.46	0	6	2.73	OBL	1
Carex scoparia	0	0	0	0.1	0.1	0.04	0.02	0	5	0.09	FACW	2
Carex tetanica	0	35	0	30	35	20.00	9.11	0	7	63.75	FACW	2
Carex vulpinoidea	0	0	0	0.1	0.1	0.04	0.02	0	4	0.07	OBL	1
Cicuta maculata	0.1	0	0	1	1	0.42	0.19	0	5	0.96	OBL	1

Dicanthelium acuminatum	0	10	0	0	0	2.00	0.91	0	6	5.46	FACW	2
Eleocharis acicularis	0	0	0	0.1	0.1	0.04	0.02	0	4	0.07	OBL	1
Eleocharis erythropoda	0	5	5	1	3	2.80	1.27	0	5	6.37	OBL	1
Eleocharis palustris	0	40	0	25	20	17.00	7.74	0	4	30.96	OBL	1
Equisetum laevigatum	0	0.1	0	0	0.1	0.04	0.02	0	4	0.07	FACW	2
Galium trifidum	0	3	0	0	0	0.60	0.27	0	8	2.19	OBL	1
Helianthus grosseratus	0	10	0	15	10	7.00	3.19	0	4	12.75	FACW	2
Helianthus nuttallii	0	0.1	0	0.1	0.1	0.06	0.03	0	6	0.16	FAC	3
Hypoxis hirsuta	0	5	0	5	5	3.00	1.37	0	7	9.56	FACW	2
Juncus balticus	0	20	0	30	15	13.00	5.92	0	6	35.52	OBL	1
Juncus brachyphyllus	0	0	0	0	0.1	0.02	0.01	0	6	0.05	FACU	4
Juncus dudleyi	0	10	0	10	10	6.00	2.73	0	5	13.66	FACW	2
Lactuca ludoviciana	0	0.1	0	0	0.1	0.04	0.02	0	3	0.05	FAC	3
Lycopus uniflorus	0	1	0	1	0	0.40	0.18	0	6	1.09	OBL	1
Melilotus officinalis	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACU	4
Panicum virgatum	0	10	0	0	0	2.00	0.91	0	4	3.64	FAC	3
Phalaris arundinacea	0	0	0	25	10	7.00	3.19	1	0	0.00	FACW	2
Poa pratensis	0	30	0	35	20	17.00	7.74	1	0	0.00	FACU	4
Polygonum coccineum	0	0.1	0.1	0	0	0.04	0.02	0	2	0.04	OBL	1
Polygonum punctatum	0.1	10	15	0.1	0.1	5.06	2.30	0	4	9.22	OBL	1
Rosa arkansana	0	0.1	0	0	0	0.02	0.01	0	4	0.04	FACU	4
Rudbeckia hirta	0	1	0	1	1	0.60	0.27	0	4	1.09	FACU	4
Sagittaria latifolia	0.1	0	0.1	0	0	0.04	0.02	0	5	0.09	OBL	1
Smilacina stellata	0	1	0	0	0	0.20	0.09	0	4	0.36	FAC	3
Solidago canadensis	0	5	0	15	15	7.00	3.19	0	2	6.37	FACU	4
Spartina pectinata	0	20	0	20	30	14.00	6.37	0	5	31.87	FACW	2
Stellaria longifolia	0	0	0	0	0.1	0.02	0.01	0	7	0.06	OBL	1
Symphyotrichum lanceolatus	0	10	0	0.1	0.1	2.04	0.93	0	3	2.79	FACW	2

Toxicodendron rydbergii	0	0	0	0	1	0.20	0.09	0	1	0.09	FAC	3
Typha latifolia	70	25	70	1	30	39.20	17.85	0	1	17.85	OBL	1

CCWM4

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Achillea millefolium	5	3	3	0	0	2.20	0.72	0	2	1.44	FACU	4
Agrostis stolonifera	20	0	10	10	0	8.00	2.61	1	0	0.00	FAC	3
Andropogon gerardii	25	35	0	0	0	12.00	3.92	0	5	19.58	FAC	3
Apocynum cannbinum	10	5	5	15	2	7.40	2.42	0	2	4.83	FAC	3
Aster praealtus	5	0	0	0	0	1.00	0.33	0	5	1.63	FACW	2
Carex aurea	0	1	2	0	0	0.60	0.20	0	7	1.37	FACW	2
Carex brevior	5	0	0	0	0	1.00	0.33	0	4	1.31	FAC	3
Carex crawei	5	0	0	0	0	1.00	0.33	0	6	1.96	FACW	2
Carex pellita	60	55	60	65	15	51.00	16.64	0	4	66.58	OBL	1
Carex sartwellii	30	25	10	40	0	21.00	6.85	0	6	41.12	OBL	1
Carex stipata	15	10	10	30	0	13.00	4.24	0	5	21.21	OBL	1
Carex tetanica	15	10	15	5	0	9.00	2.94	0	7	20.56	FACW	2
Dicanthelium acuminatum	3	2	0	0	0	1.00	0.33	0	6	1.96	FACW	2
Eleocahris compressa	45	30	35	40	10	32.00	10.44	0	6	62.66	FACW	2
Equisetum hyemale	5	5	5	0	0	3.00	0.98	0	4	3.92	FACW	2
Erigeron strigosus	0	1	0	0	0	0.20	0.07	0	2	0.13	FAC	3
Glycyrrhiza lepidota	5	2	5	0	0	2.40	0.78	0	4	3.13	FACU	4
Helianthus maximiliani	10	10	3	0	0	4.60	1.50	0	4	6.01	UPL	5
Helianthus nuttallii	2	0	0	0	0	0.40	0.13	0	6	0.78	FAC	3
Juncus balticus	20	15	10	25	5	15.00	4.90	0	6	29.37	OBL	1
Juncus dudleyi	15	0	5	0	0	4.00	1.31	0	5	6.53	FACW	2
Lactuca ludoviciana	10	0	0	0	0	2.00	0.65	0	3	1.96	FAC	3

Mentha arvensis	0	3	5	0	1	1.80	0.59	0	4	2.35	FACW	2
Panicum virgatum	70	70	60	40	0	48.00	15.67	0	4	62.66	FAC	3
Poa pratensis	35	35	35	15	0	24.00	7.83	1	0	0.00	FACU	4
Polygonum amphibium	0	0	1	0	1	0.40	0.13	0	6	0.78	OBL	1
Polygonum coccineum	0	0	3	3	5	2.20	0.72	0	2	1.44	FACW	2
Schoenoplectus acutus	0	0	5	5	15	5.00	1.63	0	5	8.16	OBL	1
Schoenoplectus pungens	0	0	3	3	5	2.20	0.72	0	4	2.87	OBL	1
Schoenoplectus taebernaemontani	0	0	0	0	10	2.00	0.65	0	5	3.26	OBL	1
Sisyrinchium montanum	2	1	0	0	0	0.60	0.20	0	5	0.98	FAC	3
Solidago canadensis	2	10	5	10	0	5.40	1.76	0	2	3.52	FACU	4
Spartina pectinata	15	10	0	10	0	7.00	2.28	0	5	11.42	FACW	2
Trifolium hybridum	5	0	0	0	0	1.00	0.33	1	0	0.00	FACU	4
Typha latifolia	0	0	5	0	70	15.00	4.90	0	1	4.90	OBL	1

CCWM5

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrostis stolonifera	0	15	0	0	0	3.00	1.58	1	0	0.00	FAC	3
Aster praealtus	0	1	0	0	0	0.20	0.11	0	5	0.53	FACW	2
Boehmaria cylindrica	1	1	0	1	0	0.60	0.32	0	6	1.90	OBL	1
Calamagrostis canadensis	15	30	0	0	0	9.00	4.74	0	6	28.45	OBL	1
Calamagrostis stricta	25	5	0	0	0	6.00	3.16	0	6	18.97	FACW	2
Carex atherodes	0	2	0	0	0	0.40	0.21	0	6	1.26	OBL	1
Carex crawei	0	0	1	0	0	0.20	0.11	0	6	0.63	FACW	2
Carex emoryi	0	0	3	0	0	0.60	0.32	0	5	1.58	OBL	1
Carex lacustris	0	0	0	5	0	1.00	0.53	0	6	3.16	OBL	1
Carex nebrascensis	0	0	3	0	0	0.60	0.32	0	5	1.58	OBL	1
Carex pellita	30	30	30	0	0	18.00	9.48	0	4	37.93	OBL	1

Carex sartwellii	0	0	3	0	0	0.60	0.32	0	6	1.90	OBL	1
Carex scoparia	30	40	30	0	0	20.00	10.54	0	5	52.69	FACW	2
Carex vulpinoidea	0	0	1	0	0	0.20	0.11	0	4	0.42	OBL	1
Cicuta maculata	4	2	0	1	0	1.40	0.74	0	5	3.69	OBL	1
Eleocharis acicularis	5	5	0	1	1	2.40	1.26	0	4	5.06	OBL	1
Eleocharis compressa	15	15	15	0	0	9.00	4.74	0	6	28.45	FACW	2
Eleocharis erythropoda	0	1	0	1	1	0.60	0.32	0	5	1.58	OBL	1
Eleocharis wolfii	1	1	0	0	1	0.60	0.32	0	7	2.21	OBL	1
Helianthus nuttallii	3	0	0	0	0	0.60	0.32	0	6	1.90	FAC	3
Juncus balticus	0	10	0	3	1	2.80	1.48	0	6	8.85	OBL	1
Leersia oryzoides	0	0	0	5	0	1.00	0.53	0	4	2.11	OBL	1
Onoclea sensibilis	5	1	0	0	0	1.20	0.63	0	7	4.43	FACW	2
Phalaris arundinacea	0	20	30	25	5	16.00	8.43	1	0	0.00	FACW	2
Phragmites australis	0	0	0	30	0	6.00	3.16	1	0	0.00	FACW	2
Poa pratensis	5	20	0	0	0	5.00	2.63	1	0	0.00	FACU	4
Polygonum amphibium	10	10	10	5	10	9.00	4.74	0	6	28.45	OBL	1
Polygonum coccineum	0	2	0	0	1	0.60	0.32	0	2	0.63	FACW	2
Polygonum lapathifolium	0	0	0	1	1	0.40	0.21	0	2	0.42	OBL	1
Rudbeckia hirta	5	5	0	0	0	2.00	1.05	0	4	4.21	FACU	4
Schoenoplectus acuctus	0	0	0	10	0	2.00	1.05	0	5	5.27	OBL	1
Schoenoplectus pungens	0	0	0	5	3	1.60	0.84	0	4	3.37	OBL	1
Solidago canadensis	5	1	0	0	0	1.20	0.63	0	2	1.26	FACU	4
Sparganium eurycarpum	15	0	0	10	40	13.00	6.85	0	5	34.25	OBL	1
Spartina pectinata	40	15	15	0	5	15.00	7.90	0	5	39.52	FACW	2
Stachys pilosa	3	1	0	1	0	1.00	0.53	0	5	2.63	OBL	1
Teucrium canadense	5	1	1	1	2	2.00	1.05	0	4	4.21	FACW	2
Typha latifolia	45	0	0	65	65	35.00	18.44	0	1	18.44	OBL	1

CCWM6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Achillea millefolium	10	10	3	0	0	4.60	1.60	0	2	3.20	FACU	4
Alopecuris aequalis	65	65	20	65	30	49.00	17.03	0	6	102.15	OBL	1
Alopecuris arundinacea	3	15	0	5	5	5.60	1.95	1	0	0.00	FACW	2
Amorpha canescens	0	0	1	0	0	0.20	0.07	0	6	0.42	UPL	5
Andropogon gerardii	0	0	20	0	0	4.00	1.39	0	5	6.95	FAC	3
Calamagrostis canadensis	0	0	10	10	15	7.00	2.43	0	6	14.59	OBL	1
Carex brevior	0	1	0	0	0	0.20	0.07	0	4	0.28	FAC	3
Carex crawei	3	0	0	0	0	0.60	0.21	0	6	1.25	FACW	2
Carex cristatella	0	1	0	0	0	0.20	0.07	0	5	0.35	FACW	2
Carex gravida	0	0	0	0	1	0.20	0.07	0	4	0.28	FACU	4
Carex hystericina	10	1	0	5	0	3.20	1.11	0	5	5.56	OBL	1
Carex interior	1	1	0	0	0	0.40	0.14	0	7	0.97	OBL	1
Carex nebrascensis	5	0	25	25	3	11.60	4.03	0	5	20.15	OBL	1
Carex pellita	30	45	25	25	30	31.00	10.77	0	4	43.09	OBL	1
Carex praegracilis	0	0	15	0	0	3.00	1.04	0	4	4.17	FACW	2
Carex sartwellii	0	0	5	0	25	6.00	2.08	0	6	12.51	OBL	1
Carex scoparia	20	25	55	35	30	33.00	11.47	0	5	57.33	FACW	2
Carex tetanica	25	20	5	20	10	16.00	5.56	0	7	38.92	FACW	2
Carex vulpinoidea	15	15	1	15	0	9.20	3.20	0	4	12.79	OBL	1
Cicuta maculata	0	0	1	1	0	0.40	0.14	0	5	0.69	OBL	1
Cinna arundinacea	10	0	0	0	0	2.00	0.69	0	5	3.47	FACW	2
Cyperus squarrosus	1	0	0	0	0	0.20	0.07	0	2	0.14	OBL	1
Eleocharis acicularis	0	1	0	0	0	0.20	0.07	0	4	0.28	OBL	1
Eleocharis compressa	10	10	10	15		9.00	3.13	0	6	18.76	FACW	2
Eleocharis palustirs	0	0	0	25	10	7.00	2.43	0	4	9.73	OBL	1

Eleocharis wolfii	1	3	5	5	0	2.80	0.97	0	7	6.81	OBL	1
Equisetum hyemale	3	5	1	1	0	2.00	0.69	0	4	2.78	FACW	2
Helianthius maximilliani	0	0	3	0	0	0.60	0.21	0	4	0.83	UPL	5
Helianthus petiolaris	0	0	3	0	0	0.60	0.21	0	1	0.21	UPL	5
Hordeum jubatum	0	0	0	5	5	2.00	0.69	0	1	0.69	FACW	2
Hypoxis hirsuta	1	1	0	1	0	0.60	0.21	0	7	1.46	FACW	2
Juncus balticus	3	10	10	10	1	6.80	2.36	0	6	14.18	OBL	1
Juncus canadensis	1	0	0	0	0	0.20	0.07	0	8	0.56	OBL	1
Juncus dudleyi	3	5	1	10	5	4.80	1.67	0	5	8.34	FACW	2
Juncus torreyi	1	3	1	1	0	1.20	0.42	0	4	1.67	FACW	2
Lactuca canadensis	0	0	1	0	0	0.20	0.07	0	2	0.14	FACU	4
Lotus purshianus	0	0	1	0	0	0.20	0.07	0	3	0.21	FAC	3
Poa pratensis	40	40	40	30	25	35.00	12.16	1	0	0.00	FACU	4
Prunella vulgaris	5	5	2	3	0	3.00	1.04	1	0	0.00	FACW	2
Schoenoplectus pungens	1	0	0	0	0	0.20	0.07	0	4	0.28	OBL	1
Scutelaria parvula	5	5	3	5	0	3.60	1.25	0	6	7.51	FACU	4
Solidago canadensis	0	0	5	0	0	1.00	0.35	0	2	0.69	FACU	4
Spartina pectinata	30	30	0	10	10	16.00	5.56	0	5	27.80	FACW	2
Symphyotrichium praealtum	0	0	1	0	0	0.20	0.07	0	5	0.35	FACW	2
Teucrium canadense	0	0	3	1	0	0.80	0.28	0	4	1.11	FACW	2
Trifolium repens	3	5	3	0	0	2.20	0.76	1	0	0.00	FACU	4

CCWM7

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis exarata	0	0	0	0	0.1	0.02	0.01	0	9	0.09	FACW	2
Agrostis hyemalis	0	10	0	25	25	12.00	6.33	0	4	25.31	FACU	4
Agrostis stolonifera	0	5	5	5	0	3.00	1.58	1	0	0.00	FAC	3

Alisma triviale	20	1	1	3	3	5.60	2.95	0	4	11.81	OBL	1
Alopecuris aequalis	3	1		5	15	4.80	2.53	0	6	15.19	OBL	1
Ambrosia psilotachya	0	1	5	0	0	1.20	0.63	0	1	0.63	FAC	3
Aster lanceolatus	0	5	1	1	2	1.80	0.95	0	3	2.85	FACW	2
Aster praealtus	0	2	1	3	1	1.40	0.74	0	5	3.69	FACW	2
Calamagrostis canadensis	0	0	0	15	5	4.00	2.11	0	6	12.65	OBL	1
Carex aurea	0	0	0	0	1	0.20	0.11	0	7	0.74	FACW	2
Carex bebbii	0	0	0	3	0	0.60	0.32	0	7	2.21	FACW	2
Carex cristatella	0	0	0	1	0	0.20	0.11	0	5	0.53	FACW	2
Carex diandra	0	1	0	0	0	0.20	0.11	0	9	0.95	OBL	1
Carex interior	0	0	3	1	1	1.00	0.53	0	7	3.69	OBL	1
Carex meadii	0	0	3	1	1	1.00	0.53	0	6	3.16	FAC	3
Carex nebrascensis	1	1	0	10	5	3.40	1.79	0	5	8.96	OBL	1
Carex parryana	0	1	0	0	0	0.20	0.11	0	7	0.74	FACW	2
Carex pellita	5	35	55	55	45	39.00	20.56	0	4	82.25	OBL	1
Carex praegracilis	0	30	0	10	10	10.00	5.27	0	4	21.09	FACW	2
Carex sartwellii	0	0	25	1	3	5.80	3.06	0	6	18.35	OBL	1
Carex scoparia	0	0	5	3	3	2.20	1.16	0	5	5.80	FACW	2
Carex vulpinoidea	0	0	0	0	1	0.20	0.11	0	4	0.42	OBL	1
Dicanthelium oligosanthes	0	2	0	0	0	0.40	0.21	0	4	0.84	FACU	4
Dicanthelium wilcoxianum	0	5	5	0	0	2.00	1.05	0	7	7.38	UPL	5
Eleocharis acicularis	0	0	3	1	5	1.80	0.95	0	4	3.80	OBL	1
Eleocharis elliptica	0	1	0	0	0	0.20	0.11	0	7	0.74	OBL	1
Eleocharis palustris	0	0	0	15	25	8.00	4.22	0	4	16.87	OBL	1
Elymus riparius	0	0	0	0	0.1	0.02	0.01	0	5	0.05	FAC	3
Epilobium ciliatum	0	0	0	1	0	0.20	0.11	0	6	0.63	OBL	1
Equisetum hyemale	0	2	1	1	1	1.00	0.53	0	4	2.11	FACW	2
Galium trifidum	0	3	1	1	1	1.20	0.63	0	8	5.06	OBL	1

Geum aleppicum	0	0	3	1	1	1.00	0.53	0	6	3.16	FACU	4
Glycherriza lepidota	0	10	0	3	5	3.60	1.90	0	4	7.59	FACU	4
Hordeum jubatum	0	0	0	3	0	0.60	0.32	0	1	0.32	FACW	2
Juncus dudleyi	0	5	0	0	1	1.20	0.63	0	5	3.16	OBL	1
Lotus purshianus	0	10	5	0	1	3.20	1.69	0	3	5.06	FAC	3
Lycopus americanus	0	10	1	1	3	3.00	1.58	0	4	6.33	OBL	1
Panicum virgatum	0	35	45	1	1	16.40	8.65	0	4	34.59	FAC	3
Phalaris arundinacea	0	0	0	15	0	3.00	1.58	1	0	0.00	FACW	2
Phalaris canariensis	0	3	0	1	1	1.00	0.53	1	0	0.00	FACU	4
Poa pratensis	0	10	15	0	0	5.00	2.64	1	0	0.00	FACU	4
Sagittaria latifolia	5	10	0	1	5	4.20	2.21	0	5	11.07	OBL	1
Salix exigua	85	30	0	5	10	26.00	13.71	0	3	41.13	OBL	1
Salix petiolaris	0	0	0	0	0.1	0.02	0.01	0	9	0.09	OBL	1
Schoenoplectus tabernaemontani	0	0	0	1	1	0.40	0.21	0	5	1.05	OBL	1
Scirpus microcarpus	0	0	0	0	1	0.20	0.11	0	9	0.95	OBL	1
Sparganium eurycarpum	0	0	0	1	0	0.20	0.11	0	5	0.53	OBL	1
Symphoricarpos albus	0	0	0	1	0	0.20	0.11	0	10	1.05	FACU	4
Tuecrium canadense	0	5	5	5	1	3.20	1.69	0	4	6.75	FACW	2
Typha angustifolia	0	0	0	3	5	1.60	0.84	1	0	0.00	OBL	1
Typha latifolia	0	0	0	15	0	3.00	1.58	0	1	1.58	OBL	1

CCWM8

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis hyemalis	10	10	0	0	0	4.00	2.02	0	4	8.06	FACU	4
Agrostis stolonifera	20	20	20	15	15	18.00	9.07	1	0	0.00	FAC	3
Aster falcatus	0	0	1	0	1	0.40	0.20	0	4	0.81	FAC	3
Aster lanceolatus	1	1	1	0	1	0.80	0.40	0	3	1.21	FACW	2

Aster praealtus	1	1	0	0	0	0.40	0.20	0	5	1.01	FACW	2
Calamagrostis canadensis	10	10	10	10	5	9.00	4.54	0	6	27.22	OBL	1
Carex interior	0	0	1	1	0	0.40	0.20	0	7	1.41	OBL	1
Carex nebrascensis	15	15	15	20	10	15.00	7.56	0	5	37.80	OBL	1
Carex pellita	10	10	10	10	25	13.00	6.55	0	4	26.21	OBL	1
Carex praegracilis	0	0	0	0	10	2.00	1.01	0	4	4.03	FACW	2
Carex scoparia	15	10	15	10	15	13.00	6.55	0	5	32.76	FACW	2
Carex tetanica	5	5	3	0	10	4.60	2.32	0	7	16.23	FACW	2
Cicuta maculata	5	5	3	3	3	3.80	1.92	0	5	9.58	OBL	1
Cystopteris fragilis	2	0	0	0	0	0.40	0.20	0	6	1.21	FACU	4
Eleocahris compressa	0	2	5	10	10	5.40	2.72	0	6	16.33	FACW	2
Eleocharis erythropoda	5	5	5	15	5	7.00	3.53	0	5	17.64	OBL	1
Eleocharis palustris	1	0	0	0	0	0.20	0.10	0	4	0.40	OBL	1
Eleocharis wolfii	1	0	0	0	0	0.20	0.10	0	7	0.71	OBL	1
Epilobium coloratum	5	10	0	0	5	4.00	2.02	0	5	10.08	OBL	1
Epilobium leptophyllum	1	1	1	2	1	1.20	0.60	0	7	4.23	FACW	2
Equisetum arvense	1	0	1	1	1	0.80	0.40	0	4	1.61	FAC	3
Equisetum hymalis	0	1	0	0	1	0.40	0.20	0	4	0.81	FACW	2
Eupatorium maculatum	3	3	0	2	1	1.80	0.91	0	6	5.44	OBL	1
Galium tinctorium	1	1	1	1	1	1.00	0.50	0	7	3.53	FACW	2
Galium trifidum	0	0	1	1	1	0.60	0.30	0	8	2.42	OBL	1
Helianthus grosseratus	15	15	5	15	15	13.00	6.55	0	4	26.21	FACW	2
Helianthus nuttallii	1	0	1	0	1	0.60	0.30	0	6	1.81	FAC	3
Hordeum jubatum	0	0	10	10	10	6.00	3.02	0	1	3.02	FACW	2
Hypoxis hirsuta	1	1	1	0	1	0.80	0.40	0	7	2.82	FACW	2
Juncus balticus	0	0	0	0	1	0.20	0.10	0	6	0.60	OBL	1
Juncus dudleyi	5	5	5	10	10	7.00	3.53	0	5	17.64	FACW	2
Juniperus virginiana	0	0	1	1	0	0.40	0.20	0	1	0.20	FACU	4

Lotus purshianus	0	1	0	0	1	0.40	0.20	0	3	0.60	FACW	2
Lycopus americanus	0	0	0	1	1	0.40	0.20	0	4	0.81	OBL	1
Lysimachia thrysiflora	0	0	1	0	0	0.20	0.10	0	7	0.71	OBL	1
Panicum virgatum	0	15	2	0	10	5.40	2.72	0	4	10.89	FAC	3
Poa pratensis	10	10	10	5	10	9.00	4.54	1	0	0.00	FACU	4
Polygonum amphibium	0	0	0	10	5	3.00	1.51	0	6	9.07	OBL	1
Rosa woodsii	3	3	3	1	1	2.20	1.11	0	4	4.44	FACU	4
Salix exigua	0	0	0	0	1	0.20	0.10	0	3	0.30	OBL	1
Salix petiolaris	0	0	0	0	1	0.20	0.10	0	9	0.91	OBL	1
Solidago canadensis	5	5	5	0	10	5.00	2.52	0	2	5.04	FACU	4
Solidago mollis	3	5	3	1	3	3.00	1.51	0	4	6.05	UPL	5
Spartina pectinata	40	5	40	40	45	34.00	17.14	0	5	85.69	FACW	2

CCWM9

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Achillea millefolium	0	0	0	0	1	0.20	0.08	0	2	0.16	FACU	4
Agrostis hyemalis	5	10	25	30	5	15.00	5.83	0	4	23.33	FACU	4
Agrostis stolonifera	20	10	10	10	15	13.00	5.06	1	0	0.00	FAC	3
Alopecuris aequalis	65	35	50	65	65	56.00	21.78	0	6	130.66	OBL	1
Alopecuris arundinacea	3	3	3	0	3	2.40	0.93	1	0	0.00	FACW	2
Carex lacustris	10	20	0	5	0	7.00	2.72	0	6	16.33	OBL	1
Carex pellita	5	5	20	30	0	12.00	4.67	0	4	18.67	OBL	1
Carex praegracilis	0	0	0	0	5	1.00	0.39	0	4	1.56	FACW	2
Carex sartwellii	0	0	10	10	0	4.00	1.56	0	6	9.33	OBL	1
Carex scoparia	45	10	40	40	15	30.00	11.67	0	5	58.33	FACW	2
Carex tetanica	10	10	10	5	10	9.00	3.50	0	7	24.50	FACW	2
Carex vulpinoidea	3	0	1	0	1	1.00	0.39	0	4	1.56	OBL	1

Cicuta maculata	1	1	1	1	1	1.00	0.39	0	5	1.94	OBL	1
Eleocharis acicularis	0	0	0	1	0	0.20	0.08	0	4	0.31	OBL	1
Eleocharis compressa	10	10	10	10	10	10.00	3.89	0	6	23.33	FACW	2
Eleocharis erythropoda	10	10	10	10	10	10.00	3.89	0	5	19.44	OBL	1
Equisetum hyemale	10	5	0.1	0	1	3.22	1.25	0	4	5.01	FACW	2
Erigeron strigosus	0	0	0	0	1	0.20	0.08	0	2	0.16	FAC	3
Helianthus nuttallii	1	0	0	0	1	0.40	0.16	0	6	0.93	FAC	3
Hordeum jubatum	0	0	10	10	0	4.00	1.56	0	1	1.56	FACW	2
Hypoxis hirsuta	1	0.1	0.1	0	1	0.44	0.17	0	7	1.20	FACW	2
Juncus dudleyi	3	10	10	10	15	9.60	3.73	0	5	18.67	FACW	2
Juncus longistylus	0	0	1	0	0	0.20	0.08	0	7	0.54	FACW	2
Lactuca canadensis	0	0	0	0	0.1	0.02	0.01	0	2	0.02	FACU	4
Medicago lupulina	3	0	0	0.1	3	1.22	0.47	1	0	0.00	FAC	3
Melilotus albus	5	0	0	0	0.1	1.02	0.40	1	0	0.00	FACU	4
Mentha arvensis	0	0	1	3	0	0.80	0.31	0	4	1.24	FACW	2
Phalaris arundinacea	25	10	5	5	30	15.00	5.83	1	0	0.00	FACW	2
Poa pratensis	15	10	35	10	0	14.00	5.44	1	0	0.00	FACU	4
Polygonum amphibium	0	0	0	3	0	0.60	0.23	0	6	1.40	OBL	1
Sisyrinchium montanum	3	0	0	0.1	3	1.22	0.47	0	5	2.37	FAC	3
Sonchus oleraceus	1	0	0	0	1	0.40	0.16	1	0	0.00	FACU	4
Spartina pectinata	20	80	5	10	15	26.00	10.11	0	5	50.55	FACW	2
Stachys pilosa	0	0	0	0	0.1	0.02	0.01	0	5	0.04	OBL	1
Trifolium hybridum	10	5	5	5	10	7.00	2.72	1	0	0.00	FACU	4

EHWREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrostis gigantea	1	2	0	0	0	0.60	0.52	1	0	0.00	FACW	2
Agrostis hyemilis	0.1	0.1	0	0	0	0.04	0.03	0	4	0.14	FACU	4
Bolboschoenus fluviatilis	3	0	0	0	0	0.60	0.52	0	3	1.56	OBL	1
Carex pellita	20	15	45	1	0	16.20	14.03	0	4	56.13	OBL	1
Carex vulpinoidea	0.1	0	0	0	0	0.02	0.02	0	4	0.07	OBL	1
Ceratophyllum demersum	0	0	0	0.1	1	0.22	0.19	0	4	0.76	OBL	1
Cirsium arvense	1	0	0	0	0	0.20	0.17	1	0	0.00	FACU	4
Eleocharis erythropoda	1	2	1	5	1	2.00	1.73	0	5	8.66	OBL	1
Euphorbia esula	0.1	0	0	0	0	0.02	0.02	1	0	0.00	UPL	5
Hordeum jubatum	10	5	1	0	0	3.20	2.77	0	1	2.77	FACW	2
Lactuca seriola	0.1	0	0	0	0	0.02	0.02	1	0	0.00	FAC	3
Lemna minor	0.1	0.1	1	2	10	2.64	2.29	0	5	11.43	OBL	1
Lemna trisulca	0	0	0	2	10	2.40	2.08	0	8	16.63	OBL	1
Lycopus americanus	0.1	0.1	0	0	0	0.04	0.03	0	4	0.14	OBL	1
Mentha arvensis	0.1	0	0	0	0	0.02	0.02	0	4	0.07	FACW	2
Nepeta cataria	0.1	0	0	0	0	0.02	0.02	1	0	0.00	FACU	4
Phalaris arundinacea	1	40	60	40	2	28.60	24.77	1	0	0.00	FACW	2
Poa pratensis	1	1	0	0	0	0.40	0.35	1	0	0.00	FACU	4
Polygonum coccineum	1	0.1	0	0	0	0.22	0.19	0	2	0.38	FACW	2
Polygonum punctatum	0.1	0	0	0	0	0.02	0.02	0	4	0.07	OBL	1
Potomogeton illinoensis	0	0	0	0	0.1	0.02	0.02	0	7	0.12	OBL	1
Potomogeton pectinatus	0	0	0	0	0.1	0.02	0.02	0	6	0.10	OBL	1
Potomogeton zosteriformis	0	0	0	0	0.1	0.02	0.02	0	8	0.14	OBL	1
Sagittaria latifolia	0	0	0	1	0.1	0.22	0.19	0	5	0.95	OBL	1
Schoenoplectus tabernaemontani	0	0	0.1	1	0	0.22	0.19	0	5	0.95	OBL	1

Spirodela polyrhiza	0	0	0.1	3	30	6.62	5.73	0	6	34.41	OBL	1
Typha angustifolia	75	45	3	50	75	49.60	42.97	1	0	0.00	OBL	1
Urtica gracilis	2	1	0	0	0	0.60	0.52	0	1	0.52	FACW	2
Utricularia macrorhiza	0	0	0	0.1	2	0.42	0.36	0	6	2.18	OBL	1
Verbena stricta	0	0.1	0	0	0	0.02	0.02	0	2	0.03	FACW	2
Wolfia columbiana	0	0	0	0	1	0.20	0.17	0	5	0.87	OBL	1

EHW1

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alisma triviale	0.1	0.1	0.1	0.1	0.1	0.10	0.10	0	4	0.41	OBL	1
Bolboschoenus fluviatilis	15	15	10	30	40	22.00	22.56	0	3	67.68	OBL	1
Carex atherodes	0	0	0	0	0.1	0.02	0.02	0	6	0.12	OBL	1
Carex lacustris	0	1	15	0	2	3.60	3.69	0	6	22.15	OBL	1
Eleocharis acicularis	0	0	0.1	0	0.1	0.04	0.04	0	4	0.16	OBL	1
Eleocharis erythropoda	0	0	0.1	0	0.1	0.04	0.04	0	5	0.21	OBL	1
Lemna minor	0.1	0.1	0	0.1	0.1	0.08	0.08	0	5	0.41	OBL	1
Lemna trisulca	2	0.1	0	0	0.1	0.44	0.45	0	8	3.61	OBL	1
Lysimachia hybrida	0	0	0	0	0.1	0.02	0.02	0	6	0.12	OBL	1
Lysimachia thrysiflora	0	0	0	0.1	0	0.02	0.02	0	7	0.14	OBL	1
Phalaris arundinacea	0	1	2	0	5	1.60	1.64	1	0	0.00	FACW	2
Polygonum coccineum	2	3	2	4	2	2.60	2.67	0	2	5.33	FACW	2
Potomogeton illinoensis	0	0.1	0.1	0	0.1	0.06	0.06	0	7	0.43	OBL	1
Ranunculus flabellaris	0.1	0.1	0.1	0.1	0.1	0.10	0.10	0	7	0.72	OBL	1
Sagittaria latifolia	0	0	0.1	1	0.1	0.24	0.25	0	5	1.23	OBL	1
Schoenoplectus acutus	40	12	8	45	10	23.00	23.58	0	5	117.92	OBL	1
Sium suave	0.1	0.1	0.1	0.1	0.1	0.10	0.10	0	7	0.72	OBL	1
Sparganium eurycarpum	40	60	60	15	40	43.00	44.09	0	5	220.47	OBL	1

Spirodela polyrhiza	2	0.1	0.1	0	0.1	0.46	0.47	0	6	2.83	OBL	1

EHW2

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrosits gigantea	0	0.1	0	0	0.1	0.04	0.02	1	0	0.00	FACW	2
Apocynum cannabinum	0	0	0	0	0.1	0.02	0.01	0	2	0.02	FAC	3
Bolboschoenbus fluviatilis	0.1	5	0.1	0	5	2.04	1.27	0	3	3.80	OBL	1
Carex emoryi	0	0	0	0	0.1	0.02	0.01	0	5	0.06	OBL	1
Carex lacustris	0	0.1	0	0	0	0.02	0.01	0	6	0.07	OBL	1
Ceratophyllum demersum	30	0.1	30	60	0.1	24.04	14.92	0	4	59.67	OBL	1
Eleocharis acicularis	0	0.1	0	0	0.1	0.04	0.02	0	4	0.10	OBL	1
Eleocharis erythropoda	0	0.1	0	0	1	0.22	0.14	0	5	0.68	OBL	1
Galium obtusum	0	0	0	0	0.1	0.02	0.01	0	6	0.07	FACW	2
Glycyrrhiza lepidota	0	0	0	0	0.1	0.02	0.01	0	4	0.05	FACU	4
Lemna minor	1	0	0	0	0	0.20	0.12	0	5	0.62	OBL	1
Lemna trisulca	25	20	5	30	2	16.40	10.18	0	8	81.41	OBL	1
Lysimachia thrysiflora	0.1	0.1	0	0	0.1	0.06	0.04	0	7	0.26	OBL	1
Mentha arvensis	0	0	0	0	0.1	0.02	0.01	0	4	0.05	FACW	2
Phalaris arundinacea	0	2	0	0	15	3.40	2.11	1	0	0.00	FACW	2
Polygonum coccineum	0.1	25	0	0.1	15	8.04	4.99	0	2	9.98	FACW	2
Potomogeton illinoensis	0	0	5	0	0	1.00	0.62	0	7	4.34	OBL	1
Potomogeton pusillus	0.1	0	0	0	0	0.02	0.01	0	6	0.07	OBL	1
Potomogeton zosteriformis	60	0.1	60	10	0	26.02	16.15	0	8	129.16	OBL	1
Ranunculus longirostria	1	0.1	40	0.1	0	8.24	5.11	0	6	30.68	OBL	1
Ranunculus sceleratus	0	0.1	0	0	0.1	0.04	0.02	1	0	0.00	OBL	1
Sagittaria latifolia	1	0.1	0	0.1	0.1	0.26	0.16	0	5	0.81	OBL	1
Salix interior	0	2	0	0	15	3.40	2.11	0	3	6.33	OBL	1

Schoenoplectus acutus	2	30	2	30	7	14.20	8.81	0	5	44.06	OBL	1
Sium suave	0	0.1	0	0	0.1	0.04	0.02	0	7	0.17	OBL	1
Sparganium eurycarpum	0	0	0.1	0.1	0.1	0.06	0.04	0	5	0.19	OBL	1
Spartina pectinata	0	0	0	0	25	5.00	3.10	0	5	15.51	FACW	2
Spirodela polyrhiza	60	40	5	60	10	35.00	21.72	0	6	130.31	OBL	1
Typha angustifolia	0	0	0	15	0	3.00	1.86	1	0	0.00	OBL	1
Typha latifolia	25	0.1	0.1	10	10	9.04	5.61	0	1	5.61	OBL	1
Vernonia fasciculata	0	0	0	0	0.1	0.02	0.01	0	4	0.05	FAC	3
Wolffia columbiana	2	1	1	2	0.1	1.22	0.76	0	5	3.79	OBL	1

EHW3

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis gigantea	0	0	0	0	10	2.00	2.59	1	0	0.00	FACW	2
Alisma triviale	0	0	0	0	0.1	0.02	0.03	0	4	0.10	OBL	1
Alopecuris carolinianus	0	0	0	0	0.1	0.02	0.03	0	1	0.03	FACW	2
Ambrosia artemisifolia	0	0	0	0	0.1	0.02	0.03	0	0	0.00	FACU	4
Aster borealis	0	0	0	0	0.1	0.02	0.03	0	9	0.23	OBL	1
Bidens cernua	0	0	0	0	0.1	0.02	0.03	0	3	0.08	OBL	1
Bidens frondosa	0	0	0	0	0.1	0.02	0.03	0	1	0.03	FACW	2
Boehmaria cylindrica	0	0	0.1	0	0	0.02	0.03	0	6	0.16	OBL	1
Boltonia asteroides	0	0	0	0	0.1	0.02	0.03	0	3	0.08	FACW	2
Bromus japonicus	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACU	4
Carex pellita	0	0	0	0.1	30	6.02	7.81	0	4	31.23	OBL	1
Carex sartwellii	0	0	0	0.1	0	0.02	0.03	0	6	0.16	OBL	1
Carex scoparia	0	0	0	0	0.1	0.02	0.03	0	5	0.13	FACW	2
Centarium pulchellum	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACW	2
Ceratophyllum demersum	0.1	0.1	0	0	0	0.04	0.05	0	4	0.21	OBL	1

Eleocharis acicularis	0	0	0	0	2	0.40	0.52	0	4	2.08	OBL	1
Eleocharis erythropoda	0	0	0.1	0.1	20	4.04	5.24	0	5	26.20	OBL	1
Eleocharis palustris	0	0	0	2	0	0.40	0.52	0	4	2.08	OBL	1
Elodea canadensis	0.1	0.1	0	0	0	0.04	0.05	0	6	0.31	OBL	1
Euthamia gymnospermoides	0	0	0	0	0.1	0.02	0.03	0	4	0.10	FACW	2
Galium trifidum	0	0	0.1	0	0.1	0.04	0.05	0	8	0.42	OBL	1
Glyceria borealis	0	0	0	0	0.1	0.02	0.03	0	8	0.21	OBL	1
Hordeum jubatum	0	0	0	0	0.1	0.02	0.03	0	1	0.03	FACW	2
Hypericum majus	0	0	0	0	0.1	0.02	0.03	0	6	0.16	FACW	2
Juncus bufonius	0	0	0	0	0.1	0.02	0.03	0	4	0.10	OBL	1
Juncus scirpoides	0	0	0	0	0.1	0.02	0.03	0	7	0.18	FACW	2
Leersia oryzoides	0	0	0	0	0.1	0.02	0.03	0	4	0.10	OBL	1
Lemna minor	20	0.1	1	2	0.1	4.64	6.02	0	5	30.09	OBL	1
Lysimachia hybrida	0	0	0	0	0.1	0.02	0.03	0	6	0.16	OBL	1
Lysimachia thrysiflora	0	0	0	0	0.1	0.02	0.03	0	7	0.18	OBL	1
Mentha arvensis	0	0	0	0	0.1	0.02	0.03	0	4	0.10	FACW	2
Phalaris arundinacea	0	0	0.1	0	0.1	0.04	0.05	1	0	0.00	FACW	2
Phleum pratense	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACU	4
Poa compressa	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACU	4
Poa pratensis	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACU	4
Polygonum amphibium	0	0	0	0.1	1	0.22	0.29	0	6	1.71	OBL	1
Polygonum coccineum	0	0.1	0	0	0	0.02	0.03	0	2	0.05	FACW	2
Polygonum hydropiper	0	0	0	0	0.1	0.02	0.03	1	0	0.00	OBL	1
Polygonum persicaria	0	0	0.1	0	0	0.02	0.03	1	0	0.00	OBL	1
Potomogeton illinoensis	0.1	1	0	4	1	1.22	1.58	0	7	11.08	OBL	1
Potomogeton zosteriformis	0.1	0.1	0	0.1	0	0.06	0.08	0	8	0.62	OBL	1
Rorippa palustris	0	0	0	0	0.1	0.02	0.03	0	4	0.10	OBL	1
Rumex acetosella	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FAC	3

Rumex crispus	0	0	0.1	0.1	0.1	0.06	0.08	1	0	0.00	FACW	2
Sagittaria latifolia	0.1	0.1	1	0.1	2	0.66	0.86	0	5	4.28	OBL	1
Schoenoplectus acutus	0	2	0	2	3	1.40	1.82	0	5	9.08	OBL	1
Schoenoplectus pungens	0	0	0	0	0.1	0.02	0.03	0	4	0.10	OBL	1
Sium suave	0	0	0	0	0.1	0.02	0.03	0	7	0.18	OBL	1
Sparganium eurycarpum	0	0	0	0	2	0.40	0.52	0	5	2.59	OBL	1
Spirodela polyrhiza	40	0.1	10	10	0.1	12.04	15.62	0	6	93.70	OBL	1
Trifolium campestre	0	0	0	0	0.1	0.02	0.03	1	0	0.00	UPL	5
Trifolium pratense	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACU	4
Trifolium repens	0	0	0	0	0.1	0.02	0.03	1	0	0.00	FACU	4
Triglochin maritima	0	0	0	0	0.1	0.02	0.03	0	5	0.13	OBL	1
Typah x glauca	60	15	50	70	0	39.00	50.58	1	0	0.00	OBL	1
Utricularia macrorhiza	1	0.1	15	2	0	3.62	4.70	0	6	28.17	OBL	1
Verbena hastata	0	0	0	0	0.1	0.02	0.03	0	4	0.10	FACW	2
Vernonia fasciculata	0	0	0	0	0.1	0.02	0.03	0	4	0.10	FAC	3

EHW4

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bidens cernua	0.1	0	0	0	0.1	0.04	0.03	0	3	0.09	OBL	1
Bolboschoenus fluviatilis	0	0.1	3	0	0	0.62	0.46	0	3	1.38	OBL	1
Calamagrostis stricta	0	1	1	0	0	0.40	0.30	0	6	1.78	FACW	2
Carex comosa	0.1	0	0	0	0	0.02	0.01	0	5	0.07	OBL	1
Carex pellita	0	3	18	0	0	4.20	3.12	0	4	12.46	OBL	1
Carex scoparia	0	1	3	0	0	0.80	0.59	0	5	2.97	FACW	2
Ceratophyllum demersum	0	0	0	5	15	4.00	2.97	0	4	11.87	OBL	1
Eleocharis erythropoda	0	1	2	0.1	0	0.62	0.46	0	5	2.30	OBL	1
Lemna minor	0.1	0	0	0	0	0.02	0.01	0	5	0.07	OBL	1

Lemna trisulca	0	0	0	0	0.1	0.02	0.01	0	8	0.12	OBL	1
Lysimachia thrysiflora	3	2	20	0	0.1	5.02	3.72	0	7	26.07	OBL	1
Myriophyllum sibirium	0	0	0	0	1	0.20	0.15	0	6	0.89	OBL	1
Phalaris arundinacea	0	0	1	0	0	0.20	0.15	1	0	0.00	FACW	2
Polygonum amphibium	0.1	0	25	0	0	5.02	3.72	0	6	22.34	OBL	1
Polygonum coccineum	6	8	2	0	0.1	3.22	2.39	0	2	4.78	FACW	2
Potomogeton nodosus	0.1	0	0	15	25	8.02	5.95	0	5	29.75	OBL	1
Potomogeton pectinatus	0	0	0	0	40	8.00	5.93	0	6	35.61	OBL	1
Rumex stenophyllus	0	0	0	0.1	0	0.02	0.01	1	0	0.00	FACW	2
Sagittaria cuneata	1	0	0	0.1	0	0.22	0.16	0	5	0.82	OBL	1
Sagittaria latifolia	1	6	10	1	0	3.60	2.67	0	5	13.35	OBL	1
Schoenoplectus acutus	45	15	70	0	15	29.00	21.51	0	5	107.57	OBL	1
Sium suave	0.1	0.1	0	0.1	0	0.06	0.04	0	7	0.31	OBL	1
Sparganium eurycarpum	0	0	3	0	0	0.60	0.45	0	5	2.23	OBL	1
Spartina pectinata	0	1	3	0	0	0.80	0.59	0	5	2.97	FACW	2
Spirodela polyrhiza	1	0.1	0	1	30	6.42	4.76	0	6	28.58	OBL	1
Stachys pilosa	0.1	0	0.1	0	0	0.04	0.03	0	5	0.15	OBL	1
Typha angustifolia	0	90	0	0	0	18.00	13.35	1	0	0.00	OBL	1
Typha latifolia	65	0	25	1	40	26.20	19.44	0	1	19.44	OBL	1
Utricularia macrochiza	1	0	0	1	0	0.40	0.30	0	6	1.78	OBL	1
Zizania palustris	0.1	0	0	40	5	9.02	6.69	0	8	53.53	OBL	1

EHW5

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Alisma triviale	0	0	0	0	0.1	0.02	0.02	0	4	0.08	OBL	1
Carex pellita	0	0.1	0	0	5	1.02	1.00	0	4	4.00	OBL	1
Ceratophyllum demersum	0.1	0	0	0.1	0	0.04	0.04	0	4	0.16	OBL	1

Eleocharis eryhtropoda	0	0.1	0	0	0.1	0.04	0.04	0	5	0.20	OBL	1
Phalaris arundinacea	0.1	5	0	0	0	1.02	1.00	1	0	0.00	FACW	2
Polygonum amphibium	0.1	0.1	1	0	1	0.44	0.43	0	6	2.59	OBL	1
Polygonum coccineum	0	0.1	0	0	0	0.02	0.02	0	2	0.04	FACW	2
Sagittaria latifolia	0	0.1	0	0	0.1	0.04	0.04	0	5	0.20	OBL	1
Schoenoplectus acutus	0.1	10	0.1	1	2	2.64	2.59	0	5	12.94	OBL	1
Schoenoplectus pungens	0	0.1	0	0	1	0.22	0.22	0	4	0.86	OBL	1
Sparganium eurycarpum	0.1	0.1	0	0	0.1	0.06	0.06	0	5	0.29	OBL	1
Spartina pectinata	0	0	0	0	0.1	0.02	0.02	0	5	0.10	FACW	2
Spirodela polyrhiza	50	2	0.1	45	0.1	19.44	19.06	0	6	114.33	OBL	1
Typha angustifolia	60	80	95	70	80	77.00	75.48	1	0	0.00	OBL	1

EHW6

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Carex pellita	0	0	0	0.1	0	0.02	0.02	0	4	0.08	OBL	1
Carex scoparia	0	0	0	0.1	0	0.02	0.02	0	5	0.09	FACW	2
Ceratophyllum demersum	0	0	0	0	1	0.20	0.19	0	4	0.76	OBL	1
Eleocharis acicularis	0	0	0	0.1	0	0.02	0.02	0	4	0.08	OBL	1
Eleocharis palustris	0	0	0	2	0	0.40	0.38	0	4	1.52	OBL	1
Leersia oryzoides	0	0	0	0.1	0	0.02	0.02	0	4	0.08	OBL	1
Polygonum coccineum	1	0.1	2	0	0.1	0.64	0.61	0	2	1.21	FACW	2
Potomogeton illinoensis	0	0	0	0	0.1	0.02	0.02	0	7	0.13	OBL	1
Potomogeton nodosus	0.1	0.1	1	25	0.1	5.26	4.99	0	5	24.93	OBL	1
Sagittaria latifolia	0	0	0	0.1	0	0.02	0.02	0	5	0.09	OBL	1
Schoenoplectus acutus	15	10	1	35	8	13.80	13.08	0	5	65.42	OBL	1
Schoenoplectus pungens	0	0	0	0.1	0	0.02	0.02	0	4	0.08	OBL	1
Sparganium eurycarpum	0	0	0	0.1	0	0.02	0.02	0	5	0.09	OBL	1

Spartina pectinata	0	0	0	0.1	0	0.02	0.02	0	5	0.09	FACW	2
Typha angustifolia	80	65	65	20	70	60.00	56.88	1	0	0.00	OBL	1
Utricularia macrorhiza	20	25	30	5	45	25.00	23.70	0	6	142.21	OBL	1

EHW7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bolboshoenus fluviatilis	0	0	0	0	0.1	0.02	0.01	0	3	0.04	OBL	1
Carex atherodes	8	2	10	0	0	4.00	2.83	0	6	16.99	OBL	1
Carex pellita	15	4	30	0	5	10.80	7.65	0	4	30.59	OBL	1
Carex sartwellii	6	3	5	0.1	1	3.02	2.14	0	6	12.83	OBL	1
Eleocharis eryhtropoda	10	5	15	1	3	6.80	4.82	0	5	24.08	OBL	1
Lysimachia thrysiflora	0	10	0	1	0.1	2.22	1.57	0	7	11.00	OBL	1
Myriophyllum sibiricum	0	0	12	0	0	2.40	1.70	0	6	10.20	OBL	1
Phalaris arundinacea	0.1	2	0.1	1	1	0.84	0.59	1	0	0.00	FACW	2
Polygonum amphibium	1	1	1	15	2	4.00	2.83	0	6	16.99	OBL	1
Polygonum coccineum	0	9	0	0	0	1.80	1.27	0	2	2.55	FACW	2
Potomogeton nodosus	1	3	20	12	1	7.40	5.24	0	5	26.20	OBL	1
Ranunculus flabellaris	0.1	0	0	0.1	0	0.04	0.03	0	7	0.20	OBL	1
Sagittaria latifolia	0	1	0.1	0.1	0.1	0.26	0.18	0	5	0.92	OBL	1
Schoenoplectus acutus	35	70	15	30	70	44.00	31.16	0	5	155.79	OBL	1
Schoenoplectus pungens	3	2	20	0	0	5.00	3.54	0	4	14.16	OBL	1
Sium suave	0.1	0.1	0	0	0	0.04	0.03	0	7	0.20	OBL	1
Sparganium eurycarpum	0.1	1	0	0.1	40	8.24	5.83	0	5	29.17	OBL	1
Spartina pectinata	0	1	0	0	0	0.20	0.14	0	5	0.71	FACW	2
Spirodela polyrhiza	0.1	0.1	0.1	0.1	0.1	0.10	0.07	0	6	0.42	OBL	1
Stachys pilosa	0.1	0	0	0	0	0.02	0.01	0	5	0.07	OBL	1
Triglochin maritima	0	0	1	0	0	0.20	0.14	0	5	0.71	OBL	1

Typha angustifolia	40	5	0	70	25	28.00	19.83	1	0	0.00	OBL	1
Typha latifolia	0	0	11	10	10	6.20	4.39	0	1	4.39	OBL	1
Utricularia macrorhiza	1	1	20	6	0.1	5.62	3.98	0	6	23.88	OBL	1

EHW8

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis hyemalis	0	0	0	0.1	0	0.02	0.02	0	4	0.07	FACU	4
Agrostis stolonifera	0	0.1	0	0	0	0.02	0.02	1	0	0.00	FAC	3
Alisma triviale	1	0.1	2	0.1	1	0.84	0.74	0	4	2.97	OBL	1
Ambrosia artemisifolia	0	0.1	0	0	0	0.02	0.02	0	0	0.00	FACU	4
Apocynum cannabinum	0	0	0	0.1	0.1	0.04	0.04	0	2	0.07	FAC	3
Aster praealtus	0	0.1	0	0.1	0.1	0.06	0.05	0	5	0.27	FACW	2
Calamagrostis stricta	0.1	3	0	0	0.1	0.64	0.57	0	6	3.39	FACW	2
Carex crawei	0	0.1	0	0	0	0.02	0.02	0	6	0.11	FACW	2
Carex pellita	30	18	40	10	45	28.60	25.28	0	4	101.13	OBL	1
Carex scoparia	0	0.1	0	0	0	0.02	0.02	0	5	0.09	FACW	2
Centarium pulchellum	0	0.1	0	0.1	0	0.04	0.04	1	0	0.00	FACW	2
Coreopsis tinctoria	0	0.1	0	0.1	0	0.04	0.04	0	1	0.04	FAC	3
Eleocharis acicularis	1	0.1	0	0	0.1	0.24	0.21	0	4	0.85	OBL	1
Eleocharis erythropoda	15	0.1	5	45	25	18.02	15.93	0	5	79.65	OBL	1
Eleocharis palustris	0	8	0	5	5	3.60	3.18	0	4	12.73	OBL	1
Euthamia gymnospermoides	0	0.1	0	0	0	0.02	0.02	0	4	0.07	FACW	2
Hordeum jubatum	0	0.1	0	0.1	0	0.04	0.04	0	1	0.04	FACW	2
Juncus alpinoarticulatus	0	0.1	0	0.1	0.1	0.06	0.05	0	7	0.37	OBL	1
Juncus dudleyi	0	13	0	0	0	2.60	2.30	0	5	11.49	FACW	2
Juncus torreyi	0	0	0	1	0.1	0.22	0.19	0	4	0.78	FACW	2
Leersia oryzoides	0	0	0	0.1	0	0.02	0.02	0	4	0.07	OBL	1

Lespedeza capitata	0	0.1	0	0	0	0.02	0.02	0	5	0.09	UPL	5
Lycopus americanus	0	0.1	0	1	0.1	0.24	0.21	0	4	0.85	OBL	1
Lythrum alatum	0	1	0	2	0	0.60	0.53	0	6	3.18	OBL	1
Mentha arvensis	0	0	0	1	0.1	0.22	0.19	0	4	0.78	FACW	2
Panicum acuminatum	0	0.1	0	0.1	0	0.04	0.04	0	6	0.21	FACW	2
Panicum virgatum	0	8	0	4	1	2.60	2.30	0	4	9.19	FAC	3
Phalaris arundinacea	1	0	1	0.1	1	0.62	0.55	1	0	0.00	FACW	2
Polygonum persicaria	0	0.1	0	0.1	0	0.04	0.04	1	0	0.00	OBL	1
Potomogeton nodosus	3	0	8	0.1	6	3.42	3.02	0	5	15.12	OBL	1
Ranunculus cymbalaria	0	0.1	0	0	0	0.02	0.02	0	3	0.05	OBL	1
Sagittaria latifolia	11	0.1	20	0.1	12	8.64	7.64	0	5	38.19	OBL	1
Schoenoplectus acutus	12	0	25	10	0.1	9.42	8.33	0	5	41.64	OBL	1
Schoenoplectus pungens	8	25	0.1	15	0.1	9.64	8.52	0	4	34.09	OBL	1
Sium suave	0	0	0	0.1	0.1	0.04	0.04	0	7	0.25	OBL	1
Sparganium eurycarpum	0	0	2	0.1	0.1	0.44	0.39	0	5	1.94	OBL	1
Spartina pectinata	0	1	0	2	5	1.60	1.41	0	5	7.07	FACW	2
Stachys pilosa	0	0.1	0	0.1	0.1	0.06	0.05	0	5	0.27	OBL	1
Triglochin maritima	2	12	1	0.1	10	5.02	4.44	0	5	22.19	OBL	1
Typha angustifolia	15	0	25	5	30	15.00	13.26	1	0	0.00	OBL	1
Typha latifolia	1	0.1	0	0	0	0.22	0.19	0	1	0.19	OBL	1
Vernonia fasciculata	0	0.1	0	0	0.1	0.04	0.04	0	4	0.14	FAC	3

EHW9

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Alisma triviale	0	0	0.1	0.1	0	0.04	0.03	0	4	0.13	OBL	1
Bolboschoenus fluviatilis	0	0	0.1	0.1	0	0.04	0.03	0	3	0.10	OBL	1
Calamagrostis stricta	0	0	0	0.1	0	0.02	0.02	0	6	0.10	FACW	2

Carex pelitta	0	0	0	3	0	0.60	0.49	0	4	1.95	OBL	1
Ceratophyllum demersum	1	0	3	0.1	0.1	0.84	0.68	0	4	2.72	OBL	1
Eleocharis erythropoda	0	0	0	1	0	0.20	0.16	0	5	0.81	OBL	1
Lemna minor	0.1	5	1	0.1	1	1.44	1.17	0	5	5.84	OBL	1
Lemna trisulca	3	1	2	1	1	1.60	1.30	0	8	10.37	OBL	1
Polygonum amphibium	0	0	0.1	1	0	0.22	0.18	0	6	1.07	OBL	1
Polygonum punctatum	0	0	0.1	0	0	0.02	0.02	1	0	0.00	OBL	1
Potomogeton pectinatus	0	0	0	1	0	0.20	0.16	0	6	0.97	OBL	1
Rumex stenophyllus	0	0	0	0.1	0	0.02	0.02	1	0	0.00	FACW	2
Sagittaria latifolia	0	0	0.1	0.1	0	0.04	0.03	0	5	0.16	OBL	1
Schoenoplectus acutus	1	0	0	0.1	1	0.42	0.34	0	5	1.70	OBL	1
Schoenoplectus pungens	0	0	0	1	0	0.20	0.16	0	4	0.65	OBL	1
Sparganium eurycarpum	0	0	0	0.1	0	0.02	0.02	0	5	0.08	OBL	1
Spartina pectinata	0	0	0	0.1	0	0.02	0.02	0	5	0.08	FACW	2
Spirodela polyrhiza	30	60	55	25	70	48.00	38.90	0	6	233.43	OBL	1
Typha angustifolia	15	65	0	0	35	23.00	18.64	1	0	0.00	OBL	1
Typha latifolia	45	15	70	30	25	37.00	29.99	0	1	29.99	OBL	1
Utricularia macrorhiza	12	0.1	0.1	6	8	5.24	4.25	0	6	25.48	OBL	1
Wolffia columbiana	5	10	1	2	3	4.20	3.40	0	5	17.02	OBL	1

MRREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Acalypha rhomboidea	10	5	1	0	0	3.20	0.83	0	0	0.00	FACU	4
Acer negundo	0	0	0	0	3	0.60	0.16	0	1	0.16	FAC	3
Acer saccarinum	0	0	3	3	10	3.20	0.83	0	4	3.33	FACW	2
Agastache nepetoides	5	0	1	0	0	1.20	0.31	0	5	1.56	FAC	3
Agertina altissima	10	5	5	0	0	4.00	1.04	0	4	4.17	FACU	4

Amaranthus tuberculatus	75	65	40	40	45	53.00	13.80	0	0	0.00	FACW	2
Ambrosia artemisifolia	0	0	0	0	3	0.60	0.16	0	0	0.00	FACU	4
Ambrosia trifida	25	20	10	10	10	15.00	3.91	0	0	0.00	FACW	2
Bidens frondosa	5	10	10	10	10	9.00	2.34	0	1	2.34	FACW	2
Carex laeviconica	15	5	10	10	10	10.00	2.60	0	4	10.42	OBL	1
Chenopodium album	30	25	30	15	20	24.00	6.25	1	0	0.00	FAC	3
Conyza canadensis	10	10	10	10	10	10.00	2.60	0	0	0.00	FACU	4
Cyperus odoratus	0	0	1	0	0	0.20	0.05	0	3	0.16	FACW	2
Echinocloa muricata	0	5	0	5	0	2.00	0.52	0	0	0.00	OBL	1
Eclipta prostrata	10	10	10	10	10	10.00	2.60	0	2	5.21	FACW	2
Elymus virginicus	25	5	5	5	3	8.60	2.24	0	4	8.96	FAC	3
Erechtites hieraciflora	5	3	5	5	5	4.60	1.20	0	1	1.20	FAC	3
Frageria vesca	10	5	10	10	10	9.00	2.34	0	6	14.06	UPL	5
Frageria virginiana	0	0	0	0	3	0.60	0.16	0	5	0.78	FACU	4
Galium obtusum	0	0	2	3	3	1.60	0.42	0	6	2.50	FACW	2
Geum vernum	0	0	0	0	1	0.20	0.05	0	5	0.26	FACU	4
Humulus japonicus	15	10	10	50	0	17.00	4.43	1	0	0.00	FACU	4
Lamium amplexicaule	5	1	10	0	0	3.20	0.83	1	0	0.00	UPL	5
Leersia oryzoides	0	0	1	0	0	0.20	0.05	0	4	0.21	OBL	1
Medicago lupulina	5	5	5	5	5	5.00	1.30	1	0	0.00	FAC	3
Morus alba	10	10	10	0	0	6.00	1.56	1	0	0.00	FAC	3
Panicum capillare	10	10	10	10	10	10.00	2.60	0	0	0.00	FAC	3
Parthenocissus vitacea	0	1	5	1	1	1.60	0.42	0	4	1.67	FAC	3
Phalaris arundinacea	0	5	5	10	15	7.00	1.82	1	0	0.00	FACW	2
Phyla lanceolata	0	0	2	0	0	0.40	0.10	0	3	0.31	OBL	1
Phytolacca americana	0	3	5	3	1	2.40	0.63	0	0	0.00	FAC	3
Pilea pumila	1	1	0	1	1	0.80	0.21	0	4	0.83	FAC	3
Platanus occidentalis	0	0	1	0	1	0.40	0.10	0	7	0.73	FAC	3

Polygonum lapathifolium	65	65	80	75	75	72.00	18.75	0	2	37.50	OBL	1
Polygonum punctatum	3	0	0	0	0	0.60	0.16	0	4	0.63	OBL	1
Populus deltoides	0	0	3	0	0	0.60	0.16	0	3	0.47	FAC	3
Potentilla norvegica	1	0	0	0	3	0.80	0.21	0	2	0.42	FAC	3
Rorippa palustris	0	0	0	0	10	2.00	0.52	0	4	2.08	OBL	1
Rumex crispus	2	1	1	1	0	1.00	0.26	1	0	0.00	FACW	2
Sanicula canadensis	0	0	1	5	5	2.20	0.57	0	3	1.72	FACU	4
Setaria viridis	10	10	10	10	10	10.00	2.60	1	0	0.00	FAC	3
Sicyos angulatus	15	15	25	25	10	18.00	4.69	0	1	4.69	FAC	3
Solanum ptycanhum	5	5	5	10	10	7.00	1.82	0	0	0.00	FACU	4
Sorghum halapense	5	15	3	3	3	5.80	1.51	1	0	0.00	FACU	4
Teucrium canadense	10	10	1	1	10	6.40	1.67	0	4	6.67	FACW	2
Toxicodendron rydbergii	20	20	20	15	25	20.00	5.21	0	1	5.21	FAC	3
Veronica peregrina	30	10	5	10	10	13.00	3.39	0	1	3.39	OBL	1
Vitis riparia	0	0	1	10	5	3.20	0.83	0	3	2.50	FAC	3

MR1

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Abutilon theophrasti	30	30	10	10	35	23.00	5.88	1	0	0.00	UPL	5
Acalypha virginica	10	3	0	3	3	3.80	0.97	0	2	1.94	FACU	4
Agertina altissimum	0	0	0	0	1	0.20	0.05	0	4	0.20	FACU	4
Amaranthus tuberculatus	10	10	0	10	5	7.00	1.79	0	0	0.00	FACW	2
Ambrosia artemisifolia	1	1	0	0	0	0.40	0.10	0	0	0.00	FACU	4
Bidens frondosa	3	0	0	0	0	0.60	0.15	0	1	0.15	FACW	2
Carex laeviconica	10	10	20	10	0	10.00	2.55	0	4	10.22	OBL	1
Cephalanthus occidentalis	0	0	1	1	1	0.60	0.15	0	6	0.92	OBL	1
Chamaechrista fasciculata	0	0	0	0	1	0.20	0.05	0	1	0.05	FACU	4

Chenopodium album	10	10	15	10	10	11.00	2.81	1	0	0.00	FAC	3
Chenopodium simplex	40	30	5	40	35	30.00	7.66	0	1	7.66	UPL	5
Conyza canadensis	0	0	5	0	0	1.00	0.26	0	0	0.00	FACU	4
Echinocloa muricata	10	10	10	0	10	8.00	2.04	0	0	0.00	OBL	1
Elymus virgicus	0	0	20	0	0	4.00	1.02	0	4	4.09	FAC	3
Frageria virginiana	0	0	0	0	1	0.20	0.05	0	5	0.26	FACU	4
Geum canadense	0	0	0	1	0	0.20	0.05	0	3	0.15	FACU	4
Gleditsia triacanthos	0	0	0	0	1	0.20	0.05	0	1	0.05	FAC	3
Gymnocladius dioica	0	0	1	0	0	0.20	0.05	0	5	0.26	UPL	5
Helianthus annuus	40	55	20	65	75	51.00	13.03	0	0	0.00	FACU	4
Humulus japonicus	45	65	45	70	75	60.00	15.33	1	0	0.00	FACU	4
Lamium amplexicaule	35	35	35	50	10	33.00	8.43	1	0	0.00	UPL	5
Leersia oryxoides	10	10	10	0	1	6.20	1.58	0	4	6.34	OBL	1
Medicago lupulina	0	0	0	0	3	0.60	0.15	0	0	0.00	FAC	3
Melilotus officianalis	5	10	0	5	5	5.00	1.28	1	0	0.00	FACU	4
Morus alba	3	0	1	0	0	0.80	0.20	1	0	0.00	FAC	3
Oxalis dillenii	0	2	0	2	1	1.00	0.26	0	0	0.00	UPL	5
Panicum capillare	10	10	0	3	5	5.60	1.43	0	0	0.00	FAC	3
Parietaria pensylvanica	0	0	1	0	0	0.20	0.05	0	0	0.00	FAC	3
Phalaris arundinacea	45	35	45	30	45	40.00	10.22	1	0	0.00	FACW	2
Phytolaca americana	0	0	2	0	0	0.40	0.10	0	0	0.00	FAC	3
Pilea pumila	0	3	0	0	0	0.60	0.15	0	4	0.61	FAC	3
Polygonum aviculare	0	2	0	3	3	1.60	0.41	1	0	0.00	FACW	2
Polygonum lapathifolium	50	50	30	50	50	46.00	11.75	0	2	23.51	OBL	1
Polygonum pensylvanicum	10	10	5	3	5	6.60	1.69	0	0	0.00	FACW	2
Polygonum punctatum	10	10	10	10	10	10.00	2.55	0	4	10.22	OBL	1
Quercus rubra	0	0	1	0	0	0.20	0.05	0	5	0.26	FACU	4
Rorippa palustris	0	3	3	3	3	2.40	0.61	0	4	2.45	OBL	1

Rumex crispus	0	0	0	1	0	0.20	0.05	1	0	0.00	FACW	2
Setaria faberi	25	20	20	20	20	21.00	5.37	1	0	0.00	UPL	5
Solanum ptycnanthum	2	2	5	2	5	3.20	0.82	0	0	0.00	FACU	4
Stachys tenuifolia	3	3	0	3	0	1.80	0.46	0	4	1.84	FACW	2
Urtica dioica	5	0	5	5	10	5.00	1.28	0	1	1.28	FACW	2
Verbena bracteata	5	5	5	5	5	5.00	1.28	0	0	0.00	FACU	4
Verbena urticifolia	0	3	3	3	3	2.40	0.61	0	3	1.84	UPL	5
Veronica peregrina	10	10	5	10	10	9.00	2.30	0	1	2.30	OBL	1
Vitis riparius	5	5	5	10	5	6.00	1.53	0	3	4.60	FAC	3

MR2

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Acalypha rhomboidea	1	1	0	0	5	1.40	1.18	0	0	0.00	FACU	4
Acer negundo	0	0	0	0	1	0.20	0.17	0	1	0.17	FAC	3
Acer saccharinum	40	0	0	1	0	8.20	6.90	0	4	27.61	FACW	2
Agertina altissima	1	3	10	1	5	4.00	3.37	0	4	13.47	FACU	4
Alliaria petiolata	0	0	0	5	0	1.00	0.84	1	0	0.00	FACW	2
Amaranthus tuberculatus	0	0	0	0	1	0.20	0.17	0	0	0.00	FACW	2
Ambrosia trifida	3	0	0	0	0	0.60	0.51	0	0	0.00	FACW	2
Ampelopsis cordata	3	3	0	10	2	3.60	3.03	0	4	12.12	UPL	5
Arctium minus	0	0	0	3	0	0.60	0.51	1	0	0.00	UPL	5
Asclepias syriaca	0	1	0	0	0	0.20	0.17	0	1	0.17	FAC	3
Bidens connata	0	0	0	2	0	0.40	0.34	0	3	1.01	OBL	1
Bromus inermis	0	10	0	0	0	2.00	1.68	1	0	0.00	FACU	4
Bromus japonicus	0	3	0	0	0	0.60	0.51	1	0	0.00	FACU	4
Carex brevior	0	0	15	10	10	7.00	5.89	0	4	23.57	FAC	3
Carex hyalenolepis	1	5	0	0	0	1.20	1.01	0	7	7.07	OBL	1

Carex laeviconica	1	25	0	0	0	5.20	4.38	0	4	17.51	OBL	1
Celtis occidentalis	0	1	1	1	0	0.60	0.51	0	4	2.02	FACU	4
Cephalanthus occidentalis	2	0	0	1	0	0.60	0.51	0	6	3.03	OBL	1
Chenopodium simplex	0	3	3	0	0	1.20	1.01	0	1	1.01	UPL	5
Comelina communis	1	5	0	0	0	1.20	1.01	1	0	0.00	FAC	3
Conyza canadensis	0	1	0	1	1	0.60	0.51	0	0	0.00	FACU	4
Cornus drummondii	0	1	2	5	0	1.60	1.35	0	3	4.04	FAC	3
Cyperus odoratus	0	0	0	0	3	0.60	0.51	0	3	1.52	FACW	2
Echinocloa muricata	1	0	0	1	5	1.40	1.18	0	0	0.00	OBL	1
Eclipta prostrata	0	0	0	10	1	2.20	1.85	0	2	3.70	FACW	2
Elymus villosus	0	0	0	5	0	1.00	0.84	0	5	4.21	FACU	4
Elymus virginicus	5	20	0	5	20	10.00	8.42	0	4	33.67	FAC	3
Eragrostis hypnoides	0	0	0	0	3	0.60	0.51	0	5	2.53	FAC	3
Erechtites hierachfolius	1	0	0	1	1	0.60	0.51	0	1	0.51	FAC	3
Fallopia convolvulus	3	1	1	0	0	1.00	0.84	1	0	0.00	FACU	4
Fallopia scandens	3	0	0	0	0	0.60	0.51	0	1	0.51	FACU	4
Fraxinus americana	1	5	0	0	1	1.40	1.18	0	6	7.07	FACU	4
Galium circaezenus	0	1	0	0	0	0.20	0.17	0	5	0.84	UPL	5
Geum canadensis	1	1	5	0	0	1.40	1.18	0	3	3.54	FACU	4
Gleditsia triacanthos	15	0	0	5	0	4.00	3.37	0	1	3.37	FAC	3
Hibiscus laevis	0	0	0	1	0	0.20	0.17	0	4	0.67	OBL	1
Juglans nigra	0	1	0	0	0	0.20	0.17	0	5	0.84	FACU	4
Lamium amplexicaule	1	0	0	0	1	0.40	0.34	1	0	0.00	UPL	5
Leonorus cardiaca	0	1	0	0	0	0.20	0.17	1	0	0.00	FACU	4
Lobelia siphilitica	0	0	0	0	1	0.20	0.17	0	6	1.01	OBL	1
Lycopus americanus	0	0	0	0	1	0.20	0.17	0	4	0.67	OBL	1
Morus alba	1	1	0	0	0	0.40	0.34	1	0	0.00	FAC	3
Muhlenbergia mexicana	1	2	2	0	1	1.20	1.01	0	4	4.04	FACW	2

Oenethera biennis	0	0	0	0	5	1.00	0.84	0	1	0.84	FACU	4
Parthenocissus vitacea	1	5	5	2	0	2.60	2.19	0	4	8.75	FAC	3
Phalaris arundinacea	25	10	0	10	85	26.00	21.89	1	0	0.00	FACW	2
Phytolacca americana	1	1	0	1	1	0.80	0.67	0	0	0.00	FAC	3
Pilea pumila	0	0	0	0	1	0.20	0.17	0	4	0.67	FAC	3
Polygonum lapathifolium	0	0	0	0	2	0.40	0.34	0	2	0.67	OBL	1
Polygonum punctatum	0	0	0	0	1	0.20	0.17	0	4	0.67	OBL	1
Polygonum virginianum	1	0	0	0	0	0.20	0.17	0	4	0.67	FACW	2
Populus deltoides	1	0	0	1	1	0.60	0.51	0	3	1.52	FAC	3
Ribes missouriensis	0	5	1	0	0	1.20	1.01	0	4	4.04	FACU	4
Sanicula canadensis	0	1	1	0	0	0.40	0.34	0	3	1.01	FACU	4
Setaria faberi	0	0	0	2	5	1.40	1.18	1	0	0.00	UPL	5
Setaria viridis	0	5	0	0	0	1.00	0.84	1	0	0.00	FAC	3
Sicyos angulata	1	1	0	0	0	0.40	0.34	0	1	0.34	FAC	3
Smilax hispida	0	3	3	1	0	1.40	1.18	0	4	4.71	FAC	3
Solanum ptychanthum	0	1	1	1	0	0.60	0.51	0	0	0.00	FACU	4
Solidago canadensis	0	0	0	0	5	1.00	0.84	0	2	1.68	FACU	4
Symphoricarpos orbiculatus	0	0	0	1	0	0.20	0.17	0	2	0.34	FACU	4
Teucrium canadense	1	0	0	0	0	0.20	0.17	0	4	0.67	FACW	2
Toxicodendron rydbergii	5	5	5	0	0	3.00	2.53	0	1	2.53	FAC	3
Ulmus americana	1	0	0	0	0	0.20	0.17	0	3	0.51	FAC	3
Urtica dioica	5	3	0	0	3	2.20	1.85	0	1	1.85	FACW	2
Verbascum thapsis	0	3	0	0	0	0.60	0.51	1	0	0.00	UPL	5
Verbena urticifolia	0	1	0	0	0	0.20	0.17	0	3	0.51	UPL	5
Verbesina alterniflora	0	1	0	0	0	0.20	0.17	0	4	0.67	FAC	3
Veronica peregrina	0	0	0	0	1	0.20	0.17	0	1	0.17	OBL	1
Vitis riparia	5	5	0	1	0	2.20	1.85	0	3	5.56	FAC	3
Xanthium strumarium	0	0	0	0	1	0.20	0.17	0	1	0.17	FAC	3

MR3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Abutilon theophrasti	55	40	55	25	30	41.00	13.29	1	0	0.00	UPL	5
Amaranthus tuberculatus	60	80	75	65	45	65.00	21.08	0	0	0.00	FACW	2
Chenopodium alba	40	50	40	20	30	36.00	11.67	1	0	0.00	FAC	3
Conyza canadensis	10	10	5	5	1	6.20	2.01	0	0	0.00	FACU	4
Echinocloa crus-galli	25	10	20	40	35	26.00	8.43	1	0	0.00	FACW	2
Helianthus annuus	5	5	5	5	5	5.00	1.62	0	0	0.00	FACU	4
Ipomoea hederacea	10	10	10	3	0	6.60	2.14	1	0	0.00	FACU	4
Polygonum aviculare	0	0	0	5	2	1.40	0.45	1	0	0.00	FACW	2
Polygonum lapathifolium	40	25	15	25	50	31.00	10.05	0	2	62.00	OBL	1
Polygonum persicaria	50	50	50	15	15	36.00	11.67	1	0	0.00	OBL	1
Rumex crispus	5	1	1	0	5	2.40	0.78	1	0	0.00	FACW	2
Setaria faberi	20	10	10	30	30	20.00	6.49	1	0	0.00	UPL	5
Sida spinosa	1	1	1	0	1	0.80	0.26	1	0	0.00	UPL	5
Veronica peregrina	40	35	35	10	35	31.00	10.05	0	1	31.00	OBL	1

MR4

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Abutilon theophrasti	1	0	1	0	0	0.40	0.24	1	0	0.00	UPL	5
Acalypha rhomboidea	1	0	0	0	0	0.20	0.12	0	0	0.00	FACU	4
Amaranthus tuberculatus	5	5	5	2	2	3.80	2.31	0	0	0.00	FACW	2
Ambrosia trifida	100	80	20	90	100	78.00	47.39	0	0	0.00	FACW	2
Apocynum cannabinum	1	0	0	0	1	0.40	0.24	0	2	0.49	FAC	3
Bidens frondosa	1	0	1	1	0	0.60	0.36	0	1	0.36	FACW	2
Boehmaria cylindrica	1	0	0	0	0	0.20	0.12	0	6	0.73	OBL	1

Carex laeviconica	5	1	5	5	1	3.40	2.07	0	4	8.26	OBL	1
Celastrus scandens	0	1	0	0	0	0.20	0.12	0	4	0.49	FACU	4
Cephalanthus occidentalis	0	10	0	0	0	2.00	1.22	0	6	7.29	OBL	1
Chenopodium alba	20	15	15	5	5	12.00	7.29	1	0	0.00	FAC	3
Chenopodium simplex	1	0	0	0	0	0.20	0.12	0	1	0.12	UPL	5
Chenopodium standleyanum	1	1	1	0	0	0.60	0.36	0	4	1.46	UPL	5
Cicuta maculata	0	0	1	0	0	0.20	0.12	0	5	0.61	OBL	1
Fallopia convolvulus	1	1	3	0	1	1.20	0.73	1	0	0.00	FACU	4
Humulus japonicus	0	0	10	0	0	2.00	1.22	1	0	0.00	FACU	4
Juniperus virginianum	0	0	0	0	1	0.20	0.12	0	1	0.12	FACU	4
Medicago lupulina	0	0	0	0	1	0.20	0.12	1	0	0.00	FAC	3
Morus alba	1	1	1	1	1	1.00	0.61	1	0	0.00	FAC	3
Parthenocissus vitacea	0	1	1	1	0	0.60	0.36	0	4	1.46	FAC	3
Phalaris arundinacea	0	1	5	5	10	4.20	2.55	1	0	0.00	FACW	2
Polygonum coccineum	0	0	1	5	1	1.40	0.85	0	2	1.70	FACW	2
Polygonum lapathifolium	15	25	100	15	10	33.00	20.05	0	2	40.10	OBL	1
Polygonum punctatum	0	0	1	0	0	0.20	0.12	0	4	0.49	OBL	1
Rumex crispus	0	0	0	0	1	0.20	0.12	1	0	0.00	FACW	2
Salix exigua	0	0	45	25	15	17.00	10.33	0	3	30.98	OBL	1
Sicyos angulata	0	0	1	1	0	0.40	0.24	0	1	0.24	FAC	3
Veronica peregrina	1	0	0	0	0	0.20	0.12	0	1	0.12	OBL	1
Vitis riparia	0	1	1	1	0	0.60	0.36	0	3	1.09	FAC	3

MR5

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Abutilon theophrasti	1	1	0	1	0	0.60	0.24	1	0	0.00	UPL	5
Acalypha rhomboidea	10	25	10	15	3	12.60	4.95	0	0	0.00	FACU	4

Acer saccharinum	1	1	0	1	1	0.80	0.31	0	4	1.26	FACW	2
Agertina altissimum	15	60	10	15	10	22.00	8.63	0	4	34.54	FACU	4
Amaranthus tuberculatus	25	30	10	25	0	18.00	7.06	0	0	0.00	FACW	2
Ambrosia trifida	0	0	1	0	0	0.20	0.08	0	0	0.00	FACW	2
Bidens connata	1	10	0	0	1	2.40	0.94	0	3	2.83	OBL	1
Cannabis sativa	0	1	0	0	0	0.20	0.08	1	0	0.00	FACU	4
Cephalanthus occidentalis	5	1	1	25	0	6.40	2.51	0	6	15.07	OBL	1
Chenopodium alba	1	1	3	1	0	1.20	0.47	1	0	0.00	FAC	3
Chenopodium simplex	0	0	10	5	0	3.00	1.18	0	1	1.18	UPL	5
Conyza canadensis	5	1	5	10	0	4.20	1.65	0	0	0.00	FACU	4
Echinocloa crus-galli	0	0	1	0	0	0.20	0.08	1	0	0.00	FACW	2
Echinocloa muricata	5	5	1	5	0	3.20	1.26	0	0	0.00	OBL	1
Eclipta prostrata	15	30	25	20	5	19.00	7.46	0	2	14.91	FACW	2
Eragrostis hypnoides	0	0	0	1	0	0.20	0.08	0	5	0.39	FAC	3
Fallopia convulvulus	1	1	1	0	0	0.60	0.24	1	0	0.00	FACU	4
Hibiscus laevis	5	15	10	10	1	8.20	3.22	0	4	12.87	OBL	1
Humulus japonicus	40	65	75	70	0	50.00	19.62	1	0	0.00	FACU	4
Lamium amplexicaule	1	1	1	0	0	0.60	0.24	1	0	0.00	UPL	5
Mediago lupulina	0	0	0	0	5	1.00	0.39	1	0	0.00	FAC	3
Oxalis dilenii	0	0	1	0	1	0.40	0.16	0	0	0.00	UPL	5
Phalaris arundinacea	60	45	5	65	0	35.00	13.74	1	0	0.00	FACW	2
Phyla lanceolata	25	25	20	20	10	20.00	7.85	0	3	23.55	OBL	1
Polygonum aviculare	0	1	3	1	0	1.00	0.39	1	0	0.00	FACW	2
Polygonum coccinium	1	1	0	0	0	0.40	0.16	0	2	0.31	FACW	2
Polygonum lapathifolium	55	70	5	5	0	27.00	10.60	0	2	21.19	OBL	1
Populus deltoides	3	1	0	0	1	1.00	0.39	0	3	1.18	FAC	3
Potentilla norvegica	0	5	5	1	3	2.80	1.10	0	2	2.20	FAC	3
Rorippa palustris	0	15	0	1	1	3.40	1.33	0	4	5.34	OBL	1

Rumex crispus	0	0	1	0	0	0.20	0.08	1	0	0.00	FACW	2
Rumex fueginus	0	1	0	5	5	2.20	0.86	0	3	2.59	FACW	2
Setaria faberi	5	1	5	5	0	3.20	1.26	1	0	0.00	UPL	5
Solanum ptychanthium	3	3	1	3	5	3.00	1.18	0	0	0.00	FACU	4
Teucrium canadense	1	1	0	1	0	0.60	0.24	0	4	0.94	FACW	2

MR6

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Abutilon theophrasti	25	15	10	15	15	16.00	13.03	1	0	0.00	UPL	5
Amaranthus tuberculatus	10	10	10	10	15	11.00	8.96	0	0	0.00	FACW	2
Ambrosia artemisifolium	0	0	0	1	0	0.20	0.16	0	0	0.00	FACU	4
Carex hyanolepis	0	0	1	0	2	0.60	0.49	0	7	3.42	OBL	1
Chamaecrista fasciculata	1	1	1	1	1	1.00	0.81	0	1	0.81	FACU	4
Chenopodium album	5	1	1	15	1	4.60	3.75	1	0	0.00	FAC	3
Conyza canadensis	1	1	1	1	1	1.00	0.81	0	0	0.00	FACU	4
Cyclachaena xanthiifolia	10	10	5	5	10	8.00	6.51	0	0	0.00	FAC	3
Echinocloa crus-galli	10	10	10	5	1	7.20	5.86	1	0	0.00	FACW	2
Echinocloa muricata	1	1	1	5	5	2.60	2.12	0	0	0.00	OBL	1
Euphorbiae glyptosperma	5	5	1	5	5	4.20	3.42	0	0	0.00	UPL	5
Helianthus annuus	0	1	1	1	15	3.60	2.93	0	0	0.00	FACU	4
Panicum capillare	1	0	0	0	5	1.20	0.98	0	0	0.00	FAC	3
Pascopyrum smithii	0	0	0	0	1	0.20	0.16	0	3	0.49	FACU	4
Phalaris arundinacea	0	5	25	0	1	6.20	5.05	1	0	0.00	FACW	2
Phytolacca americana	0	1	0	0	0	0.20	0.16	0	0	0.00	FAC	3
Polygonum coccineum	1	1	0	0	1	0.60	0.49	0	2	0.98	FACW	2
Polygonum lapthifolium	10	20	50	45	20	29.00	23.62	0	2	47.23	OBL	1
Portulaca oleracea	1	0	1	0	0	0.40	0.33	0	0	0.00	FAC	3

Rorippa palustis	0	0	0	1	1	0.40	0.33	0	4	1.30	OBL	1
Rumex crispus	10	10	10	5	5	8.00	6.51	1	0	0.00	FACW	2
Rumex fueginus	1	0	0	0	0	0.20	0.16	0	3	0.49	FACW	2
Setaria faberi	15	20	15	10	20	16.00	13.03	1	0	0.00	UPL	5
Trifolium hybridum	0	0	0	1	1	0.40	0.33	1	0	0.00	FACU	4

MR7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Abutilon theophrasti	5	1	5	5	5	4.20	1.99	1	0	0.00	UPL	5
Amaranthus tuberculatus	5	2	0	10	1	3.60	1.71	0	0	0.00	FACW	2
Ambrosia trifida	3	3	0	2	10	3.60	1.71	0	0	0.00	FACW	2
Apocynum cannabinum	1	2	1	2	1	1.40	0.66	0	2	1.33	FACW	2
Cannabis sativa	1	1	0	1	1	0.80	0.38	1	0	0.00	FACU	4
Chenopodium album	1	1	1	1	0	0.80	0.38	1	0	0.00	FAC	3
Conyza canadensis	5	0	1	0	0	1.20	0.57	0	0	0.00	FACU	4
Coreopsis tinctoria	5	5	5	5	5	5.00	2.37	0	1	2.37	FAC	3
Cyclachaena xanthiifolia	0.1	0	0	0	0	0.02	0.01	0	0	0.00	FAC	3
Echinocloa muricata	0	0	1	0	0	0.20	0.09	0	0	0.00	OBL	1
Erechtites hieraciifolia	1	0	0	1	0	0.40	0.19	0	1	0.19	FAC	3
Fallopia convulvulus	0	0	1	1	0	0.40	0.19	1	0	0.00	FACU	4
Helianthus annuus	75	75	70	75	70	73.00	34.66	0	0	0.00	FACU	4
Oenthera biennis	1	0	1	0	0	0.40	0.19	0	1	0.19	FACU	4
Phalaris arundinacea	0	0	25	10	15	10.00	4.75	1	0	0.00	FACW	2
Phyla leanceolata	0	0	1	0	0	0.20	0.09	0	3	0.28	OBL	1
Polygonum lapathifolium	75	75	80	75	75	76.00	36.08	0	2	72.17	OBL	1
Rumex crispus	1	0	0	0	1	0.40	0.19	1	0	0.00	FACW	2
Salix exigua	0	0	5	0	0	1.00	0.47	0	3	1.42	OBL	1

Setaria faberi	3	3	5	5	10	5.20	2.47	1	0	0.00	UPL	5
Thlaspi arvense	5	5	0	0	1	2.20	1.04	1	0	0.00	FACU	4
Typha angustifolia	0	0	55	20	15	18.00	8.55	1	0	0.00	OBL	1
Veronica peregrina	1	1	1	5	5	2.60	1.23	0	1	1.23	OBL	1

MR8

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Abuliton theophrasti	0	1	1	1		0.60	0.42	1	0	0.00	UPL	5
Acalypha rhomboidea	0	0	1	1		0.40	0.28	0	0	0.00	FACU	4
Amaranthus tuberculatus	1	5	5	1		2.40	1.67	0	0	0.00	FACW	2
Ambrosia artemisifolia	1	5	1	1		1.60	1.12	0	0	0.00	FACU	4
Chenopodium album	25	15	10	45		19.00	13.24	1	0	0.00	FAC	3
Chenopodium simplex	0	0	1	5		1.20	0.84	0	1	0.84	UPL	5
Conyza canadensis	10	5	10	10		7.00	4.88	0	0	0.00	FACU	4
Cyperus odoratus	0	1	0	0		0.20	0.14	0	3	0.42	FACW	2
Echinocloa crus-galli	10	5	1	1		3.40	2.37	1	0	0.00	FACW	2
Eleocharis acicularis	0	0.1	0	0		0.02	0.01	0	4	0.06	OBL	1
Eragrostis hypnoides	0	1	0	1		0.40	0.28	0	5	1.39	FAC	3
Erechtites hieraciifolia	0	0	1	0		0.20	0.14	0	1	0.14	FAC	3
Helianthus annuss	1	0	5	5		2.20	1.53	0	0	0.00	FACU	4
Humulus japonicus	15	3	10	30		11.60	8.09	1	0	0.00	FACU	4
Lactuca saligna	0	1	0	0		0.20	0.14	1	0	0.00	FACU	4
Lamium amplexicaule	0	0.1	0	0		0.02	0.01	1	0	0.00	UPL	5
Panicum capillare	5	5	10	20		8.00	5.58	0	0	0.00	FAC	3
Phalaris arundinacea	45	45	85	40		43.00	29.97	1	0	0.00	FACW	2
Pilea pumila	0	0	1	0		0.20	0.14	0	4	0.56	FAC	3
Polygonum lapathifolium	25	15	60	40		28.00	19.52	0	2	39.04	OBL	1

Populus deltoides	0	0.1	1	0		0.22	0.15	0	3	0.46	FAC	3
Rorippa palustris	20	10	1	10		8.20	5.72	0	4	22.86	OBL	1
Rumex crispus	1	1	0	0		0.40	0.28	1	0	0.00	FACW	2
Setaria faberi	5	1	5	5		3.20	2.23	1	0	0.00	UPL	5
Urtica dioica	0	0	0	1		0.20	0.14	0	1	0.14	FACW	2
Verbena stricta	0	1	0	0		0.20	0.14	0	2	0.28	UPL	5
Xanthium strumarium	3	3	0	1		1.40	0.98	0	1	0.98	FAC	3

MR9

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Abutilon theophrasti	1	0	0	0	0	0.20	0.14	1	0	0.00	UPL	5
Acalypha rhomboidea	0	0	1	0	0	0.20	0.14	0	0	0.00	FACU	4
Ambrosia trifida	1	1	0	0	1	0.60	0.43	0	0	0.00	FACW	2
Cannabis sativa	15	15	15	25	15	17.00	12.27	1	0	0.00	FACU	4
Chenopodium album	75	80	80	75	70	76.00	54.83	1	0	0.00	FAC	3
Chenopodium simplex	10	20	10	5	5	10.00	7.22	0	1	7.22	UPL	5
Conium maculatum	0	0	5	0	0	1.00	0.72	1	0	0.00	FACW	2
Echinocloa muricata	1	0	0	0	0	0.20	0.14	0	0	0.00	OBL	1
Elymus virginicus	5	1	0	0	1	1.40	1.01	0	4	4.04	FAC	3
Helianthus annuus	5	3	5	5	1	3.80	2.74	0	0	0.00	FACU	4
Humulus japonicus	0	0	1	1	0	0.40	0.29	1	0	0.00	FACU	4
Lamium amplexicaule	1	0	0	0	0	0.20	0.14	1	0	0.00	UPL	5
Morus alba	0	0	1	1	1	0.60	0.43	1	0	0.00	FAC	3
Phalaris arundinacea	15	20	25	10	15	17.00	12.27	1	0	0.00	FACW	2
Phytolacca americana	0	0	0	0	1	0.20	0.14	0	0	0.00	FAC	3
Setaria faberi	5	1	1	0	1	1.60	1.15	1	0	0.00	UPL	5
Sicyos angulata	0	0	0	1	0	0.20	0.14	0	1	0.14	FAC	3

Solanum ptychanthum	0	0	0	0	1	0.20	0.14	0	0	0.00	FACU	4
Thlaspi arvense	1	0	1	0	0	0.40	0.29	1	0	0.00	FACU	4
Urtica dioica	0	1	5	0	1	1.40	1.01	0	1	1.01	FACW	2
Veronica peregrina	0	0	20	5	5	6.00	4.33	0	1	4.33	OBL	1

NR1

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alisma triviale	10	0	10	0	10	6.00	6.01	0	4	24.05	OBL	1
Amorpha fruticosa	5	0	0	3	0	1.60	1.60	0	5	8.02	OBL	1
Amphicarpea bracteata	0	0	0	1	0	0.20	0.20	0	4	0.80	FACW	2
Aster praealtus	1	1	1	1	1	1.00	1.00	0	5	5.01	FACW	2
Carex crawei	0	0	5	5	0	2.00	2.00	0	6	12.02	FACW	2
Carex emoryi	0	0	5	0	0	1.00	1.00	0	5	5.01	OBL	1
Carex hystericina	0	1	0	0	0	0.20	0.20	0	5	1.00	OBL	1
Carex tetanica	0	0	5	5	0	2.00	2.00	0	7	14.03	FACW	2
Cicuta maculata	1	1	1	0	0	0.60	0.60	0	5	3.01	OBL	1
Cornus drummondii	0	0	5	0	5	2.00	2.00	0	3	6.01	FAC	3
Epilobum ciliatum	0	0	0	0	1	0.20	0.20	0	6	1.20	OBL	1
Equisetum arvense	30	15	15	0	5	13.00	13.03	0	4	52.10	FAC	3
Erigeron philadelphicus	0	0	1	0	0	0.20	0.20	0	3	0.60	FAC	3
Eupatorium perfoliatum	1	1	1	0	0	0.60	0.60	0	5	3.01	OBL	1
Galium aparine	0	0	1	0	0	0.20	0.20	0	0	0.00	FACU	4
Galium triflorum	0	0	1	1	0	0.40	0.40	0	4	1.60	FACU	4
Geum canadense	0	0	0	1	0	0.20	0.20	0	3	0.60	FACU	4
Heracleum lanatum	0	0	5	0	0	1.00	1.00	0	6	6.01	FACW	2
Impatiens carpensis	0	25	5	10	5	9.00	9.02	0	4	36.07	FACW	2
Lysimachia thrysiflora	0	0	0	0	1	0.20	0.20	0	7	1.40	OBL	1

Lythrum salicaria	10	20	15	20	35	20.00	20.04	1	0	0.00	OBL	1
Mentha canadensis	0	5	0	1	0	1.20	1.20	0	4	4.81	FACW	2
Nepeta cataria	0	0	1	1	0	0.40	0.40	1	0	0.00	FACU	4
Parthenocissus vitacea	0	1	0	1	0	0.40	0.40	0	4	1.60	FAC	3
Phalaris arundinacea	10	5	0	15	0	6.00	6.01	1	0	0.00	FACW	2
Poa pratensis	0	10	15	10	15	10.00	10.02	1	0	0.00	FACU	4
Ribes americanum	0	1	1	1	0	0.60	0.60	0	6	3.61	FACW	2
Ribes missouriense	0	1	0	0	0	0.20	0.20	0	4	0.80	FACU	4
Sagittaria latifolia	0	0	10	0	5	3.00	3.01	0	5	15.03	OBL	1
Salix exigua	0	0	0	5	0	1.00	1.00	0	3	3.01	OBL	1
Solidago gigantea	0	0	0	0	3	0.60	0.60	0	3	1.80	FACW	2
Sparganium eurycarpum	10	0	5	0	5	4.00	4.01	0	5	20.04	OBL	1
Spartina pectinata	5	1	1	0	1	1.60	1.60	0	5	8.02	FACW	2
Thalactrum dasycarpum	0	0	1	1	0	0.40	0.40	0	4	1.60	FACW	2
Toxicodendron rydbergii	0	0	5	1	0	1.20	1.20	0	1	1.20	FAC	3
Typha latifolia	10	15	0	0	10	7.00	7.01	0	1	7.01	OBL	1
Viola sororia	0	0	1	1	1	0.60	0.60	0	3	1.80	FAC	3
Vitis riparia	0	1	1	0	1	0.60	0.60	0	3	1.80	FAC	3

NR2

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Achillea millefolium	0	0	0	0	1	0.20	0.09	0	2	0.19	FACU	4
Alopecurus carolinianus	10	0	0	5	0	3.00	1.41	0	1	1.41	FACW	2
Aster laevis	0	0	0	1	1	0.40	0.19	0	5	0.94	UPL	5
Calamagrostis stricta	10	15	0	0	10	7.00	3.29	0	6	19.74	FACW	2
Carex crawei	0	1	0	0	0	0.20	0.09	0	6	0.56	FACW	2
Carex emoryi	15	5	10	10	30	14.00	6.58	0	5	32.89	OBL	1

Carex interior	45	45	0	0	25	23.00	10.81	0	7	75.66	OBL	1
Carex pellita	10	20	5	0	5	8.00	3.76	0	4	15.04	OBL	1
Carex tetanica	25	0	0	0	15	8.00	3.76	0	7	26.32	FACW	2
Cerastium fontanum	0	0	0	1	1	0.40	0.19	1	0	0.00	FACU	4
Cirsium altissimum	1	0	5	5	0	2.20	1.03	0	1	1.03	FAC	3
Convulvus arvense	5	0	0	1	1	1.40	0.66	1	0	0.00	UPL	5
Crepis tectorum	1	0	1	1	1	0.80	0.38	1	0	0.00	UPL	5
Desmodium canadense	0	0	0	1	0	0.20	0.09	0	5	0.47	FAC	3
Eleocharis compressa	0	0	1	0	0	0.20	0.09	0	6	0.56	FACW	2
Eleocharis erythropoda	20	0	35	40	30	25.00	11.75	0	5	58.74	OBL	1
Eleocharis palustris	1	10	0	0	0	2.20	1.03	0	4	4.14	OBL	1
Equisetum arvense	1	0	0	1	1	0.60	0.28	0	4	1.13	FAC	3
Equisetum hymale	0	1	0	0	0	0.20	0.09	0	4	0.38	FACW	2
Equisetum laevigatum	1	0	1	1	1	0.80	0.38	0	4	1.50	FACW	2
Erigeron bellidiastrum	1	0	1	1	1	0.80	0.38	0	4	1.50	UPL	5
Hypoxis hirsuta	10	1	5	5	5	5.20	2.44	0	7	17.11	FACW	2
Juncus balticus	1	0	0	0	5	1.20	0.56	0	6	3.38	OBL	1
Lysimachia thrysiflora	5	10	0	0	1	3.20	1.50	0	7	10.53	OBL	1
Pascopyrum smithii	5	0	0	1	5	2.20	1.03	0	3	3.10	FACU	4
Poa pratensis	25	10	10	20	20	17.00	7.99	1	0	0.00	FACU	4
Schoenoplectus acutus	0	1	0	0	0	0.20	0.09	0	5	0.47	OBL	1
Schoenoplectus pungens	1	0	0	0	0	0.20	0.09	0	4	0.38	OBL	1
Senecio plattensis	0	0	1	1	0	0.40	0.19	0	5	0.94	FACU	4
Sisyrinchium montanum	5	0	5	1	1	2.40	1.13	0	5	5.64	FAC	3
Spartina pectinata	50	80	40	30	25	45.00	21.15	0	5	105.73	FACW	2
Stachys pilosa	1	0	0	1	1	0.60	0.28	0	5	1.41	OBL	1
Stellaria longifolia	1	1	1	1	1	1.00	0.47	0	7	3.29	OBL	1
Strophostyles leiosperma	0	0	1	0	0	0.20	0.09	0	4	0.38	UPL	5

Taraxacum laevigatum	10	1	5	5	5	5.20	2.44	1	0	0.00	FACU	4
Thalictrum dasycarpum	15	15	15	15	15	15.00	7.05	0	4	28.20	FACW	2
Trifolium pratensis	15	0	10	10	10	9.00	4.23	1	0	0.00	FACU	4
Viola sororia	10	1	10	5	5	6.20	2.91	0	3	8.74	FAC	3

NR3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Acer negunda	0	0	1	0	0	0.20	0.10	0	2	1.01	FAC	3
Alsima triviale	0	0	0	1	5	1.20	0.59	0	4	2.01	OBL	1
Amorpha fruticosa	5	5	1	5	1	3.40	1.68	0	5	2.51	OBL	1
Amphicarpea bracteata	1	0	1	0	0	0.40	0.20	0	4	2.01	FACW	2
Aster praealtus	1	0	1	0	0	0.40	0.20	0	5	2.51	FACW	2
Bolboschoenus fluviatilis	1	0	0	5	1	1.40	0.69	0	3	1.51	OBL	1
Carex comosa	1	0	0	3	3	1.40	0.69	0	5	2.51	OBL	1
Carex emoryi	30	10	50	5	15	22.00	10.90	0	5	2.51	OBL	1
Carex pellita	10	0	10	0	0	4.00	1.98	0	4	2.01	OBL	1
Carex praegracilis	0	0	0	1	0	0.20	0.10	0	4	2.01	FACW	2
Carex scoparia	0	0	0	1	0	0.20	0.10	0	5	2.51	FACW	2
Carex stipata	5	0	1	0	0	1.20	0.59	0	5	2.51	OBL	1
Carex vulpinoidea	30	0	25	25	15	19.00	9.42	0	4	2.01	OBL	1
Cerastium fontanum	1	1	5	1	0	1.60	0.79	1	0	0.00	FACU	4
Cicuta maculata	1	0	1	0	1	0.60	0.30	0	5	2.51	OBL	1
Cirsium arvense	0	0	1	0	0	0.20	0.10	1	0	0.00	FACU	4
Cornus drummondii	0	0	3	0	0	0.60	0.30	0	3	1.51	FAC	3
Eleocharis acicularis	0	5	0	3	0	1.60	0.79	0	4	2.01	OBL	1
Eleocharis palustris	5	10	10	10	15	10.00	4.96	0	4	2.01	OBL	1
Equisetum arvense	15	15	10	0	10	10.00	4.96	0	4	2.01	FAC	3

Equisetum laevigatum	1	1	0	0	0	0.40	0.20	0	4	2.01	FACW	2
Erigeron philadelphicus	1	0	1	0	0	0.40	0.20	0	3	1.51	FAC	3
Heracleum lanatum	10	1	10	0	5	5.20	2.58	0	6	3.02	FACW	2
Impatiens capensis	0	5	10	3	5	4.60	2.28	0	4	2.01	FACW	2
Juncus balticus	2	1	5	1	5	2.80	1.39	0	6	3.02	OBL	1
Juncus dudleyi	1	0	1	0	0	0.40	0.20	0	5	2.51	FACW	2
Lycopus asper	1	1	1	1	1	1.00	0.50	0	5	2.51	OBL	1
Lysimachia ciliata	1	0	0	0	1	0.40	0.20	0	5	2.51	FACW	2
Lysimachia thrysiflora	3	1	0	0	3	1.40	0.69	0	7	3.52	OBL	1
Lythrum alatum	25	5	20	30	25	21.00	10.41	0	6	3.02	OBL	1
Nepeta cataria	0	0	3	0	0	0.60	0.30	1	0	0.00	FACU	4
Parthenocissus vitacea	1	0	1	0	0	0.40	0.20	0	4	2.01	FAC	3
Phalaris arundinacea	50	25	40	10	10	27.00	13.38	1	0	0.00	FACW	2
Poa pratensis	10	10	10	5	5	8.00	3.96	1	0	0.00	FACU	4
Populus deltoides	0	3	0	0	0	0.60	0.30	0	3	1.51	FAC	3
Potamogeton pectinatus	0	0	0	1	1	0.40	0.20	0	6	3.02	OBL	1
Quercus macrocarpa	0	0	1	0	1	0.40	0.20	0	5	2.51	FACU	4
Rosa arkansana	1	5	1	0	0	1.40	0.69	0	4	2.01	FACU	4
Rosa woodsii	0	0	1	0	0	0.20	0.10	0	4	2.01	FACU	4
Sagittaria latifolia	5	5	0	10	10	6.00	2.97	0	5	2.51	OBL	1
Salix exigua	15	25	5	0	0	9.00	4.46	0	3	1.51	OBL	1
Schoenoplectus acutus	1	1	0	1	0	0.60	0.30	0	5	2.51	OBL	1
Schoenoplectus pungens	3	5	0	0	1	1.80	0.89	0	4	2.01	OBL	1
Solidago canadensis	1	1	1	0	1	0.80	0.40	0	2	1.01	FACU	4
Solidago gigantea	1	1	5	0	0	1.40	0.69	0	3	1.51	FACW	2
Sparganium eurycarpum	0	5	0	1	1	1.40	0.69	0	5	2.51	OBL	1
Spirodela polyrhiza	0	0	0	1	1	0.40	0.20	0	6	3.02	OBL	1
Stachys pilosa	0	0	1	0	1	0.40	0.20	0	5	2.51	OBL	1

Stellaria media	0	0	1	0	0	0.20	0.10	1	0	0.00	UPL	5
Trifolium pratense	5	1	1	0	0	1.40	0.69	1	0	0.00	FACU	4
Typha angustifolia	0	5	15	20	15	11.00	5.45	1	0	0.00	OBL	1
Typha latifolia	15	0	15	5	5	8.00	3.96	0	1	0.50	OBL	1
Verbena hastata	0	1	0	1	1	0.60	0.30	0	4	2.01	FACW	2
Vitis riparia	0	0	1	1	1	0.60	0.30	0	3	1.51	FAC	3
Xanthium strumarium	0	5	5	0	0	2.00	0.99	0	1	0.50	FAC	3

NR4

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Aster ericoides	0	0	0	1	0	0.20	0.26	0	3	0.79	FACU	4
Bolboshcoenus fluviatilis	40	1	1	0	10	10.40	13.72	0	3	41.16	OBL	1
Bromus inermis	0	0	0	10	0	2.00	2.64	1	0	0.00	FACU	4
Carex emoryi	10	10	0	5	5	6.00	7.92	0	5	39.58	OBL	1
Carex lacustris	0	20	65	15	0	20.00	26.39	0	6	158.31	OBL	1
Carex praegracilis	0	0	0	1	0	0.20	0.26	0	4	1.06	FACW	2
Carex tetanica	0	0	0	1	0	0.20	0.26	0	7	1.85	FACW	2
Cirsium altissimum	0	0	0	1	0	0.20	0.26	0	1	0.26	FAC	3
Eleocharis palustris	5	1	0	0	0	1.20	1.58	0	4	6.33	OBL	1
Hordeum jubatum	3	0	0	0	0	0.60	0.79	0	1	0.79	FACW	2
Juniperus viriginiana	0	0	0	1	0	0.20	0.26	0	1	0.26	FACU	4
Lycopus americanus	0	0	0	1	0	0.20	0.26	0	4	1.06	OBL	1
Lysimachia thrysiflora	1	1	0	1	0	0.60	0.79	0	7	5.54	OBL	1
Parthenocissus vitacea	0	0	0	1	0	0.20	0.26	0	4	1.06	FAC	3
Phragmites australis var americana	15	10	10	0	5	8.00	10.55	0	3	31.66	FACW	2
Poa pratensis	0	0	0	25	0	5.00	6.60	1	0	0.00	FACU	4
Polygonum coccineum	1	1	0	1	0	0.60	0.79	0	2	1.58	FACW	2

Populus deltoides	0	0	0	30	0	6.00	7.92	0	3	23.75	FAC	3
Potamogeton natans	0	0	0	0	1	0.20	0.26	0	7	1.85	OBL	1
Potamogeton pectinatus	0	1	1	0	0	0.40	0.53	0	6	3.17	OBL	1
Ranunculus scelratus	1	1	0	1	0	0.60	0.79	0	3	2.37	OBL	1
Rosa woodsii	0	0	0	1	0	0.20	0.26	0	4	1.06	FACU	4
Schoenoplectus acutus	0	1	1	1	1	0.80	1.06	0	5	5.28	OBL	1
Smilacina stellatum	0	0	0	1	0	0.20	0.26	0	4	1.06	FAC	3
Solidago missouriensis	0	0	0	1	0	0.20	0.26	0	5	1.32	UPL	5
Sparganium eurycarpum	25	10	5	3	5	9.60	12.66	0	5	63.32	OBL	1
Spirodela polyrhiza	1	1	0	0	1	0.60	0.79	0	6	4.75	OBL	1
Symphoricarpos occidentalis	0	0	0	1	0	0.20	0.26	0	2	0.53	FACU	4
Thalictrum dasycarpum	0	0	0	1	0	0.20	0.26	0	4	1.06	FACW	2
Trifolium pratense	0	0	0	1	0	0.20	0.26	1	0	0.00	FACU	4
Typha angustifolia	1	0	0	0	1	0.40	0.53	1	0	0.00	OBL	1
Vitis riparia	0	0	0	1	0	0.20	0.26	0	3	0.79	FAC	3

NR5

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia psilotachia	5	5	5	0	1	3.20	1.20	0	1	1.20	FAC	3
Andropogon gerardii	15	20	15	5	0	11.00	4.12	0	5	20.61	FAC	3
Bromus inermis	10	10	25	15	5	13.00	4.87	1	0	0.00	FACU	4
Carex bebbii	0	0	0	0	1	0.20	0.07	0	7	0.52	OBL	1
Carex pellita	0	0	0	30	10	8.00	3.00	0	4	11.99	OBL	1
Carex praegracilis	30	25	35	35	15	28.00	10.49	0	4	41.98	FACW	2
Carex vulpinoidea	15	10	15	25	50	23.00	8.62	0	4	34.48	OBL	1
Chenopodium album	0	0	0	0	1	0.20	0.07	1	0	0.00	FAC	3
Cirsium arvense	0	1	0	0	0	0.20	0.07	1	0	0.00	FACU	4

Convulvulus arvense	0	0	0	5	1	1.20	0.45	1	0	0.00	UPL	5
Eleocharis engelmannii	1	1	0	10	0	2.40	0.90	0	3	2.70	FACW	2
Eleocharis erythropoda	25	25	20	35	35	28.00	10.49	0	5	52.47	OBL	1
Equisetum laevigatum	1	5	5	5	1	3.40	1.27	0	4	5.10	FACW	2
Hordeum jubatum	10	5	5	25	30	15.00	5.62	0	1	5.62	FACW	2
Hypoxis hirsuta	1	5	5	1	5	3.40	1.27	0	7	8.92	FACW	2
Juncus balticus	1	0	1	0	0	0.40	0.15	0	6	0.90	OBL	1
Lactuca ludoviciana	1	0	0	1	0	0.40	0.15	0	3	0.45	FAC	3
Medicago lupulinus	20	10	15	15	25	17.00	6.37	1	0	0.00	FAC	3
Nassella viridula	25	10	5	0	0	8.00	3.00	0	4	11.99	FACU	4
Oxalis stricta	0	0	1	1	0	0.40	0.15	0	0	0.00	FACU	4
Poa pratensis	30	25	30	25	20	26.00	9.75	1	0	0.00	FACU	4
Rorippa palustris	0	0	0	1	1	0.40	0.15	0	4	0.60	OBL	1
Rumex crispus	0	0	0	1	0	0.20	0.07	1	0	0.00	FACW	2
Schizachyrium scoparium	5	0	0	0	0	1.00	0.37	0	4	1.50	FACU	4
Schoenoplectus pungens	0	1	1	0	10	2.40	0.90	0	4	3.60	OBL	1
Sisyrinchium montanum	5	10	5	0	1	4.20	1.57	0	5	7.87	FAC	3
Sorghastrum nutans	1	1	0	0	0	0.40	0.15	0	5	0.75	FACU	4
Spartina pectinata	10	5	15	40	40	22.00	8.25	0	5	41.23	FACW	2
Taraxicum officinale	1	1	1	5	5	2.60	0.97	1	0	0.00	FACU	4
Thlaspi arvense	0	0	1	0	0	0.20	0.07	1	0	0.00	FACU	4
Trifolium hybridum	10	15	15	15	15	14.00	5.25	1	0	0.00	FACU	4
Trifolium pratense	10	10	45	50	15	26.00	9.75	1	0	0.00	FACU	4
Veronica peregrina	0	0	0	0	1	0.20	0.07	0	1	0.07	OBL	1
Viola sororia	1	1	1	1	0	0.80	0.30	0	3	0.90	FAC	3

NR6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alisma triviale	0	0	0	0	1	0.20	0.12	0	4	0.48	OBL	1
Ambrosia artemisifolia	10	0	10	10	10	8.00	4.80	0	0	0.00	FACU	4
Ambrosia trifida	1	15	0	0	0	3.20	1.92	0	0	0.00	FACW	2
Amorpha fruticosa	0	5	0	0	0	1.00	0.60	0	5	3.00	OBL	1
Amphicarpea bracteata	3	0	3	0	0	1.20	0.72	0	4	2.88	FACW	2
Arctium minus	1	0	1	0	0	0.40	0.24	1	0	0.00	UPL	5
Aster praealtus	1	0	5	0	0	1.20	0.72	0	5	3.60	FACW	2
Bolboschoenus fluviatilis	0	0	0	3	5	1.60	0.96	0	3	2.88	OBL	1
Bromus inermis	5	0	0	0	0	1.00	0.60	1	0	0.00	FACU	4
Carex blanda	0	1	0	0	1	0.40	0.24	0	2	0.48	FAC	3
Carex emoryi	10	85	20	10	10	27.00	16.19	0	5	80.94	OBL	1
Carex lacustris	10	0	10	10	1	6.20	3.72	0	6	22.30	OBL	1
Carex pellita	5	10	5	5	10	7.00	4.20	0	4	16.79	OBL	1
Carex sprengellii	1	0	1	0	0	0.40	0.24	0	6	1.44	FAC	3
Celtis occidentalis	1	0	1	1	0	0.60	0.36	0	4	1.44	FACU	4
Chenopodium fremontii	0	1	0	0	0	0.20	0.12	0	3	0.36	UPL	5
Convulvulus arvense	0	1	0	0	0	0.20	0.12	1	0	0.00	UPL	5
Cornus drummondii	1	0	1	1	0	0.60	0.36	0	3	1.08	FAC	3
Cornus sericea	1	0	0	0	0	0.20	0.12	0	6	0.72	FACW	2
Drymocallis arguta	1	0	0	0	0	0.20	0.12	0	6	0.72	FACU	4
Eleocharis aciculatis	1	0	0	5	5	2.20	1.32	0	4	5.28	OBL	1
Eleocharis erythropoda	0	0	0	0	10	2.00	1.20	0	5	6.00	OBL	1
Eleocharis palustris	0	0	0	0	5	1.00	0.60	0	4	2.40	OBL	1
Elymus canadensis	5	0	10	0	0	3.00	1.80	0	5	8.99	FACU	4
Elymus villosus	15	0	10	10	5	8.00	4.80	0	5	23.98	FACU	4

Equisetum arvense	1	0	1	1	0	0.60	0.36	0	4	1.44	FAC	3
Erigeron philadelphicus	1	0	1	0	0	0.40	0.24	0	3	0.72	FAC	3
Frageria vesca	0	1	0	0	0	0.20	0.12	0	6	0.72	UPL	5
Fraxinus pennsylvanica	1	0	1	1	0	0.60	0.36	0	2	0.72	FACW	2
Galium aparine	1	0	3	0	0	0.80	0.48	0	0	0.00	FACU	4
Galium triflorum	5	0	5	0	0	2.00	1.20	0	4	4.80	FACU	4
Geum aleppicum	1	0	5	0	0	1.20	0.72	0	6	4.32	FACU	4
Helianthus nuttalii	1	0	0	0	0	0.20	0.12	0	6	0.72	FAC	3
Heracleum lanatum	20	0	20	0	0	8.00	4.80	0	6	28.78	FACW	2
Impatiens capensis	10	0	5	0	0	3.00	1.80	0	4	7.19	FACW	2
Lemna trisulca	0	0	0	1	1	0.40	0.24	0	8	1.92	OBL	1
Lycopus asper	1	0	1	1	0	0.60	0.36	0	4	1.44	OBL	1
Lysimachia thrysiflora	10	5	10	10	5	8.00	4.80	0	7	33.57	OBL	1
Lythrum salicaria	45	0	20	40	30	27.00	16.19	1	0	0.00	OBL	1
Medicago sativa	0	1	0	0	0	0.20	0.12	1	0	0.00	UPL	5
Melilotus officinalis	0	5	0	0	0	1.00	0.60	1	0	0.00	FACU	4
Mirabilis nyctaginea	1	0	0	0	0	0.20	0.12	0	1	0.12	UPL	5
Oxalis violacea	0	3	0	0	0	0.60	0.36	0	5	1.80	UPL	5
Parthenocissus vitacea	1	0	5	0	0	1.20	0.72	0	4	2.88	FAC	3
Phragmites australis	10	0	5	1	0	3.20	1.92	1	0	0.00	FACW	2
Poa pratensis	15	0	1	0	0	3.20	1.92	1	0	0.00	FACU	4
Polygonum lapathifolium	1	0	0	5	10	3.20	1.92	0	2	3.84	OBL	1
Ribes americanum	5	0	10	1	0	3.20	1.92	0	6	11.51	FACW	2
Rosa woodsii	1	0	0	0	0	0.20	0.12	0	4	0.48	FACU	4
Rumex crispus	1	0	0	0	0	0.20	0.12	1	0	0.00	FACW	2
Sagittaria calcyna	0	0	0	0	1	0.20	0.12	0	3	0.36	OBL	1
Sagittaria latifolia	0	0	0	5	5	2.00	1.20	0	5	6.00	OBL	1
Schoenoplectus acutus	0	0	0	0	1	0.20	0.12	0	5	0.60	OBL	1

Smilacina stellata	1	0	1	0	0	0.40	0.24	0	4	0.96	FAC	3
Solidago canadensis	10	0	10	1	0	4.20	2.52	0	2	5.04	FACU	4
Solidago speciosa	1	0	1	0	0	0.40	0.24	0	7	1.68	UPL	5
Sparganum eurycarpum	1	0	0	1	5	1.40	0.84	0	5	4.20	OBL	1
Spirodela polyrhiza	0	0	0	1	1	0.40	0.24	0	6	1.44	OBL	1
Stellaria longiflora	1	1	0	0	0	0.40	0.24	0	7	1.68	OBL	1
Stellaria media	1	0	1	0	0	0.40	0.24	1	0	0.00	UPL	5
Taraxacum officinale	5	0	1	0	0	1.20	0.72	1	0	0.00	FACU	4
Thalictrum dasycarpum	5	0	15	0	0	4.00	2.40	0	4	9.59	FACW	2
Thlaspi arvense	1	0	0	0	0	0.20	0.12	1	0	0.00	FACU	4
Trifolium pratense	0	1	0	0	0	0.20	0.12	1	0	0.00	FACU	4
Ulmus americana	1	0	0	0	0	0.20	0.12	0	3	0.36	FAC	3
Urtica dioca	5	0	5	1	0	2.20	1.32	0	1	1.32	FACW	2
Verbena hastata	1	0	1	1	0	0.60	0.36	0	4	1.44	FACW	2
Viola sororia	0	1	0	0	0	0.20	0.12	0	3	0.36	FAC	3
Vitis riparia	1	0	5	0	0	1.20	0.72	0	3	2.16	FAC	3
Wolffia columbiana	0	0	0	1	1	0.40	0.24	0	5	1.20	OBL	1

NR7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alisma triviale	0	0	1	0	0	0.20	0.14	0	4	0.55	OBL	1
Amorpha fruiticosa	1	35	0	5	0	8.20	5.59	0	5	27.97	OBL	1
Amphicarpa bracteata	1	0	0	1	0	0.40	0.27	0	4	1.09	FACW	2
Asclepias incarnata	0	10	0	1	0	2.20	1.50	0	4	6.00	OBL	1
Aster praealtus	0	1	0	1	1	0.60	0.41	0	5	2.05	FACW	2
Boehmaria cylindrica	5	5	0	0	0	2.00	1.36	0	6	8.19	OBL	1
Bromus inermis	15	10	0	5	0	6.00	4.09	1	0	0.00	FACU	4

Calamagrostis stricta	1	0	0	1	0	0.40	0.27	0	6	1.64	FACW	2
Carex emoryi	40	35	20	10	0	21.00	14.32	0	5	71.62	OBL	1
Carex gravida	5	0	0	0	0	1.00	0.68	0	4	2.73	FACU	4
Carex pellita	0	0	5	10	15	6.00	4.09	0	4	16.37	OBL	1
Carex scoparia	1	5	5	0	25	7.20	4.91	0	5	24.56	FACW	2
Carex stipata	0	0	5	0	0	1.00	0.68	0	5	3.41	OBL	1
Chenopodium fremontii	0	0	1	0	0	0.20	0.14	0	3	0.41	UPL	5
Eleocharis compressa	10	0	0	0	0	2.00	1.36	0	6	8.19	FACW	2
Eleocharis erythropoda	0	5	0	0	10	3.00	2.05	0	5	10.23	OBL	1
Elymus canadensis	10	15	10	10	0	9.00	6.14	0	5	30.70	FACU	4
Equisetum arvense	0	1	1	1	0	0.60	0.41	0	4	1.64	FAC	3
Equisetum laevigatum	0	0	1	0	0	0.20	0.14	0	4	0.55	FACW	2
Erigeron philadelphicus	1	0	0	0	0	0.20	0.14	0	3	0.41	FAC	3
Eupatorium maculatum	0	0	1	0	0	0.20	0.14	0	6	0.82	OBL	1
Galium aparine	0	0	1	0	0	0.20	0.14	0	0	0.00	FACU	4
Geum canadense	0	0	0	1	0	0.20	0.14	0	3	0.41	FACU	4
Glyceria striata	0	0	10	0	3	2.60	1.77	0	5	8.87	OBL	1
Glycyhrrhiza lepidota	1	0	0	0	0	0.20	0.14	0	4	0.55	FACU	4
Humulus lupulus	0	0	0	1	0	0.20	0.14	0	3	0.41	FAC	3
Lolium arundinacea	0	0	10	0	0	2.00	1.36	1	0	0.00	FACU	4
Lycopus uniflora	5	5	5	0	0	3.00	2.05	0	6	12.28	OBL	1
Lythrum salicaria	5	10	10	10	75	22.00	15.01	1	0	0.00	OBL	1
Lytsimachia thrysiflora	20	25	20	10	0	15.00	10.23	0	7	71.62	OBL	1
Medicago sativa	1	0	0	0	0	0.20	0.14	1	0	0.00	UPL	5
Parthenocissus vitacea	1	0	0	0	0	0.20	0.14	0	4	0.55	FAC	3
Phragmites australis	0	1	1	0	0	0.40	0.27	1	0	0.00	FACW	2
Poa pratensis	15	15	5	25	0	12.00	8.19	1	0	0.00	FACU	4
Schoenoplectus acutus	1	0	0	0	0	0.20	0.14	0	5	0.68	OBL	1

Schoenoplectus pungens	0	1	1	0	1	0.60	0.41	0	4	1.64	OBL	1
Schoenoplectus tabernaemontani	0	0	1	0	0	0.20	0.14	0	5	0.68	OBL	1
Smilax lasioneura	0	0	0	1	0	0.20	0.14	0	6	0.82	FAC	3
Solidago canadensis	0	1	0	1	0	0.40	0.27	0	2	0.55	FACU	4
Solidago gigantea	15	10	5	10	0	8.00	5.46	0	3	16.37	FACW	2
Sparganium emersum	0	0	5	0	0	1.00	0.68	0	9	6.14	OBL	1
Spartina pectinata	10	0	5	5	0	4.00	2.73	0	5	13.64	FACW	2
Thalictrum dasycarpum	1	1	0	1	0	0.60	0.41	0	4	1.64	FACW	2
Viola sororia	5	1	0	1	0	1.40	0.95	0	3	2.86	FAC	3
Vitis riparia	0	0	0	0	1	0.20	0.14	0	3	0.41	FAC	3

NR8

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Ambrosia psilotachia	1	5	5	0	0	2.20	0.86	0	1	0.86	FAC	3
Andropogon gerardii	5	10	10	0	0	5.00	1.96	0	5	9.80	FAC	3
Aster praealtum	1	0	0	1	0	0.40	0.16	0	5	0.78	FACW	2
Calamagrostis stricta	10	10	15	10	0	9.00	3.53	0	6	21.18	FACW	2
Carex emoryi	45	35	10	15	10	23.00	9.02	0	5	45.10	OBL	1
Carex granularis	1	0	0	0	0	0.20	0.08	0	6	0.47	FACW	2
Carex hystericina	0	0	0	0	1	0.20	0.08	0	5	0.39	OBL	1
Carex interior	5	5	5	15	0	6.00	2.35	0	7	16.47	OBL	1
Carex lacustris	0	0	0	0	15	3.00	1.18	0	6	7.06	OBL	1
Carex pellita	30	20	10	30	0	18.00	7.06	0	4	28.24	OBL	1
Carex tetanica	10	5	0	10	0	5.00	1.96	0	7	13.73	FACW	2
Chenopodium album	0	0	1	0	0	0.20	0.08	1	0	0.00	FAC	3
Eleocharis compressa	5	5	5	1	0	3.20	1.25	0	6	7.53	FACW	2
Eleocharis erythropoda	25	15	20	20	10	18.00	7.06	0	5	35.29	OBL	1

Eleocharis palustris	0	0	0	0	10	2.00	0.78	0	4	3.14	OBL	1
Equisetum arvense	15	30	30	30	0	21.00	8.24	0	4	32.94	FAC	3
Equisetum laevigatum	1	0	0	1	0	0.40	0.16	0	4	0.63	FACW	2
Erigeron bellidiastrum	1	1	1	1	0	0.80	0.31	0	4	1.25	UPL	5
Eupatorium perfoliatum	1	1	1	1	0	0.80	0.31	0	5	1.57	OBL	1
Fimbristylis autumnalis	1	0	1	1	0	0.60	0.24	0	7	1.65	OBL	1
Helianthus grosseratus	5	5	0	5	0	3.00	1.18	0	4	4.71	FACW	2
Helianthus nuttallii	1	0	0	0	0	0.20	0.08	0	6	0.47	FAC	3
Hordeum jubatum	15	0	5	10	0	6.00	2.35	0	1	2.35	FACW	2
Juncus balticus	10	5	5	5	0	5.00	1.96	0	6	11.76	OBL	1
Juncus nodosus	1	1	0	0	0	0.40	0.16	0	6	0.94	OBL	1
Juniperus virginiana	1	1	0	1	1	0.80	0.31	0	1	0.31	FACU	4
Lactuca ludoviciana	1	0	0	0	1	0.40	0.16	0	3	0.47	FAC	3
Lythrum alatum	5	1	1	0	0	1.40	0.55	0	6	3.29	OBL	1
Lythrum salicaria	20	25	1	30	55	26.20	10.27	1	0	0.00	OBL	1
Medicago lupulina	0	5	10	15	0	6.00	2.35	1	0	0.00	FAC	3
Panicum virgatum	0	1	1	0	0	0.40	0.16	0	4	0.63	FAC	3
Pascopyrum smithii	15	25	25	10	0	15.00	5.88	0	3	17.65	FACU	4
Poa pratensis	60	40	30	25	0	31.00	12.16	1	0	0.00	FACU	4
SChoenoplectus pungens	10	5	5	5	5	6.00	2.35	0	4	9.41	OBL	1
Spartina pectinata	15	5	0	10	5	7.00	2.75	0	5	13.73	FACW	2
Trifolium hybridum	5	10	40	20	0	15.00	5.88	1	0	0.00	FACU	4
Trifolium pratense	0	10	20	10	0	8.00	3.14	1	0	0.00	FACU	4
Typha angustifolia	0	0	0	1	10	2.20	0.86	1	0	0.00	OBL	1
Verbena hastata	0	1	0	5	1	1.40	0.55	0	4	2.20	FACW	2
Viola sororia	0	0	1	1	1	0.60	0.24	0	3	0.71	FAC	3

NR9

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Achillea millefolium	0	0	0	1	0	0.20	0.07	0	2	0.14	FACU	4
Alisma triviale	1	0	0	0	0	0.20	0.07	0	4	0.28	OBL	1
Alopecuris arundinacea	30	0	25	10	10	15.00	5.20	1	0	0.00	FACW	2
Bromus japonicus	0	0	0	0	5	1.00	0.35	1	0	0.00	FACU	4
Carex emoryi	20	25	10	10	0	13.00	4.51	0	5	22.55	OBL	1
Carex pellita	15	10	25	30	25	21.00	7.29	0	4	29.15	OBL	1
Carex scoparia	0	0	1	0	0	0.20	0.07	0	5	0.35	FACW	2
Carex vulpinoidea	0	5	5	1	1	2.40	0.83	0	4	3.33	OBL	1
Convulvulus arvensis	0	0	0	1	0	0.20	0.07	1	0	0.00	UPL	5
Dactylis glomerata	15	5	0	10	10	8.00	2.78	1	0	0.00	FACU	4
Eleocharis erythropoda	25	10	10	25	10	16.00	5.55	0	5	27.76	OBL	1
Hordeum jubatum	0	0	0	5	0	1.00	0.35	0	1	0.35	FACW	2
Medicago lupulina	10	15	15	10	5	11.00	3.82	1	0	0.00	FAC	3
Melilotus officinalis	0	10	10	5	5	6.00	2.08	1	0	0.00	FACU	4
Phalaris arundinacea	70	65	55	65	70	65.00	22.55	1	0	0.00	FACW	2
Poa pratensis	35	55	50	50	65	51.00	17.70	1	0	0.00	FACU	4
Polygonum lapathifolium	5	5	5	1	1	3.40	1.18	0	2	2.36	OBL	1
Rumex crispus	0	0	0	0	1	0.20	0.07	1	0	0.00	FACW	2
Taraxacum officinale	10	10	5	5	10	8.00	2.78	1	0	0.00	FACU	4
Thlaspi arvense	0	0	0	1	0	0.20	0.07	1	0	0.00	FACU	4
Trifolium hybridum	50	50	30	20	35	37.00	12.84	1	0	0.00	FACU	4
Trifolium pratense	25	30	30	20	35	28.00	9.72	1	0	0.00	FACU	4
Viola sororia	0	0	1	0	0	0.20	0.07	0	3	0.21	FAC	3

NR10

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrostis stolonifera	10	10	5	10	0	7.00	3.25	1	0	0.00	FAC	3
Alisma triviale	0	0	0	1	3	0.80	0.37	0	4	1.48	OBL	1
Amorpha fruiticosa	15	20	5	5	5	10.00	4.64	0	5	23.19	OBL	1
Amphicarpea bracteata	0	1	0	0	0	0.20	0.09	0	4	0.37	FACW	2
Boehmaria cylindrica	10	10	10	10	0	8.00	3.71	0	6	22.26	OBL	1
Bolboschoenus fluviatilis	10	10	10	15	15	12.00	5.57	0	3	16.70	OBL	1
Carex crawei	0	1	0	0	0	0.20	0.09	0	6	0.56	FACW	2
Carex lacustris	35	25	20	35	70	37.00	17.16	0	6	102.97	OBL	1
Carex lasiaocarpa	0	0	0	1	0	0.20	0.09	0	10	0.93	OBL	1
Carex scoparia	0	0	0	5	0	1.00	0.46	0	5	2.32	FACW	2
Carex stipata	0	1	1	1	0	0.60	0.28	0	5	1.39	OBL	1
Eleocharis elliptica	0	1	0	0	0	0.20	0.09	0	7	0.65	OBL	1
Elymus villosus	0	5	0	0	0	1.00	0.46	0	5	2.32	FACU	4
Galium aparine	0	1	0	0	0	0.20	0.09	0	0	0.00	FACU	4
Galium triflorum	0	1	0	0	0	0.20	0.09	0	4	0.37	FACU	4
Geum aleppicum	0	1	0	0	0	0.20	0.09	0	6	0.56	FACU	4
Geum canadense	0	1	0	0	0	0.20	0.09	0	3	0.28	FACU	4
Glyceria striata	0	5	1	0	0	1.20	0.56	0	5	2.78	OBL	1
Impatiens capensis	25	25	20	5	0	15.00	6.96	0	4	27.83	FACW	2
Lycopus americanus	1	1	1	1	0	0.80	0.37	0	4	1.48	OBL	1
Lycopus uniflorus	1	1	1	1	0	0.80	0.37	0	6	2.23	OBL	1
Lysimachia thrysiflora	5	10	5	15	25	12.00	5.57	0	7	38.96	OBL	1
Lythrum salicaria	85	80	90	75	55	77.00	35.71	1	0	0.00	OBL	1
Oxalis violacea	0	0	1	0	0	0.20	0.09	0	5	0.46	UPL	5
Parthenocissus vitacea	0	1	1	0	0	0.40	0.19	0	4	0.74	FAC	3

Persicaria coccinea	0	0	0	1	0	0.20	0.09	0	2	0.19	FACW	2
Phragmites australis	0	1	0	0	0	0.20	0.09	1	0	0.00	FACW	2
Poa pratensis	0	1	1	0	0	0.40	0.19	1	0	0.00	FACU	4
Polygonum persicaria	0	0	1	1	1	0.60	0.28	1	0	0.00	OBL	1
Ribes americanum	0	1	0	1	0	0.40	0.19	0	6	1.11	FACW	2
Rumex brittanica	1	0	0	1	1	0.60	0.28	0	8	2.23	OBL	1
Sagittaria calcyna	0	0	1	0	0	0.20	0.09	0	3	0.28	OBL	1
Sagittaria latifolia	0	3	3	3	10	3.80	1.76	0	5	8.81	OBL	1
Scutellaria galericulata	1	1	5	5	0	2.40	1.11	0	6	6.68	OBL	1
Smilacina stellata	0	3	0	0	0	0.60	0.28	0	4	1.11	FAC	3
Sparganium eurycarpum	5	0	0	5	5	3.00	1.39	0	5	6.96	OBL	1
Taraxacum officinale	0	1	0	0	0	0.20	0.09	1	0	0.00	FACU	4
Thalictrum dasycarpum	0	1	0	0	0	0.20	0.09	0	4	0.37	FACW	2
Thelipteris palustis	1	1	1	1	0	0.80	0.37	0	7	2.60	FACW	2
Toxicodendron rydbergii	0	1	0	0	0	0.20	0.09	0	1	0.09	FAC	3
Typha latifolia	1	5	3	10	10	5.80	2.69	0	1	2.69	OBL	1
Urtica dioica	10	10	5	20	0	9.00	4.17	0	1	4.17	FACW	2
Verbena hastata	1	1	1	0	0	0.60	0.28	0	4	1.11	FACW	2

RWBREF

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Azolla mexicana	0	0	0.1	0.1	0.1	0.06	0.16	0	7	1.11	OBL	1
Bolboschoenus fluviatilis	0	0	0.1	0	9	1.82	4.80	0	3	14.41	OBL	1
Ceratophyllum demersum	0	0.1	0.1	0.1	0	0.06	0.16	0	4	0.63	OBL	1
Lemna minor	0.1	0.1	0.1	0.1	0.1	0.10	0.26	0	5	1.32	OBL	1
Polygonum coccineum	18	18	5	5	30	15.20	40.11	0	2	80.21	FACW	2
Potomogeton nodosus	6	2	0	0	3	2.20	5.80	0	5	29.02	OBL	1

Sagittaria rigida	3	3	0	0	2	1.60	4.22	0	7	29.55	OBL	1
Schoenoplectus heterochaetus	8	12	12	18	0	10.00	26.39	0	5	131.93	OBL	1
Sparganium eurycarpum	0.1	0.1	0	0	2	0.44	1.16	0	5	5.80	OBL	1
Typha angustifolia	3	8	0.1	20	0	6.22	16.41	1	0	0.00	OBL	1
Typha latifolia	0	0	1	0	0	0.20	0.53	0	1	0.53	OBL	1

RWB1

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Azolla mexicana	1	0.1	2	5	2	2.02	1.43	0	7	10.04	OBL	1
Bolboschoenus fluviatilis	30	15	6	70	50	34.20	24.29	0	3	72.88	OBL	1
Certophyllum demersum	0.1	0	0	0	0	0.02	0.01	0	4	0.06	OBL	1
Echinocloa muricata	0	0.1	0	0	0.1	0.04	0.03	0	0	0.00	OBL	1
Lemna minor	1	0.1	3	0.1	0.1	0.86	0.61	0	5	3.05	OBL	1
Leptochloa fusca	0	0	0	0	0.1	0.02	0.01	0	1	0.01	OBL	1
Ludwigia palustris	0	0	0	0	0.1	0.02	0.01	0	5	0.07	OBL	1
Phalaris arundinacea	0	0.1	0	0	0	0.02	0.01	1	0	0.00	FACW	2
Polygonum bicorne	0	0.1	0	0	0.1	0.04	0.03	0	0	0.00	FACW	2
Polygonum coccineum	0	6	0	1	0	1.40	0.99	0	2	1.99	FACW	2
Polygonum lapathifolium	0	0.1	0	0	0	0.02	0.01	0	2	0.03	OBL	1
Potomogeton nodosus	1	12	1	1	2	3.40	2.42	0	5	12.08	OBL	1
Rorippa palustris	0	0.1	0	0	0	0.02	0.01	0	4	0.06	OBL	1
Sagittaria brevirostra	0	1	0	0	0	0.20	0.14	0	4	0.57	OBL	1
Sagittaria graminea	0	50	0	0	40	18.00	12.79	0	7	89.50	OBL	1
Sagittaria rigida	60	2	45	15	0	24.40	17.33	0	7	121.32	OBL	1
Schoenoplectus heterochaetus	0	22	3	0	7	6.40	4.55	0	5	22.73	OBL	1
Sparganium eurycarpum	45	25	65	35	45	43.00	30.54	0	5	152.72	OBL	1
Spirodela polyrhiza	0.1	0.1	0.1	0.1	0.1	0.10	0.07	0	6	0.43	OBL	1

Typha angustifolia	0	2	20	0	0	4.40	3.13	1	0	0.00	OBL	1
Utricularia macrorhiza	1	2	3	3	2	2.20	1.56	0	6	9.38	OBL	1

RWB2

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bolboshoenus fluviatilis	4	6	5	10	10	7.00	19.94	0	3	59.83	OBL	1
Lemna minor	0.1	0.1	0.1	0.1	0.1	0.10	0.28	0	5	1.42	OBL	1
Polygonum coccineum	26	24	30	30	30	28.00	79.77	0	2	159.54	FACW	2

RWB3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Azolla mexicana	0.1	0.1	0.1	0.1	0.1	0.10	0.11	0	7	0.78	OBL	1
Bolboschoenus fluviatilis	62	50	45	50	55	52.40	58.56	0	3	175.68	OBL	1
Lemna minor	7	3	2	3	4	3.80	4.25	0	5	21.23	OBL	1
Polygonum coccineum	10	8	6	15	8	9.40	10.51	0	2	21.01	FACW	2
Potomogeton nodosus	0.1	0	0.1	0	0	0.04	0.04	0	5	0.22	OBL	1
Sagittaria brevirostra	1	1	3	4	0	1.80	2.01	0	4	8.05	OBL	1
Sagittaria graminea	0	0	0	0	0.1	0.02	0.02	0	7	0.16	OBL	1
Schoenoplectus heterochaetus	0	2	4	0.1	2	1.62	1.81	0	5	9.05	OBL	1
Sparganium eurycarpum	8	18	30	15	20	18.20	20.34	0	5	101.70	OBL	1
Spirodela polyrhiza	0.1	0.1	0.1	0.1	0.1	0.10	0.11	0	6	0.67	OBL	1
Utricularia macrorhiza	1	2	2	2	3	2.00	2.24	0	6	13.41	OBL	1

RWB4

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bolboschoenus fluviatilis	8	3	10	3	2	5.20	23.90	0	3	71.69	OBL	1

Lemna minor	0.1	0.1	0.1	0.1	0.1	0.10	0.46	0	5	2.30	OBL	1
Polygonum coccineum	10	15	12	4	4	9.00	41.36	0	2	82.72	FACW	2
Potomogeton nodosus	4	5	12	1	4	5.20	23.90	0	5	119.49	OBL	1
Sagittaria graminea	0.1	0.1	1	0	0	0.24	1.10	0	7	7.72	OBL	1
Schoenoplectus heterochaetus	2	0.1	1	3	4	2.02	9.28	0	5	46.42	OBL	1

RWB5

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bolboschoenus fluviatilis	0	75	95	95	10	55.00	44.43	0	3	133.30	OBL	1
Lemna minor	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	5	0.40	OBL	1
Polygonum coccineum	95	60	35	30	35	51.00	41.20	0	2	82.40	FACW	2
Schoenoplectus heterochaetus	6	0.1	0.1	0	10	3.24	2.62	0	5	13.09	OBL	1
Sparganium eurycarpum	7	0	0.1	0.1	65	14.44	11.67	0	5	58.33	OBL	1

RWB6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Amaranthus tuberculatus	0	0.1	0	0	0	0.02	0.02	0	0	0.00	FACW	2
Ammannia coccinea	75	35	10	6	60	37.20	30.19	0	4	120.76	OBL	1
Bacopa rotundifolia	1	1	2	1	0.1	1.02	0.83	0	4	3.31	OBL	1
Bolboschoenus fluviatilis	1	20	1	1	15	7.60	6.17	0	3	18.50	OBL	1
Echinocloa muricata	2	1	0.1	0.1	1	0.84	0.68	0	0	0.00	OBL	1
Eleocharis acicularis	0.1	0.1	0	0.1	0	0.06	0.05	0	4	0.19	OBL	1
Eleocharis engelmanii	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	3	0.24	FACW	2
Eleocharis palustris	0	0	0.1	0.1	0	0.04	0.03	0	4	0.13	OBL	1
Heteranthera limosa	0	0.1	0.1	0	0.1	0.06	0.05	0	4	0.19	OBL	1
Heteranthera multiflora	2	3	1	3	0.1	1.82	1.48	0	6	8.86	OBL	1

Leptochloa fuscus	85	75	55	55	80	70.00	56.81	0	1	56.81	OBL	1
Lindernia dubia	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	5	0.41	OBL	1
Marsilia vestita	1	0.1	0.1	0.1	0.1	0.28	0.23	0	3	0.68	OBL	1
Polygonum bicorne	0	0.1	0.1	0.1	0.1	0.08	0.06	0	0	0.00	FACW	2
Polygonum hydropiper	0.1	0	0	0	0.1	0.04	0.03	1	0	0.00	OBL	1
Polygonum lapathifolium	0	0.1	0	0.1	0.1	0.06	0.05	0	2	0.10	OBL	1
Potomogeton nodosus	0.1	1	3	1	0.1	1.04	0.84	0	5	4.22	OBL	1
Sagittaria calycina	2	2	10	0.1	0.1	2.84	2.30	0	3	6.91	OBL	1
Schoenoplectus heterochaetus	0	0.1	0	0	0	0.02	0.02	0	5	0.08	OBL	1

RWB7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Ambrosia artemisifolia	0	0.1	0	0	0	0.02	0.02	0	0	0.00	FACU	4
Bolboschoenus fluviatilis	4	30	45	60	40	35.80	28.93	0	3	86.78	OBL	1
Chenopodium album	0	0.1	0	0	0	0.02	0.02	1	0	0.00	FAC	3
Echinocloa muricata	0.1	0	0.1	0.1	0	0.06	0.05	0	0	0.00	OBL	1
Eleocharis acicularis	2	0	0	0	0	0.40	0.32	0	4	1.29	OBL	1
Eleocharis palustris	85	0.1	0	0	0	17.02	13.75	0	4	55.01	OBL	1
Helianthus annuus	0.1	10	0.1	0	1	2.24	1.81	0	0	0.00	FACU	4
Iva annua	0.1	0	0	0	0	0.02	0.02	0	1	0.02	FAC	3
Leersia oryzoides	0.1	0.1	0.1	0.1	0.1	0.10	0.08	0	4	0.32	OBL	1
Phalaris arundinacea	0	0	0	0	1	0.20	0.16	1	0	0.00	FACW	2
Polygonum aviculare	0	0.1	0	0	0	0.02	0.02	1	0	0.00	FACW	2
Polygonum bicorne	1	6	15	3	4	5.80	4.69	0	0	0.00	FACW	2
Polygonum coccineum	60	50	45	45	75	55.00	44.44	0	2	88.88	FACW	2
Polygonum hydropiper	5	1	0	0	1	1.40	1.13	1	0	0.00	OBL	1
Polygonum lapathifolium	7	5	2	10	3	5.40	4.36	0	2	8.73	OBL	1

Schoenoplectus heterochaetus	0.1	0	0	0	0	0.02	0.02	0	5	0.08	OBL	1
Sparganium eurycarpum	0.1	0	0.1	0	0	0.04	0.03	0	5	0.16	OBL	1
Typha latifolia	0	0	0	0	1	0.20	0.16	0	1	0.16	OBL	1

RWB8

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Lemna minor	0	0.1	0.1	0	0	0.04	0.04	0	5	0.19	OBL	1
Phalaris arundinacea	0	0	0	0	0.1	0.02	0.02	1	0	0.00	FACW	2
Polygonum coccineum	30	40	15	40	12	27.40	26.32	0	2	52.63	FACW	2
Polygonum hydropiper	0.1	0.1	0	0	0.1	0.06	0.06	1	0	0.00	OBL	1
Schoenoplectus heterochaetus	10	12	2	1	0	5.00	4.80	0	5	24.01	OBL	1
Sparganium eurycarpum	3	40	65	70	0	35.60	34.19	0	5	170.96	OBL	1
Typha angustifolia	40	5	0	4	85	26.80	25.74	1	0	0.00	OBL	1
Typha latifolia	15	10	15	6	0	9.20	8.84	0	1	8.84	OBL	1

RWB9

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Acmispon purshianus	0	2	0.1	0	0	0.42	0.41	0	3	1.23	FAC	3
Alisma triviale	0	2	2	2	0	1.20	1.17	0	4	4.67	OBL	1
Ambrosia artemisifolia	0	0.1	0.1	0	0	0.04	0.04	0	0	0.00	FACU	4
Ammannia coccinea	0.1	0.1	0.1	0.1	0	0.08	0.08	0	4	0.31	OBL	1
Antennaria parlinii	0	0	0.1	0	0	0.02	0.02	0	5	0.10	UPL	5
Bacopa rotundifolia	0.1	0	0	0	0	0.02	0.02	0	4	0.08	OBL	1
Bolboschoenus fluviatilis	16	1	6	30	0.1	10.62	10.33	0	3	30.98	OBL	1
Ceratophyllum demersum	0.1	0.1	0.1	0	1	0.26	0.25	0	4	1.01	OBL	1
Chenopodium album	0	0.1	0.1	0.1	0	0.06	0.06	1	0	0.00	FACU	4

Cirsium altissimum	0	0	0.1	0	0	0.02	0.02	0	1	0.02	FAC	3
Conyza canadensis	0	0.1	0.1	0	0	0.04	0.04	0	0	0.00	FACU	4
Cuscuta polygonorum	0	0.1	0	0.1	0	0.04	0.04	0	4	0.16	FACW	2
Cyperus acuminatus	0	0	0	0.1	0	0.02	0.02	0	3	0.06	OBL	1
Cyperus erythrorhizos	0	0.1	0.1	0.1	0	0.06	0.06	0	4	0.23	OBL	1
Cyperus esculentus	0	0	0	0.1	0	0.02	0.02	0	0	0.00	FACW	2
Echinocloa muricata	0.1	12	2	10	0	4.82	4.69	0	0	0.00	OBL	1
Eleocharis acicularis	0	0.1	0.1	1	0	0.24	0.23	0	4	0.93	OBL	1
Eleocharis compressa	0	0.1	0	0	0	0.02	0.02	0	6	0.12	FACW	2
Eleocharis engelmannii	0	0.1	0.1	0.1	0	0.06	0.06	0	3	0.18	FACW	2
Eleocharis erythropoda	0	0	0.1	0	0	0.02	0.02	0	5	0.10	OBL	1
Erechtites hieracifolia	0	0.1	0.1	0.1	0	0.06	0.06	0	1	0.06	FAC	3
Helianthus annuus	0	0	0.1	0	0	0.02	0.02	0	0	0.00	FACU	4
Heteranthera multiflora	0.1	0	0	0	0	0.02	0.02	0	6	0.12	OBL	1
Juncus interior	0	0	0	0.1	0	0.02	0.02	0	4	0.08	FAC	3
Lactuca serriola	0	0.1	0.1	0.1	0	0.06	0.06	1	0	0.00	FAC	3
Leersia oryzoides	0	0	0.1	0	0	0.02	0.02	0	4	0.08	OBL	1
Lemna minor	0.1	0.1	0.1	0.1	0.1	0.10	0.10	0	5	0.49	OBL	1
Lindernia dubia	0	0.1	0	0.1	0	0.04	0.04	0	5	0.19	OBL	1
Najas guadalupensis	1	0.1	0	0	5	1.22	1.19	0	6	7.12	OBL	1
Phalaris arundinacea	0	0.1	3	1	0	0.82	0.80	1	0	0.00	FACW	2
Polygonum bicorne	0	0	0	2	0	0.40	0.39	0	0	0.00	FACW	2
Polygonum coccineum	0.1	3	8	2	0	2.62	2.55	0	2	5.10	FACW	2
Polygonum hydropiper	0	6	4	1	0	2.20	2.14	1	0	0.00	OBL	1
Polygonum lapathifolium	0	6	8	2	0	3.20	3.11	0	2	6.22	OBL	1
Polygonum pensylvanicum	2	12	12	60	0	17.20	16.73	0	0	0.00	FACW	2
Polygonum ramosissimum	0	3	0	0.1	0	0.62	0.60	0	1	0.60	FAC	3
Potentilla norvegica	0	5	1	1	0	1.40	1.36	0	2	2.72	FAC	3

Potomogeton foliosus	80	1	0	0	88	33.80	32.87	0	5	164.33	OBL	1
Potomogeton nodosus	12	0.1	0	0	8	4.02	3.91	0	5	19.54	OBL	1
Rorippa palustris	0	0.1	0.1	0.1	0	0.06	0.06	0	4	0.23	OBL	1
Rumex crispus	0	0	0.1	0.1	0	0.04	0.04	1	0	0.00	FACW	2
Rumex stenophyllus	0	0.1	1	0	0	0.22	0.21	1	0	0.00	FACW	2
Sagittaria calycina	2	2	0	0	3	1.40	1.36	0	3	4.08	OBL	1
Schoenoplectus acutus	0	1	2	0	0	0.60	0.58	0	5	2.92	OBL	1
Schoenoplectus heterochaetus	12	1	0	0	11	4.80	4.67	0	5	23.34	OBL	1
Solidago canadensis	0	0.1	1	0.1	0	0.24	0.23	0	2	0.47	FACU	4
Sparganium eurycarpum	0	10	25	2	0	7.40	7.20	0	5	35.98	OBL	1
Spirodela polyrhiza	0.1	0.1	0.1	0	0	0.06	0.06	0	6	0.35	OBL	1
Symphyptrichum lanceolatus	0	0	0.1	0.1	0	0.04	0.04	0	2	0.08	OBL	1
Taraxacum officianale	0	0	0.1	0.1	0	0.04	0.04	1	0	0.00	FACU	4
Typha angustifolia	0	10	0	0	0	2.00	1.94	1	0	0.00	OBL	1
Verbena urticifolia	0	0	0.1	0	0	0.02	0.02	0	3	0.06	FAC	3

SALREF

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Aster subulatus	1	0	0	1	1	0.60	0.60	0	0	0.00	OBL	1
Bolboschoenus maritimus	0	0	0	1	2	0.60	0.60	0	5	3.02	OBL	1
Distichilis spicata	95	96	97	95	25	81.60	82.09	0	3	246.28	FACW	2
Iva annua	5	1	1	1	0	1.60	1.61	0	1	1.61	FAC	3
Salicornia rubra	0	1	1	1	0	0.60	0.60	0	8	4.83	OBL	1
Schoenoplectus pungens	0	0	0	1	0	0.20	0.20	0	4	0.80	OBL	1
Sueda calceoliformis	0	1	0	0	0	0.20	0.20	0	5	1.01	FACW	2
Typha augustifolia	0	0	0	0	70	14.00	14.08	1	0	0.00	OBL	1

SAL1

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Ambrosia artemisifolia	20	0	75	60	75	46.00	40.93	0	0	0.00	FACU	4
Asclepias incarnata	0	0	1	1	0	0.40	0.36	0	4	1.42	OBL	1
Asclepias sullivantii	0	0	0	0	1	0.20	0.18	0	7	1.25	FAC	3
Bidens cernua	0	0	1	5	0	1.20	1.07	0	3	3.20	OBL	1
Bromus inermis	0	0	2	0	0	0.40	0.36	1	0	0.00	FACU	4
Carex brevior	10	0	5	1	15	6.20	5.52	0	4	22.06	FAC	3
Carex gravida	5	0	5	0	5	3.00	2.67	0	4	10.68	FACU	4
Carex laeviconica	5	100	0	0	0	21.00	18.68	0	4	74.73	OBL	1
Carex vulpinoidea	5	0	5	15	0	5.00	4.45	0	4	17.79	OBL	1
Celtis occidentalis	0	0	1	0	0	0.20	0.18	0	4	0.71	FACU	4
Cirsium vulgare	0	0	1	0	0	0.20	0.18	1	0	0.00	UPL	5
Conium maculatum	0	0	2	0	0	0.40	0.36	1	0	0.00	FACW	2
Cornus drummondii	0	0	1	0	0	0.20	0.18	0	3	0.53	FAC	3
Eleocharis palustris	2	0	1	0	0	0.60	0.53	0	4	2.14	OBL	1
Elymus canadensis	0	0	1	0	1	0.40	0.36	0	5	1.78	FACU	4
Euphorbia margninata	0	0	1	0	0	0.20	0.18	0	0	0.00	FACU	4
Fraxinus pennsylvanica	0	0	0	1	0	0.20	0.18	0	2	0.36	FACW	2
Gleditsia tricanthos	0	0	2	2	0	0.80	0.71	0	1	0.71	FAC	3
Hordeum jubatum	1	0	1	0	0	0.40	0.36	0	1	0.36	FACW	2
Juncus dudleyi	1	0	1	5	2	1.80	1.60	0	5	8.01	FACW	2
Lycopus americanus	2	0	1	10	0	2.60	2.31	0	4	9.25	OBL	1
Phalaris arundinacea	1	0	0	0	0	0.20	0.18	0	0	0.00	FACW	2
Phytolacca americana	0	0	1	0	0	0.20	0.18	0	0	0.00	FAC	3
Poa pratensis	0	0	0	0	10	2.00	1.78	1	0	0.00	FACU	4
Polygonum coccineum	40	0	0	0	0	8.00	7.12	0	2	14.23	FACW	2

Polygonum hydropiper	0	0	5	20	0	5.00	4.45	0	6	26.69	OBL	1
Polygonum persicaria	0	0	0	1	0	0.20	0.18	1	0	0.00	OBL	1
Rumex crispus	0	0	0	1	0	0.20	0.18	1	0	0.00	FACW	2
Solidago canadensis	0	0	0	0	1	0.20	0.18	0	2	0.36	FACU	4
Toxicodendron rydbergii	0	0	10	0	0	2.00	1.78	0	1	1.78	FAC	3
Ulmus pumila	1	0	0	0	0	0.20	0.18	1	0	0.00	FAC	3
Urtica dioica	1	0	1	0	0	0.40	0.36	0	1	0.36	FACW	2
Verbena urtricifolia	1	0	2	0	0	0.60	0.53	0	3	1.60	UPL	5
Vernonia fasciculata	1	0	2	5	1	1.80	1.60	0	4	6.41	FAC	3

SAL2

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia artemisifolia	0	0	20	0	0	4.00	3.69	0	0	0.00	FACU	4
Ambrosia trifida	0	0	2	0	0	0.40	0.37	0	0	0.00	FACW	2
Apocynum cannabinum	0	0	1	0	0	0.20	0.18	0	2	0.37	FAC	3
Asclepias incornata	0	0	1	0	0	0.20	0.18	0	4	0.74	OBL	1
Bidens cernua	0	0	1	0	0	0.20	0.18	0	3	0.55	OBL	1
Bolboschoenus fluviatilis	0	1	15	15	15	9.20	8.49	0	3	25.46	OBL	1
Carex pellita	0	0	0	10	0	2.00	1.85	0	4	7.38	OBL	1
Cornus drummondii	0	0	2	0	0	0.40	0.37	0	3	1.11	FAC	3
Desmanthus illinoiensis	0	0	1	0	0	0.20	0.18	0	5	0.92	FACU	4
Eleocharis palustris	0	0	5	0	0	1.00	0.92	0	4	3.69	OBL	1
Elymus canadensis	0	0	5	0	0	1.00	0.92	0	5	4.61	FACU	4
Fraxinus pennsylvanica	0	0	1	0	0	0.20	0.18	0	2	0.37	FACW	2
Gleditisia triacanthose	0	0	1	0	0	0.20	0.18	0	1	0.18	FAC	3
Hordeum jubatum	0	0	5	0	0	1.00	0.92	0	1	0.92	FACW	2
Juncus dudleyi	0	0	1	0	0	0.20	0.18	0	5	0.92	FACW	2

Lemna trisulca	5	1	1	1	50	11.60	10.70	0	8	85.61	OBL	1
Lycopus americanus	0	0	1	0	0	0.20	0.18	0	4	0.74	OBL	1
Lysimachia ciliata	0	0	1	0	0	0.20	0.18	0	5	0.92	FACW	2
Parthenocissus quinquefolia	0	0	1	0	0	0.20	0.18	0	5	0.92	FAC	3
Polygonum coccineum	0	1	20	1	5	5.40	4.98	0	6	29.89	FACW	2
Polygonum persicaria	0	0	5	0	0	1.00	0.92	1	0	0.00	OBL	1
Rumex crispus	0	0	1	0	0	0.20	0.18	1	0	0.00	FACW	2
Sagitaria latifolia	0	0	0	1	0	0.20	0.18	0	5	0.92	OBL	1
Schoenoplectus acutus	0	0	0	1	5	1.20	1.11	0	5	5.54	OBL	1
Setaria pumila	0	0	20	0	0	4.00	3.69	1	0	0.00	FAC	3
Sorghastum nutans	0	0	5	0	0	1.00	0.92	0	5	4.61	FACU	4
Sparganium eurycarpum	0	0	2	25	25	10.40	9.59	0	5	47.97	OBL	1
Typh x glauca	95	90	5	50	20	52.00	47.97	1	0	0.00	OBL	1
Verbena urticifolia	0	0	1	0	0	0.20	0.18	0	3	0.55	UPL	5
Wolffia columbiana	0	0	0	1	0	0.20	0.18	0	5	0.92	OBL	1

SAL3

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis stolonifera	0	0	0	1	1	0.40	0.35	1	0	0.00	FAC	3
Ambrosia artemisifolia	0	15	5	20	10	10.00	8.83	0	0	0.00	FACU	4
Bromus inermis	0	0	0	2	40	8.40	7.42	1	0	0.00	FACU	4
Carex bicknellii	0	1	0	0	0	0.20	0.18	0	6	1.06	FACU	4
Carex brevior	0	0	10	5	3	3.60	3.18	0	4	12.72	FAC	3
Carex hystracinia	1	1	0	0	0	0.40	0.35	0	5	1.77	OBL	1
Carex pellita	0	1	20	5	0	5.20	4.59	0	4	18.37	OBL	1
Carex vulpinoidea	0	3	0	0	0	0.60	0.53	0	4	2.12	OBL	1
Distichilis spicata	0	0	1	1	5	1.40	1.24	0	3	3.71	FACW	2

Eleocharis palustris	5	1	5	5	1	3.40	3.00	0	4	12.01	OBL	1
Eupatorium perfoliatum	0	0	1	0	0	0.20	0.18	0	5	0.88	OBL	1
Iva annua	0	25	25	50	50	30.00	26.50	0	1	26.50	FAC	3
Juncus dudleyi	0	1	0	20	0	4.20	3.71	0	5	18.55	FACW	2
Juncus torreyi	0	5	0	10	1	3.20	2.83	0	4	11.31	FACW	2
Juniperus virginiana	0	0	1	0	0	0.20	0.18	0	1	0.18	FACU	4
Leersia oryzoides	4	0	0	0	0	0.80	0.71	0	4	2.83	OBL	1
Lemna trisulca	2	0	0	0	0	0.40	0.35	0	8	2.83	OBL	1
Lycopus americanus	1	1	1	1	0	0.80	0.71	0	4	2.83	OBL	1
Lycopus asper	0	1	0	0	0	0.20	0.18	0	5	0.88	OBL	1
Mentha arvensis	0	0	0	1	0	0.20	0.18	0	4	0.71	FACW	2
Pascopyrum smithii	0	0	0	1	1	0.40	0.35	0	3	1.06	FACU	4
Phalaris arundinacea	0	0	15	0	0	3.00	2.65	0	0	0.00	FACW	2
Poa pratensis	0	1	1	5	0	1.40	1.24	1	0	0.00	FACU	4
Polygonum persicaria	1	0	0	0	0	0.20	0.18	1	0	0.00	OBL	1
Polygonum ramosissimum	0	0	0	0	2	0.40	0.35	0	1	0.35	FAC	3
Schoenoplectuss pungens	10	50	2	0	0	12.40	10.95	0	4	43.82	OBL	1
Scirpus pallidus	1	0	0	0	0	0.20	0.18	0	5	0.88	OBL	1
Spartina pectinata	0	0	7	0	0	1.40	1.24	0	5	6.18	FACW	2
Symphyotrichum ericoides	0	5	1	1	0	1.40	1.24	0	3	3.71	FACU	4
Trifolium repens	0	0	0	0	2	0.40	0.35	1	0	0.00	FACU	4
Typha augustifolia	75	5	2	0	0	16.40	14.49	1	0	0.00	OBL	1
Verbena stricta	0	2	0	5	2	1.80	1.59	0	2	3.18	UPL	5

SAL4

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Atriplex dioca	5	1	1	0	0	1.40	1.36	0	5	6.82	FAC	3

Bolboschoenus maritimus	1	1	1	1	10	2.80	2.73	0	5	13.65	OBL	1
Distichilis spicata	10	70	60	10	50	40.00	38.99	0	3	116.96	FACW	2
Hordeum jubtaum	1	1	0	0	0	0.40	0.39	0	1	0.39	FACW	2
Iva annua	5	2	20	10	30	13.40	13.06	0	1	13.06	FAC	3
Poa arida	2	0	2	0	1	1.00	0.97	0	6	5.85	FAC	3
Salicornia rubra	40	10	5	0	3	11.60	11.31	0	8	90.45	OBL	1
Schoenoplectuss pungens	0	5	5	75	0	17.00	16.57	0	4	66.28	OBL	1
Suedea calceoliformis	40	10	5	0	5	12.00	11.70	0	5	58.48	FACW	2
Typha x Glauca	0	0	0	10	5	3.00	2.92	1	0	0.00	OBL	1

SAL5

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Bolboschoenus maritimus	0	0	1	0.1	0	0.22	0.23	0	5	1.13	OBL	1
Eleocharis palustris	0.1	0	0	0.1	2	0.44	0.45	0	4	1.80	OBL	1
Helianthus anuus	0	0	2	0	0	0.40	0.41	0	0	0.00	FACU	4
Hordeum jubatum	0.1	0	0	0	0	0.02	0.02	0	1	0.02	FACW	2
Phalaris arundinacea	0	0	10	0	0	2.00	2.05	0	0	0.00	FACW	2
Poa pratensis	0	0	1	0	0	0.20	0.20	1	0	0.00	FACU	4
Solidago gigantea	0	0	2	0	0	0.40	0.41	0	3	1.23	FACW	2
Spartina pectinata	0	0	10	0	0	2.00	2.05	0	5	10.24	FACW	2
Typha augustifolia	100	100	70	90	100	92.00	94.19	1	0	0.00	OBL	1

SAL6

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia artemisifolia	0	1	0	0	1	0.40	0.39	0	0	0.00	FACU	4
Asclepias verticillata	0	0	0	0	1	0.20	0.20	0	3	0.59	FACU	4

Bolboschoenus maritimus	0	0	1	0	0	0.20	0.20	0	5	0.98	OBL	1
Chenopodium rubrum	0	1	1	0	0	0.40	0.39	0	4	1.57	OBL	1
Desmanthus illinoiensis	0	1	0	0	0	0.20	0.20	0	5	0.98	FACU	4
Eleocharis palustris	1	1	1	1	1	1.00	0.98	0	4	3.92	OBL	1
Elymus trachycalus	0	0	0	0	1	0.20	0.20	0	5	0.98	FACU	4
Fraxinus pennsylvanica	0	1	0	0	1	0.40	0.39	0	2	0.78	FACW	2
Helianthus annuus	0	1	0	1	1	0.60	0.59	0	0	0.00	FACU	4
Hordeum jubatum	1	1	1	0	1	0.80	0.78	0	1	0.78	FACW	2
Iva annua	1	5	1	0	1	1.60	1.57	0	1	1.57	FAC	3
Juncus torryi	0	0	0	0	1	0.20	0.20	0	4	0.78	FACW	2
Lemna trisulca	0	0	0	0	1	0.20	0.20	0	8	1.57	OBL	1
Lycopus americanus	1	1	1	1	1	1.00	0.98	0	4	3.92	OBL	1
Panicum virgatum	0	0	0	0	1	0.20	0.20	0	4	0.78	FAC	3
Phalaris arundinacea	1	30	1	1	5	7.60	7.45	0	0	0.00	FACW	2
Polygonum persicaria	1	0	1	1	0	0.60	0.59	1	0	0.00	OBL	1
Rumex crispus	0	1	1	0	0	0.40	0.39	1	0	0.00	FACW	2
Salix amygdaloides	1	0	0	1	0	0.40	0.39	0	4	1.57	FACW	2
Schoenoplectus pungens	0	0	0	0	1	0.20	0.20	0	4	0.78	OBL	1
Solidago canadensis	0	10	0	0	1	2.20	2.16	0	2	4.31	FACU	4
Solidago gigantea	0	30	0	1	0	6.20	6.08	0	3	18.24	FACW	2
Symphyotrichum ericoides	0	0	0	0	1	0.20	0.20	0	3	0.59	FACU	4
Typha x glauca	90	10	95	95	90	76.00	74.51	1	0	0.00	OBL	1
Verbena stricta	1	0	0	0	1	0.40	0.39	0	2	0.78	UPL	5
Xanthium strumarium	1	0	0	0	0	0.20	0.20	0	1	0.20	FAC	3

SAL7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W

Bolboschoenus fluviatilis	25	25	75	15	99	47.80	54.82	0	3	164.45	OBL	1
Eleocharis palustris	0	0	0	0	1	0.20	0.23	0	4	0.92	OBL	1
Lemna trisulca	50	50	25	60	1	37.20	42.66	0	8	341.28	OBL	1
Lycopus americanus	0	0	0	0	1	0.20	0.23	0	4	0.92	OBL	1
Polygonum lapathifolium	0	1	0	0	0	0.20	0.23	0	2	0.46	OBL	1
Potemogeton pectinatus	1	0	0	0	0	0.20	0.23	0	6	1.38	OBL	1
Solidago canadensis	0	0	0	0	1	0.20	0.23	0	2	0.46	FACU	4
Ulmus pumila	0	0	0	0	1	0.20	0.23	1	0	0.00	FAC	3
Wolffia columbiana	1	1	1	1	1	1.00	1.15	0	5	5.73	OBL	1

SAL8

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia artemisifolia	0	0	1	0	0	0.20	0.19	0	0	0.00	FACU	4
Apocynum cannabinum	1	0	0	0	0	0.20	0.19	0	2	0.38	FAC	3
Bolboschoenus fluviatilis	20	30	15	0	0	13.00	12.29	0	3	36.86	OBL	1
Carex laeviconica	1	3	0	0	0	0.80	0.76	0	4	3.02	OBL	1
Cirsium arvense	0	0	0	0	1	0.20	0.19	1	0	0.00	FACU	4
Eleocharis acicularis	0	1	1	1	0	0.60	0.57	0	4	2.27	OBL	1
Eleocharis palustris	1	1	1	0	1	0.80	0.76	0	4	3.02	OBL	1
Fraxinus pennsylvanica	10	10	10	2	4	7.20	6.81	0	2	13.61	FACW	2
Geum aleppicum	0	0	0	0	1	0.20	0.19	0	6	1.13	FACU	4
Hordeum jubatum	1	0	1	0	1	0.60	0.57	0	1	0.57	FACW	2
Lycopus americanus	1	0	1	1	1	0.80	0.76	0	4	3.02	OBL	1
Morus alba	0	0	0	0	1	0.20	0.19	1	0	0.00	FAC	3
Parthenocissus quinquefolia	0	0	1	0	0	0.20	0.19	0	5	0.95	FAC	3
Phalaris arundinacea	60	50	70	95	95	74.00	69.94	0	0	0.00	FACW	2
Polygonum coccineum	5	5	5	1	1	3.40	3.21	0	6	19.28	FACW	2

Polygonum hydropiper	3	1	1	1	0	1.20	1.13	1	0	0.00	OBL	1
Polygonum lapathifolium	0	1	1	1	0	0.60	0.57	0	2	1.13	OBL	1
Rumex crispus	0	0	0	0	1	0.20	0.19	1	0	0.00	FACW	2
Sagitaria latifolia	1	1	0	0	0	0.40	0.38	0	5	1.89	OBL	1
Setaria viridis	0	0	1	0	0	0.20	0.19	1	0	0.00	FAC	3
Solidago canadensis	0	0	0	0	1	0.20	0.19	0	2	0.38	FACU	4
Sparganium eurycarpum	1	0	0	0	0	0.20	0.19	0	5	0.95	OBL	1
Ulmus pumila	0	0	0	0	1	0.20	0.19	1	0	0.00	FAC	3
Verbena stricta	0	0	0	0	1	0.20	0.19	0	2	0.38	UPL	5

SAL9

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia artemisifolia	0	0	0	0	1	0.20	0.19	0	0	0.00	FACU	4
Bromus japonicus	1	0	0	0	1	0.40	0.39	1	0	0.00	FACU	4
Carex brevior	0	0	0	0	1	0.20	0.19	0	4	0.78	FAC	3
Celtis occidentalis	2	0	0	0	0	0.40	0.39	0	4	1.56	FAC	3
Cornus drummondii	1	0	0	0	0	0.20	0.19	0	3	0.58	FAC	3
Eleocharis palustris	0	1	0	0	0	0.20	0.19	0	4	0.78	OBL	1
Elymus canadensis	1	0	0	0	0	0.20	0.19	0	4	0.78	FACU	4
Hordeum jubatum	0	1	0	0	1	0.40	0.39	0	1	0.39	FACW	2
Iva annua	0	0	0	0	1	0.20	0.19	0	1	0.19	FAC	3
Juncus dudleyi	0	1	0	0	1	0.40	0.39	0	5	1.95	FACW	2
Lemna trisulca	1	0	0	1	1	0.60	0.58	0	8	4.68	OBL	1
Lycopus americanus	0	0	0	0	1	0.20	0.19	0	4	0.78	OBL	1
Pascopyrum smithii	0	0	0	0	1	0.20	0.19	0	3	0.58	FACU	4
Phalaris arundinacea	5	1	3	1	2	2.40	2.34	1	0	0.00	FACW	2
Poa pratensis	0	0	0	0	1	0.20	0.19	1	0	0.00	FACU	4

Polygonum hydropiper	1	1	0	0	1	0.60	0.58	1	0	0.00	OBL	1
Salix exigua	0	0	0	1	0	0.20	0.19	0	3	0.58	OBL	1
Solidago canadensis	1	0	0	0	1	0.40	0.39	0	2	0.78	FACU	4
Typha x glauca	90	95	97	99	92	94.60	92.20	1	0	0.00	OBL	1
Urtica dioica	0	0	0	0	1	0.20	0.19	0	1	0.19	FACW	2
Vernonia fasciculata	0	0	0	0	1	0.20	0.19	0	4	0.78	FAC	3

SALKREF

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Amphiscirpus nevadensis	5	1	0	0	0	1.2	0.5714286	0	8	4.5714286	OBL	1
Apocynum cannabinum	0	0	0	1	0	0.2	0.0952381	0	2	0.1904762	FAC	3
Calamagrostis stricta	5	10	10	5	5	7	3.3333333	0	6	20	FACW	2
Carex nrebrascensis	40	20	20	20	10	22	10.47619	0	5	52.380952	OBL	1
Carex pellita/scoparia	75	85	75	90	65	78	37.142857	0	4.5	167.14286	FACW	2
Eleocharis erythropoda	5	0	5	0	5	3	1.4285714	0	5	7.1428571	OBL	1
Juncus nodosus	0	0	0	0	1	0.2	0.0952381	0	6	0.5714286	OBL	1
Juncus torreyi	0	0	0	1	1	0.4	0.1904762	0	4	0.7619048	FACW	2
Polygonum lapathifolium	5	5	5	10	5	6	2.8571429	0	2	5.7142857	OBL	1
Schoenoplectus pungens	40	35	35	35	40	37	17.619048	0	4	70.47619	OBL	1
Spartina gracilis	15	10	15	15	20	15	7.1428571	0	6	42.857143	FACW	2
Triglochin maritima	45	25	40	35	55	40	19.047619	0	5	95.238095	OBL	1

SALK1

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis stolonifera	50	45	35	45	45	44	13.897663	1	0	0	FAC	3
Calamagrostis stricta	25	10	30	30	30	25	7.8963992	0	6	47.378395	FACW	2

Carex nebrascensis	25	10	15	15	40	21	6.6329754	0	5	33.164877	OBL	1
Carex pellita	10	15	30	30	35	24	7.5805433	0	4	30.322173	OBL	1
Carex praegracilis	25	15	10	0	10	12	3.7902716	0	4	15.161087	FACW	2
Carex scoparia	10	15	25	25	25	20	6.3171194	0	5	31.585597	FACW	2
Carex stipata	0	0	0	5	5	2	0.6317119	0	5	3.1585597	OBL	1
Eleocharis erythropoda	10	15	10	15	10	12	3.7902716	0	5	18.951358	OBL	1
Elymus repens	15	25	5	10	5	12	3.7902716	1	0	0	FAC	3
Glycyrrhiza lepidota	0	0	5	0	10	3	0.9475679	0	4	3.7902716	FACU	4
Helianthus petiolarus	0	0	1	0	0	0.2	0.0631712	0	1	0.0631712	UPL	5
Hordeum jubatum	0	5	1	1	5	2.4	0.7580543	0	1	0.7580543	FACW	2
Juncus arcticus	30	15	25	30	25	25	7.8963992	0	6	47.378395	OBL	1
Juncus dudleyi	0	5	0	0	0	1	0.315856	0	5	1.5792798	FACW	2
Lycopus americanus	1	10	10	5	10	7.2	2.274163	0	4	9.0966519	OBL	1
Medicago lupulina	10	15	10	15	5	11	3.4744157	1	0	0	FAC	3
Medicago sativa	1	0	0	0	0	0.2	0.0631712	1	0	0	UPL	5
Melilotus officinalis	10	5	5	5	15	8	2.5268478	1	0	0	FACU	4
Phleum pratense	0	0	1	5	0	1.2	0.3790272	1	0	0	FACU	4
Poa pratensis	30	20	10	10	10	16	5.0536955	1	0	0	FACU	4
Spartina pectinata	15	45	50	60	60	46	14.529375	0	5	72.646873	FACW	2
Taraxacum officinale	5	1	1	5	0	2.4	0.7580543	1	0	0	FACU	4
Trifolium repens	15	15	45	15	15	21	6.6329754	1	0	0	FACU	4

SALK2

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Calamagrostis stricta	30	30	30	15	15	24	13.620885	0	6	81.725312	OBL	1
Carex nebrascensis	45	35	40	55	50	45	25.53916	0	5	127.6958	OBL	1
Carex pellita/scoparia	55	55	40	35	30	43	24.404086	0	4.5	109.81839	FACW	2

Eleocharis acicularis	5	0	0	0	0	1	0.5675369	0	4	2.2701476	OBL	1
Polygonum coccineum	0	0	1	0	0	0.2	0.1135074	0	2	0.2270148	FACW	2
Polygonum lapathifolium	5	3	5	5	15	6.6	3.7457435	0	2	7.4914869	OBL	1
Polygonum persicaria	0	0	0	1	1	0.4	0.2270148	1	0	0	OBL	1
Schoenoplectus pungens	25	10	10	25	15	17	9.6481271	0	4	38.592509	OBL	1
Triglochin maritima	40	30	40	40	40	38	21.566402	0	5	107.83201	OBL	1
Typha latifolia	1	0	0	3	1	1	0.5675369	0	1	0.5675369	OBL	1

SALK3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrostis stolonifera	50	60	50	50	50	52	13.720317	1	0	0	FAC	3
Alopecuris arundinaceus	25	10	10	20	10	15	3.9577836	1	0	0	FACW	2
Calamagrostis stricta	30	25	5	15	35	22	5.8047493	0	6	34.828496	OBL	1
Carex nebrascensis	80	70	60	60	60	66	17.414248	0	5	87.07124	OBL	1
Carex praegracilis	35	20	0	0	10	13	3.4300792	0	4	13.720317	FACW	2
Carex scoparia	10	10	85	75	70	50	13.192612	0	5	65.963061	FACW	2
Carex stipata	15	10	0	5	15	9	2.3746702	0	5	11.873351	OBL	1
Eleocharis erythropoda	40	30	30	30	30	32	8.4432718	0	5	42.216359	OBL	1
Elyumus trachycailis	30	35	5	15	5	18	4.7493404	0	5	23.746702	UPL	5
Juncus arcticus	15	10	10	35	35	21	5.5408971	0	6	33.245383	OBL	1
Juncus dudleyi	1	0	0	0	1	0.4	0.1055409	0	5	0.5277045	FACW	2
Lycpus americanus	0	0	0	1	0	0.2	0.0527704	0	4	0.2110818	OBL	1
Medicago lupulina	5	15	5	10	15	10	2.6385224	1	0	0	FAC	3
Phalaris arundinacea	0	0	5	5	0	2	0.5277045	1	0	0	FACW	2
Poa pratensis	35	40	30	30	25	32	8.4432718	1	0	0	FACU	4
Polygonum lapathifolium	1	1	10	5	5	4.4	1.1609499	0	2	2.3218997	OBL	1
Spartina pectinata	35	25	10	30	35	27	7.1240106	0	5	35.620053	FACW	2

Trifolium repens	10	15	0	0	0	5	1.3192612	1	0	0	FACU	4

SALK4

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Amphiscirpus nevadensis	1	1	5	1	0	1.6	0.608365	0	8	4.8669202	OBL	1
Bouteloua gracilis	0	0	0	0	5	1	0.3802281	0	4	1.5209125	UPL	5
Calamagrostis stricta	20	10	5	5	10	10	3.8022814	0	6	22.813688	OBL	1
Distichilis spicata	10	15	5	0	40	14	5.3231939	0	3	15.969582	FACW	2
Eleocharis acicularis	15	0	5	0	0	4	1.5209125	0	4	6.0836502	OBL	1
Eleocharis erythropoda	30	35	35	40	0	28	10.646388	0	5	53.231939	OBL	1
Elymus trachycaulus	20	20	0	0	30	14	5.3231939	0	5	26.61597	UPL	5
Equisetum laevigatum	0	0	0	0	5	1	0.3802281	0	4	1.5209125	FACW	2
Eupatorium maculatum	0	0	1	0	0	0.2	0.0760456	0	6	0.4562738	OBL	1
Hordeum jubatum	1	1	5	1	0	1.6	0.608365	0	1	0.608365	FACW	2
Juncus arcticus	30	25	40	40	10	29	11.026616	0	6	66.159696	OBL	1
Juncus dudleyi	0	1	1	1	0	0.6	0.2281369	0	5	1.1406844	FACW	2
Juncus longistylis	0	1	0	0	1	0.4	0.1520913	0	7	1.0646388	FACW	2
Juncus marginatus	0	0	0	0	1	0.2	0.0760456	0	6	0.4562738	FACW	2
Juncus torreyi	10	5	1	1	0	3.4	1.2927757	0	4	5.1711027	FACW	2
Liatris lancifolia	0	1	0	0	0	0.2	0.0760456	0	8	0.608365	FACW	2
Lycopus asper	0	1	0	0	0	0.2	0.0760456	0	5	0.3802281	OBL	1
Melilotus officinalis	0	0	0	0	1	0.2	0.0760456	1	0	0	FACU	4
Panicum virgatum	40	40	15	15	40	30	11.406844	0	4	45.627376	FAC	3
Rudbeckia hirta	0	1	0	0	1	0.4	0.1520913	0	4	0.608365	FACU	4
Schizachyrium scoparuim	0	0	0	0	15	3	1.1406844	0	4	4.5627376	FACU	4
Schoenoplectus pungens	25	35	35	50	0	29	11.026616	0	4	44.106464	OBL	1
Solidago gigantea	5	5	1	1	0	2.4	0.9125475	0	3	2.7376426	FACW	2

Spartina pectina/gracilis	45	60	80	80	5	54	20.532319	0	5.5	112.92776	FACW	2
Sporobolus airoides	0	0	0	0	40	8	3.0418251	0	5	15.209125	FAC	3
Stachys pilosa	5	5	1	1	0	2.4	0.9125475	0	5	4.5627376	OBL	1
Symphorocarpus occidentalis	0	0	0	0	3	0.6	0.2281369	0	2	0.4562738	FACU	4
Thelypodium integriedlium	1	0	1	0	1	0.6	0.2281369	0	5	1.1406844	FAC	3
Triglochin maritima	35	35	35	10	0	23	8.7452471	0	5	43.726236	OBL	1

SALK5

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Atriplex patula	1	0	1	0	1	0.6	0.4137931	1	0	0	FAC	3
Carex pellita	10	0	0	0	0	2	1.3793103	0	4	5.5172414	OBL	1
Cleome serrulata	1	0	0	0	1	0.4	0.2758621	0	0	0	FACU	4
Distichlis spicata	15	1	5	5	15	8.2	5.6551724	0	3	16.965517	FACW	2
Elymus repens	1	0	0	0	0	0.2	0.137931	1	0	0	FAC	3
Hordeum jubatum	40	10	20	20	35	25	17.241379	0	1	17.241379	FACW	2
Juncus arcticus	25	0	5	0	1	6.2	4.2758621	0	6	25.655172	OBL	1
Lycpus americanus	0	0	0	0	1	0.2	0.137931	0	4	0.5517241	OBL	1
Potamogeton foliosus	0	5	0	0	0	1	0.6896552	0	5	3.4482759	OBL	1
Schoenoplectus pungens	100	75	100	85	90	90	62.068966	0	4	248.27586	OBL	1
Spartina gracilis	0	0	0	0	20	4	2.7586207	0	6	16.551724	FACW	2
Suaeda calceoliformis	5	0	10	5	15	7	4.8275862	0	5	24.137931	FACW	2
Triglochin maritima	0	0	0	1	0	0.2	0.137931	0	5	0.6896552	OBL	1

SALK6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Ambrosia artemisifolia	0	0	1	0	0	0.2	0.1074114	0	0	0	FACU	4

Apocynum cannabinum	1	1	0	0	0	0.4	0.2148228	0	2	0.4296455	FAC	3
Artemisia biennis	0	1	0	0	0	0.2	0.1074114	0	3	0.3222342	FACU	4
Asclepias incarnata	1	1	0	0	0	0.4	0.2148228	0	4	0.8592911	OBL	1
Bouteloua gracilis	0	1	10	0	0	2.2	1.1815252	0	4	4.726101	UPL	5
Bromus arvense	0	0	1	0	0	0.2	0.1074114	1	0	0	FACU	4
Calamagrostis stricta	0	0	5	0	0	1	0.5370569	0	6	3.2223416	OBL	1
Carex praegracilis	75	70	65	0	0	42	22.556391	0	4	90.225564	FACW	2
Ceratophyllum demersum	0	0	0	5	5	2	1.0741139	0	4	4.2964554	OBL	1
Chenopodium pratericola	0	0	1	0	0	0.2	0.1074114	0	1	0.1074114	UPL	5
Cirsium arvense	0	0	0	0		0	0	1	0	0	FACU	4
Ditichlis spicata	25	80	30	0	0	27	14.500537	0	3	43.501611	FACW	2
Eleocharis erythropoda	15	5	5	40	10	15	8.0558539	0	5	40.27927	OBL	1
Eleocharis palustris	0	0	0	10	10	4	2.1482277	0	4	8.5929108	OBL	1
Euphorbia geteri	0	0	5	0	0	1	0.5370569	0	5	2.6852846	UPL	5
Glycyrhiza lepidota	1	1	0	0	0	0.4	0.2148228	0	4	0.8592911	FACU	4
Helianthus annuus	0	1	1	0	0	0.4	0.2148228	0	0	0	FACU	4
Helianthus maximillianii	1	0	0	0	0	0.2	0.1074114	0	4	0.4296455	UPL	5
Helianthus petiolaus	1	1	0	0	0	0.4	0.2148228	0	1	0.2148228	UPL	5
Hordeum jubatum	5	10	5	0	0	4	2.1482277	0	1	2.1482277	FACW	2
Juncus arcticus	35	15	5	5	0	12	6.4446831	0	6	38.668099	OBL	1
Juncus nodosus	5	0	1	1	0	1.4	0.7518797	0	6	4.5112782	OBL	1
Leipidium densiflorum	0	0	1	0	0	0.2	0.1074114	0	0	0	FAC	3
Melilotus officinalis	1	1	5	0	0	1.4	0.7518797	1	0	0	FACU	4
Panicum capillare	0	0	1	0	0	0.2	0.1074114	0	0	0	FAC	3
Panicum virgatum	40	30	15	0	0	17	9.1299678	0	4	36.519871	FAC	3
Pascopyrum smithii	0	5	5	0	0	2	1.0741139	0	3	3.2223416	FACU	4
Phleum pratense	0	1	1	0	0	0.4	0.2148228	1	0	0	FACU	4
Poa pratensis	10	1	5	0	0	3.2	1.7185822	1	0	0	FACU	4

Potamogeton foliosus	0	0	0	5	5	2	1.0741139	0	5	5.3705693	OBL	1
Salsola tragus	0	0	1	0	0	0.2	0.1074114	1	0	0	FACU	4
Schizachyrium scoparium	0	1	0	0	0	0.2	0.1074114	0	4	0.4296455	FACU	4
Schoenolectus acutus	0	0	0	35	80	23	12.352309	0	5	61.761547	OBL	1
Schoenoplectus pungens	15	1	0	35	10	12.2	6.5520945	0	4	26.208378	OBL	1
Silene antirrhina	0	0	1	0	0	0.2	0.1074114	0	2	0.2148228	UPL	5
Spartina gracilis	0	1	1	0	0	0.4	0.2148228	0	6	1.2889366	FACW	2
Spartina pectinata	10	5	5	5	5	6	3.2223416	0	5	16.111708	FACW	2
Sporobalus airoides	0	1	0	0	0	0.2	0.1074114	0	5	0.5370569	FAC	3
Stachys pilosa	0	0	0	1	0	0.2	0.1074114	0	5	0.5370569	OBL	1
Symphyotrichium lanceolatus	1	0	0	0	0	0.2	0.1074114	0	3	0.3222342	OBL	1
Tradescantia occidentalis	0	0	1	0	0	0.2	0.1074114	0	5	0.5370569	UPL	5
Triglochin maritima	1	0	0	5	5	2.2	1.1815252	0	5	5.9076262	OBL	1

SALK7

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Agrostis stolonifera	30	30	30	30	40	32	11.065007	1	0	0	FAC	3
Apocynum cannabinum	0	0	0	1	0	0.2	0.0691563	0	2	0.1383126	FAC	3
Calamagrostis stricta	0	0	0	0	35	7	2.4204703	0	6	14.522822	OBL	1
Carex nebrascensis	30	30	50	50	50	42	14.522822	0	5	72.614108	OBL	1
Carex pellita	30	50	30	40	55	41	14.17704	0	4	56.70816	OBL	1
Carex scoparia	10	5	15	30	30	18	6.2240664	0	5	31.120332	FACW	2
Carex stipata	0	0	0	0	30	6	2.0746888	0	5	10.373444	OBL	1
Eleocharis erythropoda	30	30	50	50	30	38	13.139696	0	5	65.698479	OBL	1
Juncus dudleyi	0	0	0	0	10	2	0.6915629	0	5	3.4578147	FACW	2
Mentha canadensis	0	0	5	1	0	1.2	0.4149378	0	4	1.659751	FACW	2
Poa pratensis	30	30	50	30	30	34	11.75657	1	0	0	FACU	4

Polygonum hydropiper	0	1	1	1	0	0.6	0.2074689	1	0	0	OBL	1
Polygonum lapathifolium	5	5	10	10	10	8	2.7662517	0	2	5.5325035	OBL	1
Schoenoplectus pungens	0	10	10	15	10	9	3.1120332	0	4	12.448133	OBL	1
Spartina pectinata	50	50	35	60	50	49	16.943292	0	5	84.716459	FACW	2
Trifolium repens	0	1	5	0	0	1.2	0.4149378	1	0	0	FACU	4

SALK8

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Agrostis stolonifera	0	0	0	5	5	2	0.8865248	1	0	0	FACU	4
Alopecuris arundinaceus	0	0	0	3	25	5.6	2.4822695	1	0	0	FACW	2
Amphiscirpus nevadensis	0	1	0	0	0	0.2	0.0886525	0	8	0.7092199	OBL	1
Aster lanceolatus	1	5	0	3	3	2.4	1.0638298	0	3	3.1914894	OBL	1
Calamagrostis canadensis	0	0	1	0	0	0.2	0.0886525	0	6	0.5319149	OBL	1
Calamagrostis stricta	25	5	25	30	20	21	9.3085106	0	6	55.851064	FACW	2
Carex nebrascensis	0	1	10	5	0	3.2	1.4184397	0	5	7.0921986	OBL	1
Carex pellita/praegracilis	40	40	40	50	40	42	18.617021	0	4	74.468085	FACW	2
Carex tetanica	0	0	0	1	0	0.2	0.0886525	0	7	0.6205674	FACW	2
Eleocharis acicularis	1	0	0	1	0	0.4	0.177305	0	4	0.7092199	OBL	1
Eleocharis erythropoda	40	40	40	40	40	40	17.730496	0	5	88.652482	OBL	1
Eleocharis palustris	15	10	1	0	0	5.2	2.3049645	0	4	9.2198582	OBL	1
Elymus lanceolatus	1	0	0	0	0	0.2	0.0886525	0	5	0.4432624	FAC	3
Eupatorium maculatum	1	1	1	2	1	1.2	0.5319149	0	6	3.1914894	OBL	1
Hordeum jubatum	1	5	0	1	5	2.4	1.0638298	0	1	1.0638298	FACW	2
Juncus arcticus	0	0	5	1	5	2.2	0.9751773	0	6	5.8510638	OBL	1
Juncus dudleyi	0	0	0	5	0	1	0.4432624	0	5	2.2163121	FACW	2
Juncus torreyi	0	1	0	1	5	1.4	0.6205674	0	4	2.4822695	FACW	2
Lycopus americana	0	0	0	1	1	0.4	0.177305	0	4	0.7092199	OBL	1

Melilotus album	1	0	0	1	1	0.6	0.2659574	1	0	0	FACU	4
Muhlenbergia asperifolia	0	0	0	1	0	0.2	0.0886525	0	5	0.4432624	FACW	2
Phalaris arundinacea	0	0	0	0	2	0.4	0.177305	1	0	0	FACW	2
Poa pratensis	0	0	0	1	0	0.2	0.0886525	1	0	0	FACU	4
Schoenoplectus acutus	0	5	1	0	0	1.2	0.5319149	0	5	2.6595745	OBL	1
Schoenoplectus pungens	60	60	60	50	60	58	25.70922	0	4	102.83688	OBL	1
Solidago gigantea	0	0	0	3	0	0.6	0.2659574	0	3	0.7978723	FACW	2
Spartina gracilis	30	25	10	30	25	24	10.638298	0	6	63.829787	FACW	2
Stachys pilosa	0	1	0	1	1	0.6	0.2659574	0	5	1.3297872	OBL	1
Triglochin maritima	10	10	10	5	3	7.6	3.3687943	0	5	16.843972	OBL	1
Verbena hastata	1	0	0	3	1	1	0.4432624	0	4	1.7730496	FACW	2

SALK9

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia psilotachya	0	0	3	3	0	1.2	1.1090573	0	1	1.1090573	FAC	3
Ceratophyllum demersum	0	0	0	0	3	0.6	0.5545287	0	4	2.2181146	OBL	1
Chenopodium album	1	0	1	1	0	0.6	0.5545287	1	0	0	FAC	3
Distichlis spicata	15	1	40	15	0	14.2	13.123845	0	3	39.371534	FACW	2
Eleocharis palustris	55	5	40	40	0	28	25.878004	0	4	103.51201	OBL	1
Helianthus annuus	3	0	3	1	0	1.4	1.2939002	0	0	0	FACU	4
Hordeum jubatum	5	0	10	5	0	4	3.6968577	0	1	3.6968577	FACW	2
Lepidium densiflorum	0	0	0	1	0	0.2	0.1848429	0	0	0	FAC	3
Panicum virgatum	1	0	1	5	1	1.6	1.4787431	0	4	5.9149723	FAC	3
Potamogeton foliosus	0	15	0	0	30	9	8.3179298	0	5	41.589649	OBL	1
Schoenoplectus acutus	30	25	5	0	0	12	11.090573	0	5	55.452865	OBL	1
Schoenoplectus pungens	15	1	15	25	0	11.2	10.351201	0	4	41.404806	OBL	1
Solidago altissima	5	0	0	0	0	1	0.9242144	0	2	1.8484288	FACU	4

Stachys pilosa	45	0	20	30	0	19	17.560074	0	5	87.80037	OBL	1
Typha angustifolia	0	15	1	5	0	4.2	3.8817006	1	0	0	OBL	1

SWPREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Amaranthus retroflexus	0	1	1	0	0	0.40	0.31	0	0	0.00	FACU	4
Ambrosia grayi	1	1	0	0	0	0.40	0.31	0	0	0.00	FAC	3
Ambrosia psilotachya	0	1	0	0	3	0.80	0.62	0	1	0.62	FAC	3
Artemisia ludoviciana	0	1	0	0	0	0.20	0.16	0	4	0.62	FACU	4
Chenopodium rubrum	0	3	0	0	1	0.80	0.62	0	4	2.49	OBL	1
Coreopsis tinctoria	1	0	0	0	1	0.40	0.31	0	1	0.31	FAC	3
Echinocloa crus-galli	1	0	1	0	1	0.60	0.47	1	0	0.00	FACW	2
Eleocharis acicularis	20	80	60	45	80	57.00	44.32	0	4	177.29	OBL	1
Eleocharis palustris	80	35	70	50	50	57.00	44.32	0	4	177.29	OBL	1
Heteranthera limosa	1	1	1	15	0	3.60	2.80	0	4	11.20	OBL	1
Leptochloa fusca	0	0	1	0	0	0.20	0.16	0	1	0.16	OBL	1
Marsilea vestita	0	0	0	1	0	0.20	0.16	0	3	0.47	OBL	1
Polygonum bicorne	10	0	5	15	1	6.20	4.82	0	0	0.00	FACW	2
Polygonum pensylvanicum	1	1	1	0	1	0.80	0.62	0	0	0.00	FACW	2

SWP1

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Bromus inermis	0	0	0	0	5	1.00	0.60	1	0	0.00	FACU	4
Cirsium arvense	0	0	1	0	0	0.20	0.12	1	0	0.00	FACU	4
Echinochloa crus-galli	15	20	10	5	10	12.00	7.22	1	0	0.00	FACW	2
Rumex crispus	15	10	10	5	5	9.00	5.42	1	0	0.00	FACW	2

Setaria viridis	0	10	1	0	5	3.20	1.93	1	0	0.00	FAC	3
Typha angustifolia	0	0	35	90	5	26.00	15.64	1	0	0.00	OBL	1
Amaranthus blitoides	0	0	0	0	10	2.00	1.20	0	0	0.00	FACW	2
Ambrosia grayi	0	0	0	0	1	0.20	0.12	0	0	0.00	FAC	3
Coreopsis tinctoria	70	70	50	15	15	44.00	26.47	0	1	26.47	FAC	3
Eleocharis acicularis	10	5	10	5	5	7.00	4.21	0	4	16.85	OBL	1
Eleocharis engalmannii	0	0	5	0	0	1.00	0.60	0	3	1.81	FACW	2
Eleocharis palustris	5	0	0	0	10	3.00	1.81	0	4	7.22	OBL	1
Helianthus annua	0	0	0	0	1	0.20	0.12	0	0	0.00	FACU	4
Heteranthera limosa	1	1	1	0	0	0.60	0.36	0	4	1.44	OBL	1
Hordeum jubatum	0	1	1	1	10	2.60	1.56	0	1	1.56	FACW	2
Limosella aquatica	0	0	5	0	0	1.00	0.60	0	5	3.01	OBL	1
Marsilea vestita	10	10	5	5	3	6.60	3.97	0	3	11.91	OBL	1
Polygonum bicorne	75	60	45	10	15	41.00	24.67	0	0	0.00	FACW	2
Sagittaria calycina	10	10	5	0	3	5.60	3.37	0	3	10.11	OBL	1

SWP2

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
-	-	-	-	-	-	-	-	-	-	-	-	-

SWP3

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Amaranthus blitoides	40	5	5	1	10	12.20	24.30	0	0	0.00	FACW	2
Ambrosia grayi	1	1	1	0	0	0.60	1.20	0	0	0.00	FAC	3
Bassia scoparia	10	10	10	5	35	14.00	27.89	1	0	0.00	FACU	4
Echinocloa crus-galli	5	1	1	0	0	1.40	2.79	1	0	0.00	FACW	2

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Tribulus terrestris	50	10	5	5	40	22.00	43.82	1	0	0.00	UPL	5

SWP4

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Amaranthus retroflexus	1	0	0	1	0	0.40	0.40	0	0	0.00	FACU	4
Eleocharis acicularis	0	0	0	0	5	1.00	0.99	0	4	3.97	OBL	1
Eleocharis engelmannii	1	0	1	0	0	0.40	0.40	0	3	1.19	FACW	2
Eleocharis palustris	100	100	100	95	90	97.00	96.23	0	4	384.92	OBL	1
Heteranthera limosa	0	0	1	0	1	0.40	0.40	0	4	1.59	OBL	1
Hordeum jubatum	0	0	1	1	0	0.40	0.40	0	1	0.40	FACW	2
Polygonum bicorne	1	1	1	1	1	1.00	0.99	0	0	0.00	FACW	2
Sagittaria calycina	0	0	0	0	1	0.20	0.20	0	3	0.60	OBL	1

SWP5

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

SWP6

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

SWP7

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

SWP8

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

SWP9

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
-	-	-	-	-	-	-	-	-	-	-	-	-

NPRREF

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Alopecurus arundinaceus	0	3	0	0	0	0.60	0.46	1	0	0.00	FAC	3
Asclepias speciosa	0	0	0	1	0	0.20	0.15	0	1	0.15	FAC	3
Aster falcatus	0	0	1	1	0	0.40	0.30	0	4	1.22	FAC	3
Atriplex prostrata	5	5	5	5	5	5.00	3.80	1	0	0.00	FAC	3
Bassia scoparia	10	10	10	1	5	7.20	5.47	1	0	0.00	FACU	4
Carex praegracius	10	25	10	0	0	9.00	6.84	0	4	27.36	FACW	2
Cirsium arvense	1	1	0	5	1	1.60	1.22	1	0	0.00	FACU	4
Descurainia pinnata	1	1	0	0	1	0.60	0.46	0	0	0.00	UPL	5
Descurainia sophia	0	0	1	0	1	0.40	0.30	1	0	0.00	FACU	4
Distichlis stricta	85	85	85	10	65	66.00	50.15	0	3	150.46	FACW	2
Helianthus petiolaris	0	1	5	0	1	1.40	1.06	0	1	1.06	UPL	5
Juncus arcticus x balticus	10	10	15	15	1	10.20	7.75	0	6	46.50	OBL	1
Lactuca ludoviciana	0	0	0	1	1	0.40	0.30	0	3	0.91	FAC	3
Lepidium perfoliatum	1	0	0	0	0	0.20	0.15	1	0	0.00	FAC	3
Muhlenbergia asperifolia	5	5	10	60	30	22.00	16.72	0	5	83.59	FACW	2
Panicum virgatum	0	0	0	1	0	0.20	0.15	0	4	0.61	FAC	3

Plantago lanceolata	0	0	0	1	0	0.20	0.15	1	0	0.00	FAC	3
Poa arida	1	0	1	0	1	0.60	0.46	0	6	2.74	FAC	3
Poa pratensis	0	0	0	0	1	0.20	0.15	1	0	0.00	FACU	4
Polygonum erectum	1	0	1	0	0	0.40	0.30	0	1	0.30	OBL	1
Rumex crispus	0	0	0	1	0	0.20	0.15	1	0	0.00	FACW	2
Salsola tragus	0	0	0	0	3	0.60	0.46	1	0	0.00	FACU	4
Sisimbrium loesoelli	1	1	3	0	0	1.00	0.76	1	0	0.00	UPL	5
Suaeda calceoliformis	1	0	1	0	1	0.60	0.46	0	5	2.28	FACW	2
Thelypodium integrifolium	1	1	1	1	1	1.00	0.76	0	5	3.80	FAC	3
Thlaspi arvense	0	0	1	0	0	0.20	0.15	1	0	0.00	FACU	4
Triglochin maritima	5	0	1	0	0	1.20	0.91	0	5	4.56	OBL	1

NPR1

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Alopecurus arundinaceus	30	10	60	15	10	25.00	13.65	1	0	0.00	FACW	2
Amphiscarpus nevadensis	0	1	1	1	0	0.60	0.33	0	8	2.62	OBL	1
Aster falcatus	0	0	0	0	1	0.20	0.11	0	4	0.44	FAC	3
Atriplex prostrata	15	25	10	40	25	23.00	12.55	1	0	0.00	FAC	3
Bassia scoparia	20	10	10	15	50	21.00	11.46	1	0	0.00	FACU	4
Bromus japonicus	5	1	5	10	3	4.80	2.62	1	0	0.00	FACU	4
Carex pellita	0	10	0	0	0	2.00	1.09	0	4	4.37	OBL	1
Carex praegracilis	0	5	0	0	0	1.00	0.55	0	4	2.18	FACW	2
Chenopodium rubrum	1	1	0	0	0	0.40	0.22	0	4	0.87	OBL	1
Cirsium arvense	0	0	0	3	0	0.60	0.33	1	0	0.00	FACU	4
Descurainia sophia	0	0	0	1	0	0.20	0.11	1	0	0.00	UPL	5
Distichlis stricta	20	30	15	5	15	17.00	9.28	0	3	27.84	FACW	2
Eleocharis acicularis	20	10	5	0	0	7.00	3.82	0	4	15.28	OBL	1

Eleocharis macrostachya	5	10	20	20	10	13.00	7.10	0	4	28.38	OBL	1
Hordeum jubatum	20	40	25	25	25	27.00	14.74	0	1	14.74	FACW	2
Lactuca serriola	0	0	0	0	5	1.00	0.55	1	0	0.00	FAC	3
Melilotus officinalis	0	0	0	1	1	0.40	0.22	1	0	0.00	FACU	4
Muhlenbergia asperifolia	10	25	10	25	10	16.00	8.73	0	5	43.67	FACW	2
Panicum virgatum	0	5	0	0	0	1.00	0.55	0	4	2.18	FAC	3
Poa arida	0	5	0	5	1	2.20	1.20	0	6	7.21	FAC	3
Rumex crispus	3	1	0	1	1	1.20	0.66	1	0	0.00	FACW	2
Schoenoplectus pungens	0	1	0	0	0	0.20	0.11	0	4	0.44	OBL	1
Sisybrium altissium	0	1	0	0	0	0.20	0.11	1	0	0.00	FACU	4
Sisymbrium lolsoelli	1	1	1	3	3	1.80	0.98	1	0	0.00	UPL	5
Sporobolus airoides	15	15	15	15	15	15.00	8.19	0	5	40.94	FAC	3
Taraxacum officinale	1	1	1	1	1	1.00	0.55	1	0	0.00	FACU	4
Tragopogon duvius	0	0	0	0	1	0.20	0.11	1	0	0.00	FACU	4
Typha angustifolia	0	1	0	0	0	0.20	0.11	1	0	0.00	OBL	1

NPR2

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Atriplex heterosperma	5	5	1	5	1	3.40	2.90	1	0	0.00	FAC	3
Atriplex prostrata	1	0	1	0	0	0.40	0.34	1	0	0.00	FAC	3
Bassia scoparia	5	5	5	5	1	4.20	3.58	1	0	0.00	FACU	4
Carex praegracilis	10	15	0	20	15	12.00	10.24	0	4	40.96	FACW	2
Chenopodium rubrum	0	1	0	0	0	0.20	0.17	0	4	0.68	OBL	1
Cirsium arvense	0	1	0	1	0	0.40	0.34	1	0	0.00	FACU	4
Descurainia pinnata	0	1	0	0	0	0.20	0.17	0	0	0.00	UPL	5
Distichlis stricta	95	85	90	80	75	85.00	72.53	0	3	217.58	FACW	2
Hordeum jubatum	1	1	1	1	0	0.80	0.68	0	1	0.68	FACW	2

Lactuca ludoviciana	0	1	0	0	0	0.20	0.17	0	3	0.51	FAC	3
Nepeta cataria	0	0	1	0	0	0.20	0.17	1	0	0.00	FACU	4
Rumex crispus	0	1	1	0	0	0.40	0.34	1	0	0.00	FACW	2
Salsola tragus	0	1	0	1	0	0.40	0.34	1	0	0.00	FACU	4
Sporobolus airoides	0	0	0	20	15	7.00	5.97	0	5	29.86	FAC	3
Suaeda calceoliformis	5	5	1	1	0	2.40	2.05	0	5	10.24	FACW	2

NPR3

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Absolute % Cover	Relative % Cover	Invasive	CC	Weighted CC	Wetness	C of W
Carex praegracilis	30	30	35	30	30	31.00	18.90	0	4	75.61	FACW	2
Descurainia pinnata	1	1	0	0	1	0.60	0.37	0	0	0.00	UPL	5
Distichlis stricta	45	65	45	30	30	43.00	26.22	0	3	78.66	FACW	2
Eleocharis macrostachya	0	0	1	0	0	0.20	0.12	0	4	0.49	OBL	1
Elymus elongatus	50	25	50	55	60	48.00	29.27	1	0	0.00	FAC	3
Hordeum jubatum	5	15	5	5	1	6.20	3.78	0	1	3.78	FACW	2
Juncus dudleyi	0	5	5	0	0	2.00	1.22	0	5	6.10	FACW	2
Medicago lupulina	0	10	0	0	0	2.00	1.22	1	0	0.00	FAC	3
Pascopyrum smithii	1	1	10	30	35	15.40	9.39	0	3	28.17	FACU	4
Poa arida	0	5	5	5	1	3.20	1.95	0	6	11.71	FAC	3
Poa pratensis	10	5	0	0	0	3.00	1.83	1	0	0.00	FACU	4
Puccinellia distans	5	5	5	0	0	3.00	1.83	1	0	0.00	OBL	1
Ranunculus cymbalaria	0	5	0	0	0	1.00	0.61	0	3	1.83	OBL	1
Schoenoplectus pungens	1	1	1	0	0	0.60	0.37	0	4	1.46	OBL	1
Stellaria media	0	0	1	0	0	0.20	0.12	1	0	0.00	UPL	5
Suaeda calceoliformis	1	1	0	0	0	0.40	0.24	0	5	1.22	FACW	2
Taraxacum officinale	0	1	0	1	1	0.60	0.37	1	0	0.00	FACU	4
Thelypodium integrifolium	0	0	1	0	0	0.20	0.12	0	5	0.61	FAC	3

Trifolium hybridum	0	10	0	0	0	2.00	1.22	1	0	0.00	FACU	4
Trigluchin maritima	1	1	5	0	0	1.40	0.85	0	5	4.27	OBL	1

NPR4

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Andropogon gerardii	0	0	1	0	1	0.40	0.27	0	5	1.33	FAC	3
Aster falcatus	0	0	0	0	1	0.20	0.13	0	4	0.53	FAC	3
Atriplex heterosperma	5	3	5	3	0	3.20	2.13	1	0	0.00	FAC	3
Atriplex prostrata	0	1	0	0	0	0.20	0.13	1	0	0.00	FAC	3
Bassia scoparia	5	1	5	1	0	2.40	1.60	1	0	0.00	FACU	4
Bromus japonicus	25	25	35	0	0	17.00	11.32	1	0	0.00	FACU	4
Bromus tectorum	0	1	0	0	0	0.20	0.13	1	0	0.00	FACU	4
Carex praegracilis	20	10	0	0	30	12.00	7.99	0	4	31.96	FACW	2
Chenopodium album	1	1	1	3	0	1.20	0.80	1	0	0.00	FAC	3
Chenopodium rubrum	3	3	5	5	1	3.40	2.26	0	4	9.05	OBL	1
Cirsium arvense	0	0	0	1	0	0.20	0.13	1	0	0.00	FACU	4
Cleomella angustifolia	0	0	0	1	0	0.20	0.13	0	4	0.53	FAC	3
Descurainia pinnata	1	0	0	1	1	0.60	0.40	0	0	0.00	UPL	5
Distichlis stricta	50	65	50	45	40	50.00	33.29	0	3	99.87	FACW	2
Draba nemorosa	1	0	0	0	0	0.20	0.13	0	4	0.53	UPL	5
Helianthus annuus	0	0	0	1	0	0.20	0.13	0	0	0.00	FACU	4
Helianthus petiolaris	0	0	1	0	0	0.20	0.13	0	1	0.13	UPL	5
Hordeum pusillum	0	1	0	0	0	0.20	0.13	0	1	0.13	FAC	3
Juncus dudleyi	3	0	0	0	0	0.60	0.40	0	5	2.00	FACW	2
Lactuca serriola	0	0	0	1	0	0.20	0.13	1	0	0.00	FAC	3
Lepidium densiflorum	1	1	1	0	1	0.80	0.53	0	0	0.00	FAC	3
Melilotus officinalis	5	0	1	0	1	1.40	0.93	1	0	0.00	FACU	4

Muhlenbergia asperifolia	0	1	0	0	0	0.20	0.13	0	5	0.67	FACW	2
Pascopyrum smithii	10	5	5	10	25	11.00	7.32	0	3	21.97	FACU	4
Poa arida	0	0	0	0	5	1.00	0.67	0	6	3.99	FAC	3
Poa secunda	0	0	0	0	1	0.20	0.13	0	6	0.80	FACU	4
Polygonum erectum	1	1	1	1	1	1.00	0.67	0	1	0.67	OBL	1
Ratibida columnifera	0	0	0	1	0	0.20	0.13	0	4	0.53	UPL	5
Rayjacksonia annua	1	1	0	1	0	0.60	0.40	0	2	0.80	FAC	3
Spartina gracilis	5	0	0	5	0	2.00	1.33	0	6	7.99	FACW	2
Sporobulus airoides	40	30	40	60	20	38.00	25.30	0	5	126.50	FAC	3
Suaeda calceoliformis	1	1	0	0	0	0.40	0.27	0	5	1.33	FACW	2
Taraxacum officinale	0	0	0	1	0	0.20	0.13	1	0	0.00	FACU	4
Tragopogon dubius	1	0	0	0	1	0.40	0.27	1	0	0.00	FACU	4

NPR5

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia artemisifolia	1	0	0	0	5	1.20	0.66	0	0	0.00	FACU	4
Ambrosia psilostachya	1	0	0	1	5	1.40	0.78	0	1	0.78	FAC	3
Andropogon gerardii	1	0	1	1	0	0.60	0.33	0	5	1.66	FAC	3
Aster falcatus	1	0	0	0	0	0.20	0.11	0	4	0.44	FAC	3
Bassia scoparia	10	0	0	0	55	13.00	7.20	1	0	0.00	FACU	4
Carex brevior	1	3	3	3	0	2.00	1.11	0	4	4.43	FAC	3
Carex pragracilis	35	35	35	20	0	25.00	13.84	0	4	55.37	FACW	2
Chenopodum album	5	1	1	1	5	2.60	1.44	1	0	0.00	FAC	3
Cirsium arvense	1	0	0	1	1	0.60	0.33	1	0	0.00	FACU	4
Convolvulus arvensis	5	5	10	10	3	6.60	3.65	1	0	0.00	UPL	5
Coreopsis tinctoria	0	1	1	1	0	0.60	0.33	0	1	0.33	FAC	3
Distichlis stricta	50	40	40	40	25	39.00	21.59	0	3	64.78	FACW	2

Elymus trachycaulus	5	5	10	5	1	5.20	2.88	0	5	14.40	FACU	4
Helianthus annus	1	0	0	0	0	0.20	0.11	0	0	0.00	FACU	4
Hordeum jubatum	5	10	10	10	0	7.00	3.88	0	1	3.88	FACW	2
Lactuca serriola	0	0	0	1	1	0.40	0.22	1	0	0.00	FAC	3
Limosella aquatica	0	0	1	0	0	0.20	0.11	0	5	0.55	OBL	1
Panicum virgatum	40	25	50	65	10	38.00	21.04	0	4	84.16	FAC	3
Pascopyrum smithii	5	5	5	0	10	5.00	2.77	0	3	8.31	FACU	4
Poa arida	0	0	0	1	0	0.20	0.11	0	6	0.66	FAC	3
Poa pratensis	20	25	30	40	0	23.00	12.74	1	0	0.00	FACU	4
Polygonum erectum	0	1	1	1	0	0.60	0.33	0	1	0.33	OBL	1
Rumex crispus	1	0	1	1	0	0.60	0.33	1	0	0.00	FACW	2
Sporobolus airoides	10	0	5	0	0	3.00	1.66	0	5	8.31	FAC	3
Taraxacum officinale	3	1	1	1	1	1.40	0.78	1	0	0.00	FACU	4
Trifolium hybridum	10	0	0	0	5	3.00	1.66	1	0	0.00	FACU	4

NPR6

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Ambrosia psylostachya	0	1	0	0	0	0.20	0.13	0	1	0.13	FAC	3
Atriplex heterosperma	1	1	0	0	0	0.40	0.25	1	0	0.00	FAC	3
Bassia scoparia	10	10	15	5	15	11.00	6.95	1	0	0.00	FACU	4
Bromus japonicus	5	5	1	5	5	4.20	2.65	1	0	0.00	FACU	4
Bromus tectorum	0	0	0	0	1	0.20	0.13	1	0	0.00	FACU	4
Carduus nutanus	1	1	0	0	0	0.40	0.25	1	0	0.00	UPL	5
Carex praegracilis	0	15	10	10	5	8.00	5.06	0	4	20.23	FACW	2
Chenopodium album	5	5	5	5	5	5.00	3.16	1	0	0.00	FAC	3
Chenopodium pratericola	1	1	1	1	1	1.00	0.63	0	1	0.63	UPL	5
Cirsium arvense	0	1	0	0	0	0.20	0.13	1	0	0.00	FACU	4

Convolvulus arvense	0	1	1	1	0	0.60	0.38	1	0	0.00	UPL	5
Descurainia pinnata	1	1	1	0	1	0.80	0.51	0	0	0.00	UPL	5
Distichlis stricta	60	45	75	70	75	65.00	41.09	0	3	123.26	FACW	2
Glycyrhiza lepidota	0	3	0	0	0	0.60	0.38	0	4	1.52	FACU	4
Helianthus annuus	0	1	1	0	3	1.00	0.63	0	0	0.00	FACU	4
Hordeum jubatum	5	0	0	1	1	1.40	0.88	0	1	0.88	FACW	2
Hordeum pusillum	0	1	5	0	1	1.40	0.88	0	1	0.88	FAC	3
Juncus dudleyi	0	0	0	1	0	0.20	0.13	0	5	0.63	FACW	2
Lepidium desertorum	0	1	1	1	0	0.60	0.38	0	0	0.00	FAC	3
Melilotus officinalis	5	1	1	0	0	1.40	0.88	1	0	0.00	FACU	4
Panicum virgatum	0	1	0	0	0	0.20	0.13	0	4	0.51	FAC	3
Pascopyrum smithii	0	5	1	5	5	3.20	2.02	0	3	6.07	FACU	4
Poa pratensis	5	10	10	5	0	6.00	3.79	1	0	0.00	FACU	4
Polygonum errectum	1	1	1	1	1	1.00	0.63	0	1	0.63	OBL	1
Rosa arkansana	0	0	0	1	0	0.20	0.13	0	4	0.51	FACU	4
Sporobolus airoides	45	65	35	35	35	43.00	27.18	0	5	135.90	FAC	3
Taraxacum officinale	1	0	0	3	1	1.00	0.63	1	0	0.00	FACU	4

NPR7

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Alopecurus arundinacea	1	0	0	0	0	0.20	0.11	1	0	0.00	FAC	3
Asclepias incarnata	1	1	0	0	1	0.60	0.32	0	4	1.29	OBL	1
Aster praealtus	0	1	0	0	0	0.20	0.11	0	5	0.54	FACW	2
Atriplex prostrata	0	0	3	3	1	1.40	0.75	1	0	0.00	FAC	3
Carex pellita	10	0	0	10	10	6.00	3.22	0	4	12.89	OBL	1
Carex praegracilis	5	5	10	10	0	6.00	3.22	0	4	12.89	FACW	2
Cirsium arvense	1	0	0	1	1	0.60	0.32	1	0	0.00	FACU	4

Distichlis stricta	65	60	40	50	50	53.00	28.46	0	3	85.39	FACW	2
Elaeagnus angustifolia	0	1	0	0	0	0.20	0.11	1	0	0.00	FAC	3
Eleocharis erythropoda	0	0	0	1	5	1.20	0.64	0	5	3.22	OBL	1
Elymus trachycaulus	5	0	0	0	0	1.00	0.54	0	5	2.69	FACU	4
Eupatorium maculatum	0	1	0	1	0	0.40	0.21	0	6	1.29	OBL	1
Hordeum jubatum	5	5	3	5	1	3.80	2.04	0	1	2.04	FACW	2
Juncus arcticus x balticus	1	1	1	0	0	0.60	0.32	0	6	1.93	OBL	1
Juncus dudleyi	25	25	25	25	25	25.00	13.43	0	5	67.13	FACW	2
Panicum virgatum	1	10	0	0	0	2.20	1.18	0	4	4.73	FAC	3
Plantago lanceolata	0	1	0	0	1	0.40	0.21	1	0	0.00	FAC	3
Poa compressa	15	15	5	10	0	9.00	4.83	1	0	0.00	FACU	4
Schoenoplectus pungens	3	10	15	10	10	9.60	5.16	0	4	20.62	OBL	1
Solidago candensis	0	1	0	0	0	0.20	0.11	0	2	0.21	FACU	4
Spartina gracilis	30	40	80	45	45	48.00	25.78	0	6	154.67	FACW	2
Triglochin maritima	25	15	3	15	25	16.60	8.92	0	5	44.58	OBL	1

NPR8

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Amaranthus retroflexus	1	1	0	0	1	0.60	1.46	0	0	0.00	FACU	4
Chenopodium pratericola	1	0	0	0	0	0.20	0.49	0	1	0.49	UPL	5
Distichlis stricta	40	10	5	5	15	15.00	36.59	0	3	109.76	FACW	2
Eleocharis palustris	20	10	0	15	10	11.00	26.83	0	4	107.32	OBL	1
Hordeum pusillum	1	0	5	0	0	1.20	2.93	0	1	2.93	FAC	3
Pascopyrum smithii	0	0	10	3	0	2.60	6.34	0	3	19.02	FACU	4
Plagiobothrys scouleri	1	0	1	1	1	0.80	1.95	0	2	3.90	FACW	2
Plantago eriopoda	3	0	0	1	1	1.00	2.44	0	5	12.20	FAC	3
Polygonum erectum	1	0	0	0	0	0.20	0.49	0	1	0.49	OBL	1

Polygonum ramosissimum	10	3	1	1	10	5.00	12.20	0	1	12.20	FAC	3
Salsola iberica	0	0	0	1	0	0.20	0.49	1	0	0.00	FACU	4
Schedonnarus paniculatus	5	5	0	1	5	3.20	7.80	0	0	0.00	UPL	5

NPR9

Species	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Absolute % Cover**	**Relative % Cover**	**Invasive**	**CC**	**Weighted CC**	**Wetness**	**C of W**
Amaranthus powellii	0	0	0	1	0	0.20	0.22	1	0	0.00	UPL	5
Amaranthus retroflexus	0	1	1	1	0	0.60	0.66	0	0	0.00	FACU	4
Apocynum cannabinum	0	1	0	0	0	0.20	0.22	0	2	0.44	FAC	3
Asclepias pumica	3	0	0	0	0	0.60	0.66	0	4	2.63	UPL	5
Atriplex rasea	0	1	0	0	0	0.20	0.22	1	0	0.00	FACU	4
Bassia scoparia	0	0	1	1	0	0.40	0.44	1	0	0.00	FACU	4
Bouteloua dactyloides	10	3	3	0	0	3.20	3.50	0	2	7.00	FACU	4
Carex eleocharis	0	10	10	15	5	8.00	8.75	0	2	17.51	UPL	5
Chamaesyce serpyllifolia	0	1	1	1	0	0.60	0.66	0	2	1.31	UPL	5
Chenopodium incanum	1	0	0	0	0	0.20	0.22	0	3	0.66	UPL	5
Distichlis stricta	0	0	0	15	3	3.60	3.94	0	3	11.82	FACW	2
Eleocharis acicularis	10	15	10	15	10	12.00	13.13	0	4	52.52	OBL	1
Hordeum pusillum	5	1	0	5	0	2.20	2.41	0	1	2.41	FAC	3
Iva axillaris	1	0	0	1	30	6.40	7.00	0	4	28.01	FAC	3
Lactuca ludoviciana	1	1	1	1	1	1.00	1.09	0	3	3.28	FAC	3
Lippia cuneifolia	10	5	0	0	0	3.00	3.28	0	4	13.13	FAC	3
Oenothera canescens	10	3	0	0	0	2.60	2.84	0	3	8.53	FACW	2
Panicum capillare	0	0	0	1	0	0.20	0.22	0	0	0.00	FAC	3
Pascopyrum smithii	50	45	45	30	40	42.00	45.95	0	3	137.86	FACU	4
Plantago eriopoda	0	1	1	1	0	0.60	0.66	0	5	3.28	FAC	3
Poa arida	1	0	0	0	0	0.20	0.22	0	6	1.31	FAC	3

Polygonum ramosisimum	0	1	1	1	0	0.60	0.66	0	1	0.66	FAC	3
Salsola iberica	0	1	1	0	0	0.40	0.44	1	0	0.00	FACU	4
Scorzonera laciniata	1	0	0	0	0	0.20	0.22	1	0	0.00	FAC	3
Sisymbrium loesoelli	1	0	1	0	0	0.40	0.44	1	0	0.00	UPL	5
Solanum triflorum	0	0	1	0	0	0.20	0.22	0	3	0.66	UPL	5
Suaeda calceoliformis	0	0	0	1	0	0.20	0.22	0	5	1.09	FACW	2
Tragopogon dubius	1	0	1	0	0	0.40	0.44	1	0	0.00	FACU	4
Veronica peregrina	1	1	1	1	1	1.00	1.09	0	1	1.09	OBL	1

APPENDIX C: RAINWATER BASINS VOLUNTEER ROADSIDE ANURAN CALL SURVEY DATA FROM 2014 - 2016

Tables below provide presence/absence data from volunteer roadside anuran call surveys conducted at 124 wetland sites in the Rainwater Basins.

2014
Visit 1

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A1	A1_2014	1	0	1	0	0	0	1	0	0	3	0	5/15/2014	20:15	23:17	182	EBB	None	0.9	43.7	WRP
A10	A10_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	23:15	180	MW	None	1.7	43.1	Pit
A11	A11_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:56	161	MW	None	1.0	46.6	Private
A12	A12_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:54	99	MW	None	1.3	40.7	WPA
A2	A2_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	22:20	125	EBB	None	2.1	42.7	Pit
A3	A3_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	22:44	149	MW	None	4.1	45.2	Pit
A4	A4_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:24	189	MW	None	1.4	42.7	Pit
A5	A5_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:32	137	MW	None	1.8	43.9	WMA
A6	A6_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:30	75	MW	None	1.1	43.0	WMA
A7	A7_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:05	110	MW	None	1.9	43.3	Private
A8	A8_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	23:05	170	MW	None	1.1	43.7	Pit
A9	A9_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	21:41	86	MW	None	0.9	45.9	WMA
B1	B1_2014	1	0	0	0	0	0	0	0	0	1	0	5/18/2014	20:15	20:56	41	NS	None	3.4	44.9	WRP
B10	B10_2014	1	0	0	0	0	0	0	0	0	1	0	5/18/2014	20:15	21:54	99	MH	None	3.8	45.8	WPA
B2	B2_2014	1	0	1	0	0	0	0	0	0	2	0	5/18/2014	20:15	20:45	30	NS	None	3.1	52.6	WRP
B3	B3_2014	0	0	0	0	0	0	0	0	0	0	0	5/18/2014	20:15	21:07	52	NA	None	NA	NA	WRP
B4	B4_2014	0	0	0	0	0	0	0	0	0	0	0	5/18/2014	20:15	21:22	67	MH	None	2.7	52.5	Private

B5	B5_2014	1	0	0	0	0	0	0	0	0	1	0	5/18/2014	20:15	21:34	79	MH	None	3.5	45.5	Pit
B6	B6_2014	1	0	1	0	0	0	0	0	0	2	0	5/18/2014	20:15	21:17	62	MH	None	4.6	47.3	Pit
B7	B7_2014	1	1	1	0	0	0	0	0	0	3	0	5/18/2014	20:15	22:07	112	MH	None	1.5	47.9	WMA
B8	B8_2014	1	0	0	0	0	0	0	0	0	1	0	5/18/2014	20:15	21:50	95	MH	None	3.4	48.0	WMA
B9	B9_2014	1	1	1	0	0	0	0	0	0	3	0	5/18/2014	20:15	21:41	86	MH	None	1.1	50.8	WMA
C1	C1_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	1:03	288	MW	None	0.0	42.8	Private
C10	C10_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	23:11	176	AVH	None	0.9	40.9	WPA
C11	C11_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	22:39	144	AVH	None	0.9	45.8	Private
C12	C12_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:35	80	AVH	None	0.9	42.4	WRP
C2	C2_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	1:16	301	MW	None	1.4	45.3	Pit
C3	C3_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	1:25	310	MW	None	0.0	44.2	Pit
C4	C4_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	0:05	230	AVH	None	2.1	46.8	Private
C5	C5_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:47	92	AVH	None	1.5	47.2	WMA
C6	C6_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	21:22	67	AVH	None	0.9	40.6	WPA
C7	C7_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:12	177	AVH	None	0.8	42.6	WPA
C8	C8_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:43	208	AVH	None	0.8	44.8	Pit
C9	C9_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	22:47	152	AVH	None	0.9	42.8	Pit
D1	D1_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	22:09	114	MK	None	5.5	69.5	Private
D2	D2_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	22:35	140	MK	None	9	72	Pit
D3	D3_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	21:39	84	MK	None	8.0	70.4	Pit
D4	D4_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	22:46	151	MK	None	9.4	72.1	WMA
D5	D5_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	21:10	55	MK	None	7.3	69.9	WMA
D6	D6_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	22:20	125	MK	None	4.7	68.0	WRP
D7	D7_2014	1	0	1	0	0	0	1	1	0	4	0	5/14/2014	20:15	23:05	170	MK	None	8.9	68.4	WRP
E1	E1_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:10	55	AVH	None	0.8	44.8	Private

E10	E10_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:58	163	NH	None	3.1	48.2	WRP
E11	E11_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:43	88	NH	None	3.5	50.4	WRP
E12	E12_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:31	196	NH	None	2.3	48.0	WRP
E13	E13_2014	1	0	1	0	0	0	0	0	0	2	0	5/15/2014	20:15	22:15	120	NH	None	2.9	56.2	WRP
E2	E2_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:59	224	AVH	None	0.8	45.1	WMA
E3	E3_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	23:39	204	NH	None	0.9	59.7	Private
E4	E4_2014	1	0	1	0	0	0	1	0	0	3	0	5/15/2014	20:15	22:25	130	NH	None	3.8	49.2	Pit
E5	E5_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:18	63	NH	None	6.0	47.5	Pit
E6	E6_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:47	212	NH	None	7.3	46.9	WMA
E7	E7_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:50	155	NH	None	6.6	49.2	WRP
E8	E8_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:08	173	NH	None	2.0	48.0	WRP
E9	E9_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	23:20	185	NH	None	5.1	48.1	WRP
F1	F1_2014	1	1	0	0	0	0	0	0	0	2	0	5/15/2014	20:15	21:15	60	WR	None	0.0	50.4	Private
F10	F10_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:10	175	WR	None	0.0	59.6	WPA
F11	F11_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:51	216	WR	None	0.0	45.1	WPA
F12	F12_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	21:50	95	WR	None	2.6	44.8	WPA
F13	F13_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	0:05	230	WR	None	0.0	51.8	WPA
F2	F2_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:43	88	WR	None	0.0	41.7	Private
F3	F3_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	21:26	71	WR	None	1.1	47.8	Private
F4	F4_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:12	57	WR	None	0.0	47.2	Pit
F5	F5_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:00	105	WR	None	0.0	47.4	WMA
F6	F6_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	23:20	185	WR	None	0.0	47.0	WMA
F7	F7_2014	1	1	0	0	0	0	0	0	0	2	0	5/15/2014	20:15	21:40	85	WR	None	0.0	48.7	WPA
F8	F8_2014	0	0	0	0	0	0	0	0	0	0	0	5/15/2014	20:15	21:27	72	WR	None	0.0	55.2	WPA
F9	F9_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:40	205	WR	None	0.0	46.9	WPA

G1	G1_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	21:09	54	WR	None	0.0	0.0	WRP
G10	G10_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	23:29	194	MH	None	5.4	43.0	WPA
G11	G11_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:42	207	NS	None	4.7	45.6	WPA
G2	G2_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:30	75	NS	None	4.0	50.6	Private
G3	G3_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	21:48	93	MH	None	6.5	44.8	Pit
G4	G4_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:01	106	NS	None	4.4	47.6	Pit
G5	G5_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	22:15	120	NS	None	4.9	42.7	Pit
G6	G6_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	22:31	136	MH	None	2.6	41.2	Pit
G7	G7_2014	1	0	0	0	0	0	1	0	0	2	0	5/15/2014	20:15	22:45	150	MH	None	0.9	41.4	WPA
G8	G8_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:00	165	MH	None	5.4	43.6	WPA
G9	G9_2014	1	0	0	0	0	0	0	0	0	1	0	5/15/2014	20:15	23:14	179	MH	None	3.2	41.2	WPA
H1	H1_2014	1	0	0	1	0	0	0	0	0	2	0	5/14/2014	20:15	21:17	62	MK	None	7.3	69.1	WRP
H10	H10_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	21:55	100	NA	None	0.7	50.3	WRP
H11	H11_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	22:30	135	NA	None	0.7	60.4	WRP
H2	H2_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	22:18	123	NA	None	0.8	58.7	Private
H3	H3_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	22:58	163	NA	None	0.8	56.4	Private
H4	H4_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	23:24	189	NA	None	1.2	60.4	Private
H5	H5_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	23:10	175	NA	None	1.2	42.8	Private
H6	H6_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	21:30	75	NB	None	1.0	59.9	Private
H7	H7_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	22:43	148	NA	None	0.6	64.0	WMA
H8	H8_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	21:41	86	NA	None	1.1	42.1	WMA
H9	H9_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	22:06	111	NB	None	1.3	40.3	WMA
I1	I1_2014	0	0	0	0	0	0	0	0	0	0	0	5/13/2014	20:15	0:56	281	MH	None	2.9	44.5	Private
I10	I10_2014	1	0	0	0	0	0	0	0	0	1	0	5/13/2014	20:15	23:13	178	MH	None	2.9	41.9	WPA
I11	I11_2014	0	0	0	0	0	0	0	0	0	0	0	5/13/2014	20:15	1:05	290	MH	None	2.1	39.2	WRP

I12	I12_2014	1	0	0	0	0	0	0	0	0	1	0	5/13/2014	20:15	23:26	191	MH	None	2.3	44.4	WRP
I13	I13_2014	1	0	1	0	0	0	1	0	0	3	0	5/13/2014	20:15	23:47	212	MK	None	9.3	68.7	Private
I14	I14_2014	0	0	0	0	0	0	0	0	0	0	0	5/13/2014	20:15	0:28	253	MK	None	3.0	71.5	Private
I2	I2_2014	1	0	0	0	0	0	0	0	0	1	0	5/13/2014	20:15	1:15	300	MH	None	2.4	42.5	WMA
I3	I3_2014	1	0	0	0	0	0	0	0	0	1	0	5/13/2014	20:15	0:19	244	MH	None	2.9	41.3	Pit
I4	I4_2014	0	0	0	0	1	0	0	0	0	1	0	5/13/2014	20:15	22:42	147	MH	None	1.4	42.5	Pit
I5	I5_2014	0	0	0	0	0	0	0	0	0	0	0	5/13/2014	20:15	0:38	263	MH	None	1.5	42.4	Pit
I6	I6_2014	1	0	0	0	0	0	1	0	0	2	0	5/13/2014	20:15	21:53	98	MH	None	0.7	46.0	Pit
I7	I7_2014	0	0	0	0	0	0	0	0	0	0	0	5/13/2014	20:15	0:47	272	MH	None	3.2	44.2	WMA
I8	I8_2014	0	0	0	0	1	0	0	0	0	1	0	5/13/2014	20:15	22:59	164	MH	None	1.7	38.0	WMA
I9	I9_2014	1	0	1	0	0	0	0	0	0	2	0	5/13/2014	20:15	22:26	131	MH	None	3.8	46.0	WMA
J10	J10_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	0:24	249	NS	None	4.5	50.7	WRP
J11	J11_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	0:14	239	EBB	None	1.1	52.7	Private
J12	J12_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	1:45	330	EBB	None	1.4	36.4	Pit
J13	J13_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	1:26	311	EBB	None	2.2	47.6	WMA
J14	J14_2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20:15	NA	NA	MH	NA	NA	NA	WRP
J2	J2_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	0:55	280	NA	None	2.4	47.8	WRP
J3	J3_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	23:54	219	NA	None	0.9	59.4	WRP
J4	J4_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	23:59	224	NS	None	7.4	57.2	Private
J5	J5_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	0:30	255	NS	None	5.5	47.2	Pit
J6	J6_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	1:15	300	NS	None	9.7	51.9	WMA
J7	J7_2014	1	0	0	0	0	0	1	0	0	2	0	5/14/2014	20:15	0:51	276	NS	None	6.4	47.6	WMA
J8	J8_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	0:11	236	NS	None	2.0	51.4	WMA
J9	J9_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	1:02	287	NS	None	6.9	49.5	WPA
K1	K1_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	21:15	60	EBB	None	0.6	48.5	WMA

K2	K2_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	23:07	172	EBB	None	3.4	46.1	WMA
K3	K3_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	22:47	152	EBB	None	1.0	40.0	WPA
K4	K4_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	22:18	123	EBB	None	1.0	45.7	WPA
K5	K5_2014	0	0	0	0	0	0	0	0	0	0	0	5/14/2014	20:15	22:02	107	EBB	None	1.3	39.4	WPA
K6	K6_2014	1	0	1	0	0	0	1	0	0	3	0	5/14/2014	20:15	21:47	92	EBB	None	1.9	40.2	WPA
K7	K7_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	22:57	162	EBB	None	0.9	41.4	WPA
K8	K8_2014	1	0	0	0	0	0	0	0	0	1	0	5/14/2014	20:15	21:33	78	EBB	None	0.8	49.7	WPA

2014
Visit 2

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A1	A1_2014	1	0	1	0	0	0	1	0	0	3	0	5/22/2014	20:32	21:15	43	MH	None	2.2	67.1	Private
A10	A10_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	23:11	159	MH	None	3.3	65.1	WPA
A11	A11_2014	1	0	1	0	0	0	0	0	0	2	0	5/22/2014	20:32	22:54	142	MH	None	3	63.1	WRP
A12	A12_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	21:55	83	MH	None	1.5	67.3	WRP
A2	A2_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	22:22	110	MH	None	0.7	69.4	WMA
A3	A3_2014	0	0	1	0	0	0	0	0	0	1	0	5/22/2014	20:32	22:44	132	MH	None	2.7	66.2	Pit
A4	A4_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	23:20	168	MH	None	1.3	61.8	Pit
A5	A5_2014	1	0	1	0	0	0	1	0	0	3	0	5/22/2014	20:32	22:32	120	MH	None	1.6	66.3	Pit
A6	A6_2014	0	0	0	0	0	0	0	0	0	0	0	5/22/2014	20:32	21:29	57	MH	None	2.2	68	Pit
A7	A7_2014	1	0	1	0	0	0	0	0	0	2	0	5/22/2014	20:32	22:05	93	MH	None	1.7	67.7	WMA
A8	A8_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	23:03	151	MH	None	0.7	68.7	WMA
A9	A9_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	21:42	70	MH	None	0.7	68.1	WMA
B1	B1_2014	1	0	0	0	0	0	0	0	0	1	0	5/28/2014	20:32	21:22	50	MK	None	4.2	82	Private
B10	B10_2014	1	0	0	0	0	0	1	0	0	2	0	5/28/2014	20:32	22:24	112	MK	None	2.3	79.9	WRP
B2	B2_2014	1	0	0	0	1	1	0	0	0	3	0	5/28/2014	20:32	21:02	30	MK	None	5.3	81.7	Private
B3	B3_2014	1	0	0	0	0	0	0	0	0	1	0	5/28/2014	20:32	21:27	55	MK	None	0.8	82.5	Private
B4	B4_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:32	22:01	89	MK	None	2.6	79.14	Pit

B5	B5_2014	1	0	0	0	0	0	0	0	0	1	0	5/28/2014	20:32	22:04	92	MK	None	3.1	80.7	Pit
B6	B6_2014	1	0	1	0	0	1	1	0	0	4	1	5/28/2014	20:32	21:46	74	MK	None	2.7	84.1	WMA
B7	B7_2014	1	0	1	0	0	0	1	0	0	3	0	5/28/2014	20:32	22:26	114	MK	None	4.9	79.4	WMA
B8	B8_2014	1	0	1	0	0	0	1	0	0	3	0	5/28/2014	20:32	22:18	106	MK	None	2.2	79.9	WRP
B9	B9_2014	1	0	0	0	0	0	1	0	0	2	0	5/28/2014	20:32	22:12	100	MK	None	2.5	80.1	WRP
C1	C1_2014	1	0	0	0	0	0	0	0	0	1	0	5/21/2014	20:32	23:43	191	NA	None	0	63.7	Private
C10	C10_2014	1	0	0	0	0	1	0	0	0	2	0	5/21/2014	20:32	0:41	249	NA	None	1.9	62.9	WRP
C11	C11_2014	1	0	1	0	0	1	1	0	0	4	1	5/21/2014	20:32	23:05	153	NA	None	1.9	73.9	WRP
C12	C12_2014	1	0	1	0	0	1	0	0	0	3	0	5/21/2014	20:32	0:15	223	NA	None	3.5	63	WRP
C2	C2_2014	0	0	0	0	0	0	0	0	0	0	0	5/21/2014	20:32	23:35	183	NA	None	1.1	64	Private
C3	C3_2014	1	0	1	0	0	1	0	0	0	3	0	5/21/2014	20:32	23:20	168	NA	None	6.6	69.3	Private
C4	C4_2014	1	0	1	0	0	0	0	0	0	2	0	5/21/2014	20:32	21:17	45	NA	None	5.8	73.4	Private
C5	C5_2014	1	0	1	0	0	0	0	0	0	2	0	5/21/2014	20:32	0:02	210	NA	None	1.3	63.2	Private
C6	C6_2014	1	0	1	0	0	1	1	0	0	4	1	5/21/2014	20:32	0:26	234	NA	None	1.9	63.1	WMA
C7	C7_2014	1	0	0	0	0	1	0	0	0	2	0	5/21/2014	20:32	22:15	103	NA	None	6.3	70.9	WMA
C8	C8_2014	1	0	1	0	0	1	1	0	0	4	1	5/21/2014	20:32	21:36	64	NA	None	1.6	77	WMA
C9	C9_2014	1	0	0	0	0	1	0	0	0	2	0	5/21/2014	20:32	22:55	143	NA	None	4.4	76.6	WRP
D1	D1_2014	1	0	1	0	0	0	1	0	0	3	0	5/20/2014	20:32	22:29	117	MH	None	5.6	68.2	Private
D2	D2_2014	1	0	1	0	0	0	0	0	0	2	0	5/20/2014	20:32	22:44	132	MH	None	6.8	70	Pit
D3	D3_2014	1	0	1	0	0	1	1	0	0	4	1	5/20/2014	20:32	21:46	74	MH	None	7.3	71.2	WMA
D4	D4_2014	1	0	1	0	0	1	1	0	0	4	1	5/20/2014	20:32	22:55	143	MH	None	5.3	67.6	WMA
D5	D5_2014	1	0	1	0	0	1	0	0	0	3	0	5/20/2014	20:32	21:15	43	MH	None	2.4	74.7	WMA
D6	D6_2014	1	0	1	0	0	1	1	0	0	4	1	5/20/2014	20:32	22:17	105	MH	None	6.8	73.8	WPA
D7	D7_2014	1	0	1	0	0	0	1	0	0	3	0	5/20/2014	20:32	23:14	162	MH	None	3.6	69.7	WRP
E1	E1_2014	1	0	1	0	0	0	0	0	0	2	0	5/30/2014	20:32	21:48	76	EBB	None	2.6	75	Private

E10	E10_2014	1	0	1	0	0	0	0	0	0	2	0	5/30/2014	20:32	23:53	201	EBB	None	1.6	70	WPA
E11	E11_2014	1	0	0	0	0	1	1	0	0	3	0	5/30/2014	20:32	22:38	126	EBB	None	0.8	76.4	WPA
E12	E12_2014	0	0	0	0	0	0	0	0	0	0	0	5/30/2014	20:32	0:45	253	EBB	None	0.9	66.1	WRP
E13	E13_2014	0	0	0	0	0	0	1	0	0	1	0	5/30/2014	20:32	22:58	146	EBB	None	1.8	75.5	WRP
E2	E2_2014	0	0	0	0	0	0	1	0	0	1	0	5/30/2014	20:32	1:03	271	EBB	None	2	66.1	Pit
E3	E3_2014	1	0	0	0	0	0	1	0	0	2	0	5/30/2014	20:32	23:32	180	EBB	None	1.6	71.6	WMA
E4	E4_2014	0	0	0	0	0	1	0	0	0	1	0	5/30/2014	20:32	23:10	158	EBB	None	1.9	72.4	WMA
E5	E5_2014	1	0	0	0	0	1	0	0	0	2	0	5/30/2014	20:32	22:05	93	EBB	None	1.3	76.6	WMA
E6	E6_2014	0	0	0	0	0	0	0	0	0	0	0	5/30/2014	20:32	0:54	262	EBB	None	0.6	69.2	WPA
E7	E7_2014	1	0	0	0	0	1	0	0	0	2	0	5/30/2014	20:32	23:43	191	EBB	None	0.9	71.3	WPA
E8	E8_2014	1	0	0	0	0	0	0	0	0	1	0	5/30/2014	20:32	0:08	216	EBB	None	2.5	71.7	WPA
E9	E9_2014	1	0	0	0	0	0	0	0	0	1	0	5/30/2014	20:32	0:26	234	EBB	None	1	69.9	WPA
F1	F1_2014	1	0	0	0	0	0	0	0	0	1	0	5/22/2014	20:32	21:28	56	MW	None	2.6	65.6	Pit
F10	F10_2014	1	0	0	0	0	1	0	0	0	2	0	5/22/2014	20:32	23:13	161	MW	None	1.8	63.1	WPA
F11	F11_2014	1	0	0	0	0	0	0	0	0	1	0	5/22/2014	20:32	23:48	196	MW	None	3.9	61.2	Private
F12	F12_2014	1	0	0	0	0	0	0	0	0	1	0	5/22/2014	20:32	22:58	146	MW	None	1	65.8	Pit
F13	F13_2014	0	0	0	0	0	0	0	0	0	0	0	5/22/2014	20:32	23:59	207	MW	None	3.2	61.8	Pit
F2	F2_2014	0	0	0	0	0	0	0	0	0	0	0	5/22/2014	20:32	21:53	81	MW	None	1.5	64.8	Pit
F3	F3_2014	1	0	1	0	0	0	1	0	0	3	0	5/22/2014	20:32	21:40	68	MW	None	2.6	64.5	WMA
F4	F4_2014	1	0	0	0	0	0	0	0	0	1	0	5/22/2014	20:32	22:07	95	MW	None	2.4	63.7	WMA
F5	F5_2014	1	0	1	0	0	1	1	0	0	4	1	5/22/2014	20:32	22:20	108	MW	None	1.69	63.6	Private
F6	F6_2014	0	0	0	0	0	0	0	0	0	0	0	5/22/2014	20:32	23:22	170	MW	None	1.2	65.9	Pit
F7	F7_2014	1	0	1	0	0	0	0	0	0	2	0	5/22/2014	20:32	22:43	131	MW	None	2.2	64.6	WMA
F8	F8_2014	1	0	0	0	0	0	0	0	0	1	0	5/22/2014	20:32	22:32	120	MW	None	1.6	64.7	Pit
F9	F9_2014	0	0	0	0	0	0	0	0	0	0	0	5/22/2014	20:32	23:38	186	MW	None	1.6	63	Private

G1	G1_2014	1	0	0	0	0	0	0	0	0	1	0	5/21/2014	20:32	21:40	68	MH	None	7.5	70.8	Private
G10	G10_2014	0	0	0	0	0	0	0	0	0	0	0	5/21/2014	20:32	22:06	94	MH	None	6.2	70	Private
G11	G11_2014	0	0	0	0	0	0	0	0	0	0	0	5/21/2014	20:32	23:15	163	MH	None	4.4	70.2	WMA
G2	G2_2014	1	0	1	0	0	0	1	0	0	3	0	5/21/2014	20:32	21:48	76	MH	None	3.3	73.1	WMA
G3	G3_2014	1	0	1	0	0	1	1	0	0	4	1	5/21/2014	20:32	22:38	126	MH	None	5.2	68.9	WPA
G4	G4_2014	1	0	0	0	0	0	0	0	0	1	0	5/21/2014	20:32	22:48	136	MH	None	4.9	68.1	WPA
G5	G5_2014	0	0	0	0	0	0	0	0	0	0	0	5/21/2014	20:32	22:57	145	MH	None	4.8	70.8	Pit
G6	G6_2014	1	0	0	0	0	0	0	0	0	1	0	5/21/2014	20:32	22:28	116	MH	None	5.6	70.2	Pit
G7	G7_2014	1	0	1	0	0	1	1	0	0	4	1	5/21/2014	20:32	22:17	105	MH	None	4.3	70.1	WPA
G8	G8_2014	0	0	0	0	0	0	0	0	0	0	0	5/21/2014	20:32	21:54	82	MH	None	3.3	73.9	Private
G9	G9_2014	1	0	1	0	0	1	1	0	0	4	1	5/21/2014	20:32	23:06	154	MH	None	5.8	69.8	WRP
H1	H1_2014	1	0	0	1	0	0	0	0	0	2	0	5/23/2014	20:32	22:28	116	DU	None	0.6	77.1	Private
H10	H10_2014	0	0	1	0	0	0	0	0	0	1	0	5/23/2014	20:32	22:57	145	DU	None	0	69.5	WRP
H11	H11_2014	1	0	0	0	0	1	1	0	0	3	0	5/23/2014	20:32	21:58	86	DU	None	1.9	67.8	WRP
H2	H2_2014	0	0	0	0	0	0	0	0	0	0	0	5/23/2014	20:32	21:47	75	DU	None	1.2	67.9	Pit
H3	H3_2014	1	0	1	0	0	0	0	0	0	2	0	5/23/2014	20:32	22:18	106	DU	None	0	73.9	Pit
H4	H4_2014	1	0	1	0	0	1	0	0	0	3	0	5/23/2014	20:32	21:22	50	DU	None	0	75.1	WMA
H5	H5_2014	0	0	0	0	0	0	0	0	0	0	0	5/23/2014	20:32	21:37	65	DU	None	0.6	76.5	WRP
H6	H6_2014	1	0	0	1	0	1	0	0	0	3	0	5/23/2014	20:32	22:38	126	DU	None	1.3	68.6	WRP
H7	H7_2014	1	0	1	0	0	0	0	0	0	2	0	5/23/2014	20:32	22:07	95	DU	None	1.7	74	WRP
H8	H8_2014	1	0	1	0	0	1	0	0	0	3	0	5/23/2014	20:32	22:47	135	DU	None	0	77	WRP
H9	H9_2014	1	0	1	0	0	0	0	0	0	2	0	5/23/2014	20:32	23:07	155	DU	None	0.8	73.8	WRP
I1	I1_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	0:52	260	WR	None	6.8	65	Private
I10	I10_2014	1	0	0	0	0	0	0	0	0	1	0	5/20/2014	20:32	23:22	170	WR	None	8.1	69	WPA
I11	I11_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	1:07	275	WR	None	5.9	66	WPA

I12	I12_2014	1	0	1	0	0	0	0	0	0	2	0	5/20/2014	20:32	23:30	178	WR	None	6.4	68	WPA
I13	I13_2014	1	0	1	0	1	1	1	0	0	5	1	5/20/2014	20:32	23:47	195	WR	None	7	69	WPA
I14	I14_2014	0	0	1	0	0	1	0	0	0	2	0	5/20/2014	20:32	0:12	220	WR	None	5.5	67	WRP
I2	I2_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	1:15	283	WR	None	8.9	66	Private
I3	I3_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	0:25	233	WR	None	8.9	67	Private
I4	I4_2014	1	0	0	0	0	0	0	0	0	1	0	5/20/2014	20:32	23:02	150	WR	None	9.5	70	Pit
I5	I5_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	0:24	232	WR	None	7	66	WMA
I6	I6_2014	1	0	0	0	0	1	1	0	0	3	0	5/20/2014	20:32	22:27	115	WR	None	2.7	68	WMA
I7	I7_2014	0	0	1	0	0	0	0	0	0	1	0	5/20/2014	20:32	0:43	251	WR	None	7.7	66	WPA
I8	I8_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	23:11	159	WR	None	8.9	68	WPA
I9	I9_2014	1	0	1	0	0	0	0	0	0	2	0	5/20/2014	20:32	22:49	137	WR	None	5.9	70	WPA
J10	J10_2014	0	0	0	0	0	0	1	0	0	1	0	5/19/2014	20:32	0:09	217	MH	None	5.1	71.3	WPA
J11	J11_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	23:53	201	MH	None	6.4	67.5	WPA
J12	J12_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	23:45	193	MH	None	7.1	72.8	WRP
J13	J13_2014	1	0	1	0	0	1	1	0	0	4	1	5/19/2014	20:32	1:17	285	MH	None	5.9	70.7	WRP
J14	J14_2014	1	0	0	0	0	1	1	0	0	3	0	5/19/2014	20:32	1:02	270	MH	None	6.3	72.6	WRP
J2	J2_2014	1	0	1	0	0	1	1	0	0	4	1	5/20/2014	20:32	0:28	236	MH	None	3.4	71.3	Private
J3	J3_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	23:37	185	MH	None	9.8	71.9	Pit
J4	J4_2014	0	0	0	0	0	0	0	0	0	0	0	5/20/2014	20:32	0:07	215	MH	None	3.5	69	Pit
J5	J5_2014	1	0	0	0	0	0	0	0	0	1	0	5/20/2014	20:32	23:43	191	MH	None	4.9	67.7	Pit
J6	J6_2014	1	0	0	0	0	0	0	0	0	1	0	5/19/2014	20:32	0:50	258	MH	None	4.7	69.8	Pit
J7	J7_2014	1	0	1	0	0	1	0	0	0	3	0	5/19/2014	20:32	0:33	241	MH	None	4.6	71.9	WPA
J8	J8_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	23:59	207	MH	None	6.2	73.6	WPA
J9	J9_2014	1	0	1	0	0	1	1	0	0	4	1	5/19/2014	20:32	0:42	250	MH	None	5.3	71.7	WPA
K1	K1_2014	1	0	1	0	0	0	1	0	0	3	0	5/19/2014	20:32	22:38	126	MH	None	4.1	77.7	Private

K2	K2_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	21:53	81	MH	None	12.5	75.5	Pit
K3	K3_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	21:28	56	MH	None	9.7	76.1	Pit
K4	K4_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	22:15	103	MH	None	8.1	79.8	WMA
K5	K5_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	23:12	160	MH	None	10.1	72.5	WMA
K6	K6_2014	1	0	1	0	0	1	0	0	0	3	0	5/19/2014	20:32	23:00	148	MH	None	3.7	73.5	WMA
K7	K7_2014	0	0	0	0	0	0	0	0	0	0	0	5/19/2014	20:32	21:44	72	MH	None	7.5	77.1	WPA
K8	K8_2014	1	0	0	0	0	0	0	0	0	1	0	5/19/2014	20:32	22:51	139	MH	None	3.4	71.7	WRP

2014
Visit 3

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A1	A1_2014	1	0	1	0	0	1	1	0	0	4	1	5/27/2014	20:45	21:20	35	TL	None	4.7	78.1	Private
A10	A10_2014	1	1	1	0	0	1	1	0	0	5	1	5/27/2014	20:45	23:29	164	TL	None	2.5	75.6	WPA
A11	A11_2014	1	0	1	0	0	0	0	0	0	2	0	5/27/2014	20:45	23:46	181	TL	None	2.3	69.8	WRP
A12	A12_2014	1	1	1	0	1	1	0	0	0	5	0	5/27/2014	20:45	0:02	197	TL	None	1.9	69.8	WRP
A2	A2_2014	1	0	1	0	0	0	0	0	0	2	0	5/27/2014	20:45	21:44	59	TL	None	1.7	77.2	Pit
A3	A3_2014	1	0	1	0	0	1	1	0	0	4	1	5/27/2014	20:45	21:56	71	TL	None	2.7	76.4	Pit
A4	A4_2014	1	0	1	0	1	1	0	0	0	4	0	5/27/2014	20:45	22:11	86	TL	None	2.4	74.8	Pit
A5	A5_2014	1	0	1	0	0	0	1	0	0	3	0	5/27/2014	20:45	22:23	98	TL	None	2.3	72.9	Pit
A6	A6_2014	1	0	1	0	0	0	1	0	0	3	0	5/27/2014	20:45	22:35	110	TL	None	2.2	73.9	Pit
A7	A7_2014	1	0	1	0	0	1	1	0	0	4	1	5/27/2014	20:45	22:49	124	TL	None	2.4	72.4	WMA
A8	A8_2014	1	0	1	0	0	1	1	0	0	4	1	5/27/2014	20:45	23:06	141	TL	None	2.5	71.9	WMA
A9	A9_2014	1	0	1	0	0	1	1	0	0	4	1	5/27/2014	20:45	23:17	152	TL	None	2.7	73.2	WMA
B1	B1_2014	1	0	1	0	0	0	1	0	0	3	0	6/2/2014	20:45	21:51	66	MK	None	3.3	79.2	Private
B10	B10_2014	1	0	0	0	0	1	1	0	0	3	0	6/2/2014	20:45	23:53	188	MK	None	3.1	76.9	WRP
B2	B2_2014	1	0	1	0	0	0	0	0	0	2	0	6/2/2014	20:45	22:38	113	MK	None	4.2	79.4	Private
B3	B3_2014	1	0	1	0	0	0	0	0	1	3	0	6/2/2014	20:45	22:54	129	MK	None	4.4	79.4	Private
B4	B4_2014	1	0	1	0	0	1	1	0	0	4	1	6/2/2014	20:45	23:10	145	MK	None	3.1	78.3	Pit

B5	B5_2014	1	0	1	0	0	0	1	0	0	3	0	6/2/2014	20:45	23:23	158	MK	None	2.7	78.7	Pit
B6	B6_2014	1	0	1	0	0	0	1	0	0	3	0	6/2/2014	20:45	23:03	138	MK	None	4.0	79.3	WMA
B7	B7_2014	1	0	1	0	1	1	1	0	0	5	1	6/2/2014	20:45	23:59	194	MK	None	2.7	76.7	WMA
B8	B8_2014	1	0	1	0	0	0	1	0	0	3	0	6/2/2014	20:45	23:42	177	MK	None	3.0	77.2	WRP
B9	B9_2014	1	0	0	0	0	0	1	0	0	2	0	6/2/2014	20:45	23:34	169	MK	None	2.8	77.4	WRP
C1	C1_2014	1	0	1	0	0	0	0	0	0	2	0	5/29/2014	20:45	23:00	135	NA	None	1.2	78.4	Private
C10	C10_2014	1	0	0	0	0	0	1	0	0	2	0	5/29/2014	20:45	21:15	30	NA	None	3.1	76.9	WRP
C11	C11_2014	1	0	1	0	0	1	1	0	0	4	1	5/29/2014	20:45	22:40	115	NA	None	1.7	78.3	WRP
C12	C12_2014	1	0	1	0	0	1	1	0	0	4	1	5/29/2014	20:45	21:32	47	NB	None	0.7	78.1	WRP
C2	C2_2014	0	0	0	0	0	0	0	0	0	0	0	5/29/2014	20:45	23:06	141	NA	None	1.8	75.1	Private
C3	C3_2014	1	0	1	0	0	1	1	0	0	4	1	5/29/2014	20:45	23:15	150	NA	None	2.0	74.8	Private
C4	C4_2014	1	0	1	0	0	0	1	0	0	3	0	5/29/2014	20:45	0:00	195	NA	None	1.7	69.7	Private
C5	C5_2014	0	0	0	0	0	0	1	0	0	1	0	5/29/2014	20:45	21:45	60	NB	None	2.0	75.4	Private
C6	C6_2014	1	0	0	0	0	1	1	0	0	3	0	5/29/2014	20:45	21:25	40	NA	None	1.5	75.5	WMA
C7	C7_2014	1	0	1	0	0	1	0	0	0	3	0	5/29/2014	20:45	23:05	140	NA	None	1.4	72.0	WMA
C8	C8_2014	1	0	1	0	0	1	1	0	0	4	1	5/29/2014	20:45	23:46	181	NA	None	1.1	68.5	WMA
C9	C9_2014	1	0	0	0	0	1	0	0	0	2	0	5/29/2014	20:45	22:30	105	NA	None	0.8	78.2	WRP
D1	D1_2014	1	0	0	0	0	1	1	0	0	3	0	5/28/2014	20:45	22:19	94	NS	None	4.5	74.6	Private
D2	D2_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:42	117	NS	None	6.8	75.1	Pit
D3	D3_2014	1	1	1	0	0	0	0	0	0	3	0	5/28/2014	20:45	21:54	69	NS	None	5.3	76.9	WMA
D4	D4_2014	1	0	1	0	0	0	1	0	0	3	0	5/28/2014	20:45	22:51	126	NS	None	3.1	73.5	WMA
D5	D5_2014	1	0	0	0	0	0	1	0	0	2	0	5/28/2014	20:45	21:23	38	NS	None	6.4	78.9	WMA
D6	D6_2014	1	0	1	0	0	1	0	0	0	3	0	5/28/2014	20:45	22:28	103	NS	None	5.2	74.3	WPA
D7	D7_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:10	145	NS	None	7.3	74.3	WRP
E1	E1_2014	1	0	1	0	0	1	1	0	0	4	1	5/31/2014	20:45	23:42	177	EBB	None	3.5	73.1	Private

E10	E10_2014	0	0	0	0	0	1	0	0	0	1	0	5/31/2014	20:45	22:28	103	EBB	None	3.7	74.6	WPA
E11	E11_2014	1	0	0	0	0	1	0	0	0	2	0	5/31/2014	20:45	23:16	151	EBB	None	6.7	73.8	WPA
E12	E12_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	21:29	44	EBB	None	5.5	76.8	WRP
E13	E13_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	23:00	135	EBB	None	2.3	74.0	WRP
E2	E2_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	21:38	53	EBB	None	5.8	76.8	Pit
E3	E3_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:43	118	EBB	None	3.1	74.5	WMA
E4	E4_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:52	127	EBB	None	6.9	74.0	WMA
E5	E5_2014	1	0	0	0	0	1	0	0	0	2	0	5/31/2014	20:45	23:32	167	EBB	None	6.8	73.7	WMA
E6	E6_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	21:46	61	EBB	None	7.6	77.6	WPA
E7	E7_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:36	111	EBB	None	3.2	75.0	WPA
E8	E8_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:18	93	EBB	None	5.4	76.5	WPA
E9	E9_2014	1	0	0	0	0	0	0	0	0	1	0	5/31/2014	20:45	22:04	79	EBB	None	3.0	75.0	WPA
F1	F1_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	21:43	58	MW	None	6.0	76.6	Pit
F10	F10_2014	1	0	1	0	0	1	0	0	0	3	0	5/31/2014	20:45	23:09	144	MW	None	5.5	73.6	WPA
F11	F11_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	23:38	173	MW	None	4.1	72.2	Private
F12	F12_2014	0	0	0	0	0	0	1	0	0	1	0	5/31/2014	20:45	22:55	130	MW	None	2.6	74.3	Pit
F13	F13_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	23:50	185	MW	None	1.2	74.9	Pit
F2	F2_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:05	80	MW	None	4.9	75.6	Pit
F3	F3_2014	1	0	0	0	0	0	0	0	0	1	0	5/31/2014	20:45	21:54	69	MW	None	3.5	75.8	WMA
F4	F4_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:15	90	MW	None	5.2	74.1	WMA
F5	F5_2014	1	0	0	0	0	0	0	0	0	1	0	5/31/2014	20:45	22:28	103	MW	None	4.0	74.7	Private
F6	F6_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	23:18	153	MW	None	5.0	73.9	Pit
F7	F7_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:47	122	MW	None	3.4	73.9	WMA
F8	F8_2014	0	0	0	0	0	0	0	0	0	0	0	5/31/2014	20:45	22:38	113	MW	None	4.3	74.0	Pit
F9	F9_2014	1	0	0	0	0	0	0	0	0	1	0	5/31/2014	20:45	23:31	166	MW	None	4.0	73.2	Private

G1	G1_2014	1	0	0	0	0	1	1	0	0	3	0	5/30/2014	20:45	21:47	62	AVH	None	2.8	74.5	Private
G10	G10_2014	0	0	0	0	0	0	0	0	0	0	0	5/30/2014	20:45	23:37	172	AVH	None	1.4	71.2	Private
G11	G11_2014	0	0	0	0	0	0	1	0	0	1	0	5/30/2014	20:45	22:15	90	AVH	None	1.5	70.5	WMA
G2	G2_2014	1	0	0	0	0	1	0	0	0	2	0	5/30/2014	20:45	21:59	74	AVH	None	1.6	75.9	WMA
G3	G3_2014	1	0	1	0	0	1	0	0	0	3	0	5/30/2014	20:45	23:08	143	AVH	None	1.6	71.6	WPA
G4	G4_2014	0	0	0	0	0	0	0	0	0	0	0	5/30/2014	20:45	23:20	155	AVH	None	1.4	69.7	WPA
G5	G5_2014	0	0	0	0	0	0	0	0	0	0	0	5/30/2014	20:45	0:01	196	AVH	None	1.3	70.2	Pit
G6	G6_2014	0	0	0	0	0	1	0	0	0	1	0	5/30/2014	20:45	22:55	130	AVH	None	1.6	70.9	Pit
G7	G7_2014	0	0	0	0	0	1	1	0	0	2	0	5/30/2014	20:45	22:43	118	AVH	None	1.6	71.3	WPA
G8	G8_2014	1	0	0	0	0	0	0	0	0	1	0	5/30/2014	20:45	22:30	105	AVH	None	1.6	72.3	Private
G9	G9_2014	1	0	0	0	0	1	1	0	0	3	0	5/30/2014	20:45	23:48	183	AVH	None	1.3	71.5	WRP
H1	H1_2014	1	0	0	0	0	0	0	0	0	1	0	5/29/2014	20:45	22:41	116	DU	None	3.9	71.3	Private
H10	H10_2014	1	0	0	0	0	0	0	0	0	1	0	5/29/2014	20:45	23:09	144	DU	None	3.5	68.2	WRP
H11	H11_2014	0	0	0	0	0	1	1	0	0	2	0	5/29/2014	20:45	22:11	86	DU	None	5.1	72.0	WRP
H2	H2_2014	1	0	0	0	0	0	0	0	0	1	0	5/29/2014	20:45	22:00	75	DU	None	4.7	72.5	Pit
H3	H3_2014	0	0	0	0	0	0	0	0	0	0	0	5/29/2014	20:45	22:31	106	DU	None	1.0	76.1	Pit
H4	H4_2014	1	0	0	0	0	1	0	0	0	2	0	5/29/2014	20:45	21:38	53	DU	None	4.5	74.2	WMA
H5	H5_2014	0	0	0	0	0	0	0	0	0	0	0	5/29/2014	20:45	21:51	66	DU	None	4.1	72.0	WRP
H6	H6_2014	1	0	0	0	0	0	0	0	0	1	0	5/29/2014	20:45	22:50	125	DU	None	5.3	71.9	WRP
H7	H7_2014	1	0	0	0	0	0	0	0	0	1	0	5/29/2014	20:45	22:20	95	DU	None	5.1	73.0	WRP
H8	H8_2014	0	0	0	0	0	0	0	0	0	0	0	5/29/2014	20:45	22:58	133	DU	None	5.0	71.0	WRP
H9	H9_2014	0	0	0	0	0	1	0	0	0	1	0	5/29/2014	20:45	23:19	154	DU	None	3.2	69.0	WRP
I1	I1_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	0:18	213	WR	None	2.3	69.5	Private
I10	I10_2014	1	0	0	0	0	0	0	0	0	1	0	5/28/2014	20:45	22:56	131	WR	None	3.3	68.6	WPA
I11	I11_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	0:27	222	WR	None	2.3	68.8	WPA

I12	I12_2014	1	0	1	0	0	1	0	0	0	3	0	5/28/2014	20:45	23:06	141	WR	None	1.3	68.5	WPA
I13	I13_2014	1	0	1	0	0	1	1	0	0	4	1	5/28/2014	20:45	23:21	156	WR	None	2.1	71.4	WPA
I14	I14_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:46	181	WR	None	1.4	68.5	WRP
I2	I2_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	0:33	228	WR	None	2.4	67.3	Private
I3	I3_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:55	190	WR	None	1.2	70.7	Private
I4	I4_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:40	115	WR	None	1.8	70.2	Pit
I5	I5_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	0:02	197	WR	None	3.4	68.3	WMA
I6	I6_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:08	83	WR	None	1.1	72.7	WMA
I7	I7_2014	1	0	1	0	0	0	0	0	0	2	0	5/28/2014	20:45	0:09	204	WR	None	2.8	66.8	WPA
I8	I8_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:48	123	WR	None	2.8	69.8	WPA
I9	I9_2014	1	0	0	0	0	1	0	0	0	2	0	5/28/2014	20:45	22:28	103	WR	None	2.3	69.8	WPA
J10	J10_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:55	190	MH	None	2.4	65.5	WPA
J11	J11_2014	1	0	1	0	0	1	1	0	0	4	1	5/28/2014	20:45	0:17	212	NS	None	3.8	71.1	WPA
J12	J12_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:33	168	MH	None	0.0	70.6	WRP
J13	J13_2014	1	0	0	0	0	1	1	0	0	3	0	5/28/2014	20:45	0:54	249	MH	None	2.0	68.0	WRP
J14	J14_2014	1	0	1	0	0	1	1	0	0	4	1	5/28/2014	20:45	1:10	265	MH	None	3.4	68.8	WRP
J2	J2_2014	1	0	1	0	0	1	1	0	0	4	1	5/28/2014	20:45	0:54	249	NS	None	6.2	69.4	Private
J3	J3_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:25	160	MH	None	0.6	71.3	Pit
J4	J4_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	0:04	199	NS	None	4.1	71.0	Pit
J5	J5_2014	1	0	0	0	0	1	1	0	0	3	0	5/28/2014	20:45	0:36	231	NS	None	8.5	71.9	Pit
J6	J6_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	0:36	231	MH	None	2.1	68.5	Pit
J7	J7_2014	0	0	0	0	0	1	0	0	0	1	0	5/28/2014	20:45	0:18	213	MH	None	1.9	70.9	WPA
J8	J8_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	23:44	179	MH	None	1.6	70.7	WPA
J9	J9_2014	0	0	1	0	0	1	0	0	0	2	0	5/28/2014	20:45	0:27	222	MH	None	2.9	67.2	WPA
K1	K1_2014	0	0	0	0	0	0	1	0	0	1	0	5/28/2014	20:45	21:35	50	MH	None	3.0	76.5	Private

K2	K2_2014	0	0	0	0	0	0	1	0	0	1	0	5/28/2014	20:45	22:54	129	MH	None	4.5	72.2	Pit
K3	K3_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:40	115	MH	None	4.3	74.4	Pit
K4	K4_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:30	105	MH	None	3.7	73.8	WMA
K5	K5_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:18	93	MH	None	3.8	74.3	WMA
K6	K6_2014	0	0	1	0	0	1	0	0	0	2	0	5/28/2014	20:45	22:05	80	MH	None	4.2	74.2	WMA
K7	K7_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	22:47	122	MH	None	4.9	72.1	WPA
K8	K8_2014	0	0	0	0	0	0	0	0	0	0	0	5/28/2014	20:45	21:52	67	MH	None	1.4	72.6	WRP

2014
Visit 4

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A1	A1_2014	1	0	1	0	0	1	1	0	0	4	1	6/5/2014	20:45	21:32	47	TL	None	4.4	75.0	Private
A10	A10_2014	1	0	1	0	1	1	1	0	1	6	1	6/5/2014	20:45	23:24	159	TL	None	2.2	69.8	WPA
A11	A11_2014	1	0	1	0	0	0	0	0	0	2	0	6/5/2014	20:45	23:48	183	TL	None	0.8	73.5	WRP
A12	A12_2014	1	0	1	0	0	1	0	0	0	3	0	6/5/2014	20:45	0:06	201	TL	None	1.5	69.7	WRP
A2	A2_2014	1	0	1	0	0	0	0	0	0	2	0	6/5/2014	20:45	21:47	62	TL	None	4.7	73.5	WMA
A3	A3_2014	1	0	1	0	0	1	1	0	0	4	1	6/5/2014	20:45	21:57	72	TL	None	4.1	74.2	Pit
A4	A4_2014	1	0	1	0	0	1	0	0	0	3	0	6/5/2014	20:45	22:11	86	TL	None	4.5	73.6	Pit
A5	A5_2014	1	0	1	0	0	1	1	0	0	4	1	6/5/2014	20:45	22:22	97	TL	None	3.5	72.1	Pit
A6	A6_2014	1	0	1	0	0	1	1	0	0	4	1	6/5/2014	20:45	22:33	108	TL	None	3.2	72.0	Pit
A7	A7_2014	1	1	1	0	0	1	1	0	0	5	1	6/5/2014	20:45	22:46	121	TL	None	2.7	71.7	WMA
A8	A8_2014	1	0	1	0	0	1	1	0	0	4	1	6/5/2014	20:45	23:01	136	TL	None	3.1	70.2	WMA
A9	A9_2014	1	1	1	0	0	1	1	0	0	5	1	6/5/2014	20:45	23:12	147	TL	None	2.9	70.5	WMA
B1	B1_2014	1	0	0	0	0	0	0	0	0	1	0	6/8/2014	20:45	22:53	128	MK	None	5.7	69.4	Private
B10	B10_2014	1	0	0	0	0	0	0	0	0	1	0	6/8/2014	20:45	0:21	216	MK	None	4.7	68.7	WRP
B2	B2_2014	1	0	0	0	0	0	1	0	0	2	0	6/8/2014	20:45	22:42	117	MK	None	5.9	72.0	Private
B3	B3_2014	0	0	0	0	0	0	0	0	0	0	0	6/8/2014	20:45	23:13	148	MK	None	4.6	69.8	Private
B4	B4_2014	1	0	0	0	0	0	0	0	0	1	0	6/8/2014	20:45	23:32	167	MK	None	4.5	69.0	Pit

B5	B5_2014	1	0	1	0	0	0	0	0	0	2	0	6/8/2014	20:45	23:47	182	MK	None	4.3	69.1	Pit
B6	B6_2014	1	0	0	0	0	0	0	0	0	1	0	6/8/2014	20:45	23:21	156	MK	None	4.7	69.9	WMA
B7	B7_2014	1	0	1	0	1	1	1	0	0	5	1	6/8/2014	20:45	22:30	105	MK	None	5.9	72.4	WMA
B8	B8_2014	1	0	1	0	1	0	0	0	0	3	0	6/8/2014	20:45	0:10	205	MK	None	5.0	68.9	WRP
B9	B9_2014	1	0	1	0	0	0	1	0	0	3	0	6/8/2014	20:45	23:59	194	MK	None	4.0	69.0	WRP
C1	C1_2014	1	1	1	0	0	1	1	0	0	5	1	6/4/2014	20:45	20:27	1422	NB	None	0.8	62.6	Private
C10	C10_2014	1	0	0	0	0	1	0	0	0	2	0	6/4/2014	20:45	21:17	32	NA	None	1.1	69.9	WRP
C11	C11_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	21:54	69	NB	None	4.3	70.4	WRP
C12	C12_2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6/4/2014	20:45	NA	NA	NB	None	NA	NA	WRP
C2	C2_2014	0	0	0	0	0	0	0	0	0	0	0	6/4/2014	20:45	20:15	1410	NB	None	1.2	60.9	Private
C3	C3_2014	1	0	0	0	0	1	1	0	0	3	0	6/4/2014	20:45	20:39	1434	NB	None	0.7	67.4	Private
C4	C4_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	23:45	180	NB	None	0.6	68.4	Private
C5	C5_2014	1	0	1	0	0	1	0	0	0	3	0	6/4/2014	20:45	21:22	37	NB	None	2.7	69.8	Private
C6	C6_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	21:26	41	NA	None	1.4	68.8	WMA
C7	C7_2014	0	0	1	0	0	1	0	0	0	2	0	6/4/2014	20:45	20:33	1428	NB	None	1.7	65.7	WMA
C8	C8_2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6/4/2014	20:45	NA	NA	NA	None	NA	NA	WMA
C9	C9_2014	1	0	0	0	0	1	1	0	0	3	0	6/4/2014	20:45	22:05	80	NB	None	1.0	60.9	WRP
D1	D1_2014	1	0	0	0	0	1	1	0	0	3	0	6/10/2014	20:45	21:58	73	NS	None	1.8	70.3	Private
D2	D2_2014	1	0	0	0	0	0	1	0	0	2	0	6/10/2014	20:45	22:21	96	NS	None	1.4	70.0	Pit
D3	D3_2014	1	0	1	0	0	1	1	0	0	4	1	6/10/2014	20:45	21:33	48	NS	None	0.9	71.4	WMA
D4	D4_2014	0	0	1	0	0	0	0	0	0	1	0	6/10/2014	20:45	22:29	104	NS	None	0.7	64.8	WMA
D5	D5_2014	1	0	1	0	0	1	1	0	0	4	1	6/10/2014	20:45	22:57	132	NS	None	1.9	76.1	WMA
D6	D6_2014	1	0	1	0	0	1	1	0	0	4	1	6/10/2014	20:45	22:07	82	NS	None	0.0	73.8	WPA
D7	D7_2014	1	0	0	0	0	0	0	0	0	1	0	6/10/2014	20:45	22:47	122	NS	None	0.0	72.5	WRP
E1	E1_2014	1	0	1	0	0	0	1	0	0	3	0	6/2/2014	20:45	21:28	43	EBB	None	1.0	76.0	Private

E10	E10_2014	1	0	1	0	0	1	1	0	0	4	1	6/2/2014	20:45	22:54	129	EBB	None	1.7	69.2	WPA
E11	E11_2014	1	0	0	0	0	0	0	0	0	1	0	6/2/2014	20:45	21:55	70	EBB	None	1.7	69.0	WPA
E12	E12_2014	1	0	1	0	0	0	0	0	0	2	0	6/2/2014	20:45	23:51	186	EBB	None	1.7	66.6	WRP
E13	E13_2014	1	0	1	0	0	1	0	0	0	3	0	6/2/2014	20:45	22:10	85	EBB	None	1.7	71.4	WRP
E2	E2_2014	1	0	1	0	0	1	0	0	0	3	0	6/2/2014	20:45	0:11	206	EBB	None	0.0	69.2	Pit
E3	E3_2014	1	0	1	0	0	0	0	0	0	2	0	6/2/2014	20:45	22:40	115	EBB	None	1.7	69.4	WMA
E4	E4_2014	0	0	1	0	0	1	0	0	0	2	0	6/2/2014	20:45	22:22	97	EBB	None	2.0	70.2	WMA
E5	E5_2014	1	0	0	0	0	1	0	0	0	2	0	6/2/2014	20:45	21:35	50	EBB	None	2.3	71.8	WMA
E6	E6_2014	0	0	0	0	0	1	0	0	0	1	0	6/2/2014	20:45	0:00	195	EBB	None	1.9	64.8	WPA
E7	E7_2014	1	0	1	0	0	1	0	0	0	3	0	6/2/2014	20:45	22:44	119	EBB	None	2.2	68.2	WPA
E8	E8_2014	1	0	1	0	0	0	0	0	0	2	0	6/2/2014	20:45	23:10	145	EBB	None	2.8	69.6	WPA
E9	E9_2014	1	0	1	0	0	1	0	0	0	3	0	6/2/2014	20:45	23:31	166	EBB	None	0.7	65.8	WPA
F1	F1_2014	0	0	0	0	0	0	0	0	0	0	0	6/7/2014	20:45	21:40	55	MW	None	2.6	61.0	Pit
F10	F10_2014	1	0	0	0	0	1	0	0	0	2	0	6/7/2014	20:45	23:02	137	MW	None	2.4	57.7	WPA
F11	F11_2014	1	0	0	0	0	0	1	0	0	2	0	6/7/2014	20:45	23:30	165	MW	None	1.6	59.0	Private
F12	F12_2014	0	0	1	0	0	0	1	0	0	2	0	6/7/2014	20:45	22:49	124	MW	None	2.8	60.9	Pit
F13	F13_2014	0	0	0	0	0	0	0	0	1	1	0	6/7/2014	20:45	23:39	174	MW	None	1.7	58.6	Pit
F2	F2_2014	1	0	0	0	0	0	1	0	0	2	0	6/7/2014	20:45	21:59	74	MW	None	3.1	60.9	Pit
F3	F3_2014	1	0	0	0	0	1	1	0	0	3	0	6/7/2014	20:45	21:49	64	MW	None	1.9	59.3	WMA
F4	F4_2014	1	0	0	0	0	1	0	0	0	2	0	6/7/2014	20:45	22:10	85	MW	None	4.8	60.7	WMA
F5	F5_2014	1	0	0	0	0	1	1	0	0	3	0	6/7/2014	20:45	22:21	96	MW	None	2.5	59.5	Private
F6	F6_2014	0	0	0	0	0	0	0	0	0	0	0	6/7/2014	20:45	23:09	144	MW	None	1.9	59.0.	Pit
F7	F7_2014	1	0	1	0	0	1	1	0	0	4	1	6/7/2014	20:45	22:41	116	MW	None	3.2	59.5	WMA
F8	F8_2014	0	0	0	0	0	0	0	0	0	0	0	6/7/2014	20:45	22:32	107	MW	None	2.9	59.9	Pit
F9	F9_2014	1	0	0	0	0	0	1	0	0	2	0	6/7/2014	20:45	23:22	157	MW	None	1.6	57.2	Private

G1	G1_2014	1	0	0	0	0	1	1	0	0	3	0	6/10/2014	20:45	22:07	82	AVH	None	1.5	64.5	Private
G10	G10_2014	0	0	0	0	0	0	1	0	0	1	0	6/10/2014	20:45	22:38	113	AVH	None	0.9	67.5	Private
G11	G11_2014	0	0	0	0	0	0	0	0	0	0	0	6/10/2014	20:45	23:52	187	AVH	None	1.2	63.7	WMA
G2	G2_2014	1	0	0	0	0	1	0	0	0	2	0	6/10/2014	20:45	22:21	96	AVH	None	0.9	67.3	WMA
G3	G3_2014	1	0	0	0	0	1	1	0	0	3	0	6/10/2014	20:45	23:24	159	AVH	None	1.3	63.1	WPA
G4	G4_2014	0	0	0	0	0	0	0	0	0	0	0	6/10/2014	20:45	23:36	171	AVH	None	1.2	64.0	WPA
G5	G5_2014	0	0	0	0	0	0	0	0	0	0	0	6/10/2014	20:45	0:13	208	AVH	None	1.1	62.0	Pit
G6	G6_2014	0	0	0	0	0	1	0	0	0	1	0	6/10/2014	20:45	23:12	147	AVH	None	1.3	63.8	Pit
G7	G7_2014	0	0	0	0	0	1	0	0	0	1	0	6/10/2014	20:45	23:00	135	AVH	None	1.2	65.0	WPA
G8	G8_2014	1	0	0	0	0	0	0	0	0	1	0	6/10/2014	20:45	22:49	124	AVH	None	1.2	65.9	Private
G9	G9_2014	1	0	1	0	0	1	1	0	0	4	1	6/10/2014	20:45	0:02	197	AVH	None	1.1	62.6	WRP
H1	H1_2014	1	0	1	0	0	1	0	0	0	3	0	6/5/2014	20:45	23:04	139	NH	None	2.8	71.0	Private
H10	H10_2014	0	0	0	0	0	0	0	0	0	0	0	6/5/2014	20:45	22:35	110	NH	None	0.0	78.3	WRP
H11	H11_2014	1	0	0	0	0	1	1	0	0	3	0	6/5/2014	20:45	22:01	76	NH	None	0.7	74.5	WRP
H2	H2_2014	0	1	1	0	0	0	0	0	0	2	0	6/5/2014	20:45	21:50	65	NH	None	1.2	72.1	Pit
H3	H3_2014	1	0	1	0	0	0	0	0	0	2	0	6/5/2014	20:45	23:15	150	NH	None	0.0	76.1	Pit
H4	H4_2014	1	0	0	1	0	1	0	0	0	3	0	6/5/2014	20:45	21:38	53	NH	None	0.0	74.8	WMA
H5	H5_2014	0	0	0	0	0	0	0	0	0	0	0	6/5/2014	20:45	23:28	163	NH	None	0.0	74.2	WRP
H6	H6_2014	1	0	0	0	0	0	0	0	0	1	0	6/5/2014	20:45	22:53	128	NH	None	1.0	78.8	WRP
H7	H7_2014	0	1	0	0	0	0	0	0	0	1	0	6/5/2014	20:45	22:12	87	NH	None	1.4	70.9	WRP
H8	H8_2014	0	0	0	0	0	0	0	0	0	0	0	6/5/2014	20:45	22:45	120	NH	None	0.0	79.1	WRP
H9	H9_2014	1	0	0	0	0	0	0	0	0	1	0	6/5/2014	20:45	22:25	100	NH	None	0.0	78.4	WRP
I1	I1_2014	0	0	0	0	0	0	0	0	0	0	0	6/4/2014	20:45	23:55	190	WR	None	2.4	64.6	Private
I10	I10_2014	1	0	0	0	0	0	0	0	0	1	0	6/4/2014	20:45	22:46	121	WR	None	3.3	65.3	WPA
I11	I11_2014	0	0	0	0	0	0	0	0	0	0	0	6/4/2014	20:45	0:05	200	WR	None	2.9	65.2	WPA

I12	I12_2014	1	0	0	0	0	0	0	0	0	1	0	6/4/2014	20:45	22:56	131	WR	None	2.2	66.0	WPA
I13	I13_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	23:08	143	WR	None	4.0	65.9	WPA
I14	I14_2014	1	0	1	0	0	0	0	0	0	2	0	6/4/2014	20:45	23:20	155	WR	None	1.2	69.6	WRP
I2	I2_2014	0	0	0	0	0	0	0	0	0	0	0	6/4/2014	20:45	0:12	207	WR	None	0.8	66.0	Private
I3	I3_2014	1	0	1	0	0	0	1	0	0	3	0	6/4/2014	20:45	23:30	165	WR	None	3.4	65.4	Private
I4	I4_2014	1	0	0	0	0	0	0	0	0	1	0	6/4/2014	20:45	22:17	92	WR	None	3.1	67.1	Pit
I5	I5_2014	1	0	0	0	0	0	0	0	0	1	0	6/4/2014	20:45	23:40	175	WR	None	3.2	66.8	WMA
I6	I6_2014	1	0	1	0	0	0	0	0	0	2	0	6/4/2014	20:45	21:50	65	WR	None	2.0	67.1	WMA
I7	I7_2014	0	0	0	0	0	0	0	0	0	0	0	6/4/2014	20:45	23:47	182	WR	None	3.3	65.3	WPA
I8	I8_2014	1	0	0	0	0	1	0	0	0	2	0	6/4/2014	20:45	22:27	102	WR	None	4.6	65.9	WPA
I9	I9_2014	1	0	0	0	0	1	0	0	0	2	0	6/4/2014	20:45	22:09	84	WR	None	2.6	64.9	WPA
J10	J10_2014	1	0	1	0	0	0	0	0	0	2	0	6/4/2014	20:45	0:03	198	MH	None	0.0	65.5	WPA
J11	J11_2014	1	0	1	0	0	1	1	0	0	4	1	6/5/2014	20:45	21:39	54	NS	None	1.3	77.0	WPA
J12	J12_2014	1	1	0	0	0	1	0	0	0	3	0	6/4/2014	20:45	23:41	176	MH	None	2.2	66.2	WRP
J13	J13_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	1:14	269	MH	None	0.0	62.9	WRP
J14	J14_2014	1	1	1	0	0	1	1	0	0	5	1	6/4/2014	20:45	0:57	252	MH	None	2.8	62.8	WRP
J2	J2_2014	1	0	0	0	0	1	1	0	0	3	0	6/5/2014	20:45	22:16	91	NS	None	0.0	75.0	Private
J3	J3_2014	1	0	1	0	0	0	0	0	0	2	0	6/4/2014	20:45	23:30	165	MH	None	1.7	64.6	Pit
J4	J4_2014	1	0	0	0	0	1	1	0	1	4	0	6/5/2014	20:45	21:28	43	NS	None	1.3	78.9	Pit
J5	J5_2014	1	0	0	0	0	0	1	0	0	2	0	6/5/2014	20:45	21:57	72	NS	None	0.0	82.7	Pit
J6	J6_2014	1	0	0	0	0	1	0	0	0	2	0	6/4/2014	20:45	0:45	240	MH	None	2.3	64.0	Pit
J7	J7_2014	1	0	0	0	0	1	1	0	0	3	0	6/4/2014	20:45	0:27	222	MH	None	0.0	61.2	WPA
J8	J8_2014	1	0	1	0	0	0	0	0	0	2	0	6/4/2014	20:45	23:53	188	MH	None	0.0	62.3	WPA
J9	J9_2014	1	0	1	0	0	1	1	0	1	5	1	6/4/2014	20:45	0:37	232	MH	None	1.9	61.0	WPA
K1	K1_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	21:28	43	MH	None	2.4	67.7	Private

K2	K2_2014	1	0	0	0	0	0	0	0	0	1	0	6/4/2014	20:45	22:57	132	MH	None	2.9	65.0	Pit
K3	K3_2014	0	0	0	0	0	0	0	0	0	0	0	6/4/2014	20:45	22:43	118	MH	None	0.4	65.8	Pit
K4	K4_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	22:18	93	MH	None	1.4	65.1	WMA
K5	K5_2014	1	0	0	0	0	0	0	0	0	1	0	6/4/2014	20:45	22:04	79	MH	None	4.1	65.3	WMA
K6	K6_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	21:50	65	MH	None	1.6	66.6	WMA
K7	K7_2014	1	0	1	0	0	1	0	0	0	3	0	6/4/2014	20:45	22:50	125	MH	None	1.5	62.0	WPA
K8	K8_2014	1	0	1	0	0	1	1	0	0	4	1	6/4/2014	20:45	21:39	54	MH	None	2.1	65.7	WRP

2015
Visit 1

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A1	A1_2015	1	0	0	0	0	1	0	0	0	2	0	5/11/2015	20:30	21:08	38	TE	None	4.9	45.2	WRP
A10	A10_2015	1	0	0	0	0	1	0	0	0	2	0	5/11/2015	20:30	23:15	165	TE	None	6.5	43.1	Pit
A11	A11_2015	1	0	0	0	1	0	0	0	0	2	0	5/11/2015	20:30	22:55	145	TE	None	3	41.2	Private
A12	A12_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	21:49	79	TE	None	4	45.6	WPA
A2	A2_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:13	103	TE	None	5	42.5	Pit
A3	A3_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:42	132	TE	None	2.7	42.8	Pit
A4	A4_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	23:24	174	TE	None	2.7	46.6	Pit
A5	A5_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:25	115	TE	None	4.5	44.8	WMA
A6	A6_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	21:22	52	TE	None	4.6	45	WMA
A7	A7_2015	1	0	0	0	0	1	0	0	0	2	0	5/11/2015	20:30	22:01	91	TE	None	5.3	43.3	Private
A8	A8_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	23:06	156	TE	None	3.9	43.2	Pit
A9	A9_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	21:33	63	TE	None	3.5	43.7	WMA
B1	B1_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	22:14	104	Monica	None	3	44.9	WRP
B10	B10_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:55	145	Monica	None	0.6	46.9	WPA
B2	B2_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:22	112	Monica	None	1.7	44.5	WRP
B3	B3_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:05	95	Monica	None	0.9	47.7	WRP
B4	B4_2015	0	0	0	0	0	0	0	0	0	0	0	5/11/2015	20:30	21:49	79	Monica	None	1.975	47.85	Private

B5	B5_2015	0	0	0	0	0	0	0	0	0	0	0	5/11/2015	20:30	22:34	124	Monica	None	1.7	47.66	Pit
B6	B6_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	21:54	84	Monica	None	3	47.9	Pit
B7	B7_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:42	132	Monica	None	0.8	46.9	WMA
B8	B8_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	23:09	159	Monica	None	3.2	47.1	WMA
B9	B9_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	23:22	172	Monica	None	0.9	49.5	WMA
C1	C1_2015	0	0	0	0	0	0	0	0	0	0	0	5/12/2015	NA	NA	NA	DU	None	NA	NA	Private
C10	C10_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	23:59	209	DU	None	6.7	53.4	WPA
C11	C11_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	22:53	143	DU	None	7.2	54.3	Private
C12	C12_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	23:36	186	DU	None	5.4	52.4	WRP
C2	C2_2015	0	0	0	0	0	0	0	0	0	0	0	5/12/2015	20:30	23:00	150	DU	None	NA	NA	Pit
C3	C3_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	22:26	116	DU	None	4.6	52.7	Pit
C4	C4_2015	1	0	1	0	0	0	0	0	0	2	0	5/12/2015	20:30	21:54	84	DU	None	7.8	58.6	Private
C5	C5_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	23:23	173	DU	None	7.3	55.1	WMA
C6	C6_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	23:47	197	DU	None	5.9	51.8	WPA
C7	C7_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	21:19	49	DU	None	5.8	58.3	WPA
C8	C8_2015	1	0	1	0	0	1	1	0	0	4	1	5/12/2015	20:30	21:36	66	DU	None	4.7	55.4	Pit
C9	C9_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	22:44	134	DU	None	6.7	53.5	Pit
D1	D1_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	23:50	200	NL	None	3.4	58.7	Private
D2	D2_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	23:05	155	NL	None	4.4	60.9	Pit
D3	D3_2015	1	0	0	0	0	1	0	0	0	2	0	5/14/2015	20:30	0:10	220	NL	None	3.9	59.4	Pit
D4	D4_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	22:50	140	NL	None	1.9	61.5	WMA
D5	D5_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	21:35	65	NL	None	2	66.2	WMA
D6	D6_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	23:20	170	NL	None	2.7	59.3	WRP
D7	D7_2015	1	0	0	0	0	0	1	0	0	2	0	5/14/2015	20:30	22:20	110	NL	None	2.9	63.7	WRP
E1	E1_2015	1	0	1	0	0	0	1	0	0	3	0	5/12/2015	20:30	21:05	35	BW	None	5.9	60.1	Private

E10	E10_2015	1	0	0	0	0	1	1	0	0	3	0	5/12/2015	20:30	22:58	148	BW	None	4.5	51.9	WRP
E11	E11_2015	1	0	1	0	0	0	0	0	0	2	0	5/12/2015	20:30	21:41	71	BW	None	4.3	57.1	WRP
E12	E12_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	23:32	182	BW	None	7.5	53	WRP
E13	E13_2015	1	0	1	0	0	1	0	0	0	3	0	5/12/2015	20:30	22:11	101	BW	None	4.5	55.9	WRP
E2	E2_2015	0	0	0	0	0	0	0	0	0	0	0	5/12/2015	20:30	23:52	202	MH	None	7	53.8	WMA
E3	E3_2015	1	0	1	0	0	0	1	0	0	3	0	5/12/2015	20:30	22:36	126	BW	None	3.7	59.8	Private
E4	E4_2015	1	0	1	0	0	1	1	0	0	4	1	5/12/2015	20:30	22:23	113	BW	None	6.7	57.1	Pit
E5	E5_2015	1	0	1	0	0	0	1	0	0	3	0	5/12/2015	20:30	21:16	46	BW	None	6.3	58.4	Pit
E6	E6_2015	1	0	1	0	0	1	1	0	0	4	1	5/12/2015	20:30	23:38	188	MH	None	4	53.6	WMA
E7	E7_2015	1	0	1	0	0	1	1	0	0	4	1	5/12/2015	20:30	22:49	139	BW	None	4.1	53.4	WRP
E8	E8_2015	1	0	0	0	0	1	1	0	0	3	0	5/12/2015	20:30	23:13	163	BW	None	4.2	55.1	WRP
E9	E9_2015	1	0	1	0	0	1	1	0	0	4	1	5/12/2015	20:30	23:46	196	BW	None	7.2	52.9	WRP
F1	F1_2015	0	1	0	0	1	0	0	0	0	2	0	5/12/2017	20:30	22:54	144	JF	None	6.7	54.9	Private
F10	F10_2015	1	1	0	1	0	0	1	0	0	4	0	5/12/2017	20:30	21:26	56	JF	None	4.5	59	WPA
F11	F11_2015	1	1	1	0	1	0	0	0	0	4	0	5/12/2017	20:30	21:08	38	JF	None	8.5	59	WPA
F12	F12_2015	1	1	0	0	0	1	0	0	0	3	0	5/12/2017	20:30	21:48	78	JF	None	5.1	53.5	WPA
F13	F13_2015	0	0	0	0	0	0	0	0	0	0	0	5/12/2017	20:30	21:16	46	JF	None	12.1	59	WPA
F2	F2_2015	0	0	0	0	0	0	0	0	0	0	0	5/12/2017	20:30	22:36	126	JF	None	4.7	52.3	Private
F3	F3_2015	1	1	1	1	0	0	0	0	0	4	0	5/12/2017	20:30	22:43	133	JF	None	7.8	53.1	Private
F4	F4_2015	1	1	1	0	1	0	1	0	0	5	0	5/12/2017	20:30	22:25	115	JF	None	4	53.9	Pit
F5	F5_2015	1	1	1	0	0	0	0	0	0	3	0	5/12/2017	20:30	22:14	104	JF	None	3.2	53.6	WMA
F6	F6_2015	1	1	0	0	0	0	0	0	0	2	0	5/12/2017	20:30	21:33	63	JF	None	4.2	59	WMA
F7	F7_2015	1	1	1	0	0	1	0	0	0	4	0	5/12/2017	20:30	21:55	85	JF	None	4.3	53.5	WPA
F8	F8_2015	1	1	1	0	0	0	0	0	0	3	0	5/12/2017	20:30	22:05	95	JF	None	3.7	53	WPA
F9	F9_2015	1	0	1	0	0	1	0	0	0	3	0	5/12/2017	20:30	21:00	30	JF	None	2.3	60	WPA

G1	G1_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	WRP
G10	G10_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	WPA
G11	G11_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	WPA
G2	G2_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	Private
G3	G3_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	Pit
G4	G4_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	Pit
G5	G5_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	Pit
G6	G6_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	Pit
G7	G7_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	WPA
G8	G8_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	WPA
G9	G9_2015	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	5/12/2017	NA	NA	NA	NA	NA	NA	NA	WPA
H1	H1_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	21:05	35	MH	None	5	57.8	WRP
H10	H10_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	21:34	64	MH	None	2.4	55	WRP
H11	H11_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	21:57	87	MH	None	2.9	57.2	WRP
H2	H2_2015	0	0	0	0	0	0	0	0	0	0	0	5/12/2015	20:30	22:31	121	MH	None	3.5	54.3	Private
H3	H3_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	22:17	107	MH	None	NA	NA	Private
H4	H4_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	22:58	148	MH	None	6	54	Private
H5	H5_2015	1	0	1	0	0	1	0	0	0	3	0	5/12/2015	20:30	22:48	138	MH	None	3.5	52.7	Private
H6	H6_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	21:14	44	MH	None	3.6	58.6	Private
H7	H7_2015	1	0	0	0	0	1	0	0	0	2	0	5/12/2015	20:30	22:06	96	MH	None	4.2	54.7	WMA
H8	H8_2015	1	0	0	0	0	0	0	0	0	1	0	5/12/2015	20:30	21:23	53	MH	None	2.8	57.1	WMA
H9	H9_2015	1	0	1	0	0	1	1	0	0	4	1	5/12/2015	20:30	21:45	75	MH	None	3.6	55.2	WMA
I1	I1_2015	1	0	1	0	0	1	1	0	0	4	1	5/14/2015	20:30	23:46	196	NB	None	1.5	59.7	Private
I10	I10_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	22:04	94	NB	None	2.3	65.1	WPA
I11	I11_2015	1	0	1	0	0	1	1	0	0	4	1	5/14/2015	20:30	0:00	210	NB	None	4.7	59.9	WRP

I12	I12_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	22:16	106	NB	None	2.1	59	WRP
I13	I13_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	22:46	136	NB	None	1.2	64.9	Private
I14	I14_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	22:33	123	NB	None	2.1	59.1	Private
I2	I2_2015	1	0	1	0	0	1	1	0	0	4	1	5/14/2015	20:30	0:15	225	NB	None	3.8	60.5	WMA
I3	I3_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	23:03	153	NB	None	4.1	58.6	Pit
I4	I4_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	21:42	72	NB	None	0	61.9	Pit
I5	I5_2015	1	0	1	0	0	1	1	0	0	4	1	5/14/2015	20:30	23:19	169	NB	None	1.5	60.5	Pit
I6	I6_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	21:13	43	NB	None	2.8	64.4	Pit
I7	I7_2015	1	0	1	0	0	1	1	0	0	4	1	5/14/2015	20:30	23:34	184	NB	None	2.5	59.7	WMA
I8	I8_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	21:53	83	NB	None	4.8	61.4	WMA
I9	I9_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	21:33	63	NB	None	4.4	60.8	WMA
J10	J10_2015	0	0	0	0	0	0	0	0	0	0	0	5/11/2015	20:30	0:22	232	BW&MH	None	2.9	42.2	WRP
J11	J11_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	21:22	52	BW&MH	None	0	46.2	Private
J12	J12_2015	0	0	0	0	0	0	0	0	0	0	0	5/11/2015	20:30	1:03	273	BW&MH	None	4.2	41.5	Pit
J13	J13_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	23:48	198	BW&MH	None	2	42.5	WMA
J14	J14_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	22:34	124	BW&MH	None	2.2	43.7	WRP
J2	J2_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	22:07	97	BW&MH	None	2.3	43.9	WRP
J3	J3_2015	0	0	0	0	0	0	0	0	0	0	0	5/11/2015	20:30	1:14	284	BW&MH	None	1.7	42	WRP
J4	J4_2015	0	0	0	0	0	0	0	0	0	0	0	5/11/2015	20:30	21:06	36	BW&MH	None	3	44.6	Private
J5	J5_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	21:40	70	BW&MH	None	2.5	42.3	Pit
J6	J6_2015	1	0	0	0	0	0	0	0	0	1	0	5/11/2015	20:30	22:53	143	BW&MH	None	1.5	44	WMA
J7	J7_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	23:17	167	BW&MH	None	2.3	44.4	WMA
J8	J8_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	0:41	251	BW&MH	None	2.7	43.8	WMA
J9	J9_2015	1	0	0	0	0	0	1	0	0	2	0	5/11/2015	20:30	23:03	153	BW&MH	None	2	46	WPA
K1	K1_2015	1	0	1	0	0	1	1	0	0	4	1	5/14/2015	20:30	21:05	35	EBB	None	1.4	64.5	WMA

K2	K2_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	22:35	125	EBB	None	4	60.1	WMA
K3	K3_2015	1	0	1	0	0	0	0	0	0	2	0	5/14/2015	20:30	22:22	112	EBB	None	3.5	63.4	WPA
K4	K4_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	5/14/2015		NA		EBB	NA	NA	NA	WPA
K5	K5_2015	1	0	1	0	0	1	0	0	0	3	0	5/14/2015	20:30	21:44	74	EBB	None	1	63.5	WPA
K6	K6_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	5/14/2015		NA		EBB	NA	NA	NA	WPA
K7	K7_2015	1	0	1	1	0	1	1	0	0	5	1	5/14/2015	20:30	22:45	135	EBB	None	4.4	62.9	WPA
K8	K8_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	5/14/2015		NA		EBB	NA	NA	NA	WPA

2015
Visit 2

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A1	A1_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	22:02	92	TE	None	1.3	63.2	WRP
A10	A10_2015	1	0	1	0	0	1	0	0	0	3	0	5/21/2015	20:30	23:27	177	TE	None	4.1	57.6	Pit
A11	A11_2015	1	0	1	0	0	1	0	0	0	3	0	5/21/2015	20:30	23:09	159	TE	None	1.8	55.9	Private
A12	A12_2015	1	0	1	0	0	0	0	0	0	2	0	5/21/2015	20:30	22:12	102	TE	None	1.4	66.9	WPA
A2	A2_2015	1	0	1	0	0	0	1	0	0	3	0	5/21/2015	20:30	22:37	127	TE	None	0	69.4	Pit
A3	A3_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	22:59	149	TE	None	3	54.5	Pit
A4	A4_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	23:33	183	TE	None	3.5	53.4	Pit
A5	A5_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	22:46	136	TE	None	0.6	54.2	WMA
A6	A6_2015	1	0	1	0	0	0	0	0	0	2	0	5/21/2015	20:30	21:50	80	TE	None	1.6	58.9	WMA
A7	A7_2015	1	0	1	0	0	0	1	0	0	3	0	5/21/2015	20:30	22:27	117	TE	None	0.7	63.6	Private
A8	A8_2015	1	0	0	0	0	1	1	0	0	3	0	5/21/2015	20:30	23:19	169	TE	None	1.4	58.7	Pit
A9	A9_2015	1	0	0	0	0	1	1	0	0	3	0	5/21/2015	20:30	21:37	67	TE	None	1	67.7	WMA
B1	B1_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	22:25	115	Monica	None	3	55.4	WRP
B10	B10_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:18	168	Monica	None	3.8	58.7	WPA
B2	B2_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	22:31	121	Monica	None	1.5	58.8	WRP
B3	B3_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	22:15	105	Monica	None	1.1	60.2	WRP
B4	B4_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	21:47	77	Monica	None	1.4	54.4	Private

B5	B5_2015	0	0	0	0	0	0	0	0	0	0	0	5/18/2015	20:30	22:37	127	Monica	None	NA	NA	Pit
B6	B6_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	21:57	87	Monica	None	4	55	Pit
B7	B7_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	23:02	152	Monica	None	2.7	58.6	WMA
B8	B8_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:26	176	Monica	None	6.1	52.4	WMA
B9	B9_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	23:43	193	Monica	None	3.7	52.2	WMA
C1	C1_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/21/2015	20:30	NA	NA	DU	NA	NA	NA	Private
C10	C10_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	0:19	229	DU	None	3.4	52.4	WPA
C11	C11_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	23:09	159	DU	None	0	63.1	Private
C12	C12_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	23:48	198	DU	None	1.7	50.8	WRP
C2	C2_2015	0	0	0	0	0	0	0	0	0	0	0	5/21/2015	20:30	23:22	172	DU	None	1.9	56.2	Pit
C3	C3_2015	1	0	0	0	0	1	1	0	0	3	0	5/21/2015	20:30	22:46	136	DU	None	1	66.8	Pit
C4	C4_2015	1	0	1	0	0	0	0	0	0	2	0	5/21/2015	20:30	22:19	109	DU	None	0	68.9	Private
C5	C5_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	23:36	186	DU	None	2.8	53.5	WMA
C6	C6_2015	1	0	0	0	0	0	1	0	0	2	0	5/21/2015	20:30	0:00	210	DU	None	4.1	52.2	WPA
C7	C7_2015	1	0	0	0	0	1	0	0	0	2	0	5/21/2015	20:30	21:39	69	DU	None	1.1	69.5	WPA
C8	C8_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	22:01	91	DU	None	1	63.4	Pit
C9	C9_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	23:02	152	DU	None	2	59.5	Pit
D1	D1_2015	0	0	0	0	0	0	0	0	0	0	0	5/21/2015	20:30	23:13	163	NL	None	0	52.3	Private
D2	D2_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	22:38	128	NL	None	2	52.9	Pit
D3	D3_2015	0	0	0	0	0	0	0	0	0	0	0	5/21/2015	20:30	23:40	190	NL	None	1.9	50.7	Pit
D4	D4_2015	1	0	0	0	0	0	1	0	0	2	0	5/21/2015	20:30	22:17	107	NL	None	0	56.3	WMA
D5	D5_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	21:17	47	NL	None	0.6	60.8	WMA
D6	D6_2015	1	0	0	0	0	0	1	0	0	2	0	5/21/2015	20:30	22:57	147	NL	None	0	54.9	WRP
D7	D7_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	21:52	82	NL	None	1.6	56.8	WRP
E1	E1_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	21:15	45	BW	None	2.1	48.1	Private

E10	E10_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	23:31	181	BW	None	1.8	46.5	WRP
E11	E11_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	22:11	101	BW	None	2.8	47.8	WRP
E12	E12_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	0:01	211	BW	None	0	44.6	WRP
E13	E13_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	22:36	126	BW	None	2.2	48.4	WRP
E2	E2_2015	0	0	0	0	0	0	0	0	0	0	0	5/20/2015	20:30	12:18	948	MH	None	1.3	43.6	WMA
E3	E3_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	23:01	151	BW	None	1.3	47.1	Private
E4	E4_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	22:48	138	BW	None	0.8	47	Pit
E5	E5_2015	1	~	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	21:30	60	BW	None	2.3	48.2	Pit
E6	E6_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	0:34	244	BW	None	1.3	46.3	WMA
E7	E7_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	23:16	166	BW	None	0	45.9	WRP
E8	E8_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/20/2015	20:30	NA	NA	BW	NA	NA	NA	WRP
E9	E9_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/20/2015	20:30	NA	NA	BW	NA	NA	NA	WRP
F1	F1_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2017	20:30	22:50	140	JF	None	2.3	56.1	Private
F10	F10_2015	1	0	1	0	0	0	1	0	0	3	0	5/18/2017	20:30	21:38	68	JF	None	4.3	57.3	WPA
F11	F11_2015	1	0	1	0	0	0	0	0	0	2	0	5/18/2017	20:30	21:19	49	JF	None	3.2	57.6	WPA
F12	F12_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2017	20:30	21:55	85	JF	None	3.6	56.5	WPA
F13	F13_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2017	20:30	21:29	59	JF	None	1.6	57.3	WPA
F2	F2_2015	1	1	0	0	0	0	0	0	0	2	0	5/18/2017	20:30	22:35	125	JF	None	1	56.3	Private
F3	F3_2015	1	1	1	0	0	1	0	0	0	4	0	5/18/2017	20:30	22:43	133	JF	None	2	54.2	Private
F4	F4_2015	1	0	1	0	0	0	1	0	0	4	0	5/18/2017	20:30	22:28	118	JF	None	0.8	54.1	Pit
F5	F5_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2017	20:30	22:19	109	JF	None	1.1	56.1	WMA
F6	F6_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2017	20:30	21:45	75	JF	None	3.6	56.5	WMA
F7	F7_2015	1	0	0	0	0	1	1	0	0	4	0	5/18/2017	20:30	22:05	95	JF	None	1.6	57.6	WPA
F8	F8_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2017	20:30	22:11	101	JF	None	1.1	56.3	WPA
F9	F9_2015	1	0	1	0	0	0	0	0	0	2	0	5/18/2017	20:30	21:10	40	JF	None	4.5	57.9	WPA

G1	G1_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	22:17	107	AE	None	2	49	WRP
G10	G10_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	0:10	220	AE	None	3.3	45	WPA
G11	G11_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:30	180	AE	None	3.3	48	WPA
G2	G2_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	22:30	120	AE	None	1.3	49	Private
G3	G3_2015	1	0	0	0	0	1	1	0	0	3	0	5/18/2015	20:30	22:45	135	AE	None	3.6	49	Pit
G4	G4_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	22:55	145	AE	None	3.6	49	Pit
G5	G5_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:10	160	AE	None	3.7	49	Pit
G6	G6_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:40	190	AE	None	3.3	48	Pit
G7	G7_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:50	200	AE	None	3.2	46	WPA
G8	G8_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	0:00	210	AE	None	3.2	45	WPA
G9	G9_2015	1	0	0	0	0	1	1	0	0	3	0	5/18/2015	20:30	23:20	170	AE	None	3.7	49	WPA
H1	H1_2015	0	0	0	0	0	0	0	0	0	0	0	5/20/2015	20:30	23:07	157	MH	None	0	48.1	WRP
H10	H10_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	22:34	124	MH	None	0	49	WRP
H11	H11_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	21:52	82	MH	None	0	54	WRP
H2	H2_2015	0	0	0	0	0	0	0	0	0	0	0	5/20/2015	20:30	21:39	69	MH	None	1.3	50.3	Private
H3	H3_2015	0	0	0	0	0	0	0	0	0	0	0	5/20/2015	20:30	22:10	100	MH	None	0	51.5	Private
H4	H4_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	21:12	42	MH	None	2	47.8	Private
H5	H5_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	21:31	61	MH	None	1.7	48.3	Private
H6	H6_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	22:56	146	MH	None		54.5	Private
H7	H7_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	21:59	89	MH	None	2.1	47.5	WMA
H8	H8_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	22:46	136	MH	None	0	54.8	WMA
H9	H9_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	22:24	114	MH	None	2.4	47.3	WMA
I1	I1_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:30	180	NB	None	4.3	49.9	Private
I10	I10_2015	1	0	1	0	0	1	1	0	0	4	1	5/18/2015	20:30	22:05	95	NB	None	0.7	56.7	WPA
I11	I11_2015	1	0	0	0	0	0	0	0	0	1	0	5/18/2015	20:30	23:43	193	NB	None	2.6	48.7	WRP

I12	I12_2015	1	0	0	0	0	1	1	0	0	3	0	5/18/2015	20:30	22:18	108	NB	None	1	51.1	WRP
I13	I13_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	22:43	133	NB	None	0	55.2	Private
I14	I14_2015	1	0	0	0	0	1	0	0	0	2	0	5/18/2015	20:30	22:32	122	NB	None	2.1	54.4	Private
I2	I2_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	23:52	202	NB	None	2	49.7	WMA
I3	I3_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	22:56	146	NB	None	2.1	56.1	Pit
I4	I4_2015	1	0	0	0	0	1	1	0	0	3	0	5/18/2015	20:30	21:44	74	NB	None	1.1	51.1	Pit
I5	I5_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	23:08	158	NB	None	3	48.3	Pit
I6	I6_2015	1	0	1	0	0	1	1	0	0	4	1	5/18/2015	20:30	21:15	45	NB	None	NA	NA	Pit
I7	I7_2015	1	0	0	0	0	0	1	0	0	2	0	5/18/2015	20:30	23:18	168	NB	None	4.9	47.1	WMA
I8	I8_2015	1	0	0	0	0	1	0	0	0	2	0	5/18/2015	20:30	21:53	83	NB	None	1.3	50.7	WMA
I9	I9_2015	1	1	0	0	0	1	1	0	0	4	0	5/18/2015	20:30	21:33	63	NB	None	1.6	54	WMA
J10	J10_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	12:02	932	MH	None	1.4	45.4	WRP
J11	J11_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	21:58	88	BW	None	2.3	52.8	Private
J12	J12_2015	1	0	0	0	0	0	0	0	0	1	0	5/20/2015	20:30	23:31	181	MH	None	1.9	48.5	Pit
J13	J13_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	23:53	203	BW	None	1.2	52.3	WMA
J14	J14_2015	1	0	0	0	0	1	1	0	0	3	0	5/21/2015	20:30	22:47	137	BW	None	0	53.4	WRP
J2	J2_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	22:17	107	BW	None	1.8	56.6	WRP
J3	J3_2015	0	0	0	0	0	0	0	0	0	0	0	5/20/2015	20:30	23:19	169	MH	None	0	48.4	WRP
J4	J4_2015	0	0	1	0	0	0	0	0	1	2	0	5/21/2015	20:30	21:17	47	BW	None	2.8	59	Private
J5	J5_2015	0	0	0	0	0	0	0	0	0	0	0	5/21/2015	20:30	21:47	77	BW	None	1.9	56.2	Pit
J6	J6_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	23:04	154	BW	None	0	52.8	WMA
J7	J7_2015	1	0	0	0	0	1	0	0	0	2	0	5/21/2015	20:30	23:30	180	BW	None	0	54	WMA
J8	J8_2015	1	0	0	0	0	0	1	0	0	2	0	5/20/2015	20:30	23:48	198	MH	None	0.6	54.5	WMA
J9	J9_2015	1	0	0	0	0	1	1	0	0	3	0	5/21/2015	20:30	23:16	166	BW	None	0	53	WPA
K1	K1_2015	1	0	0	0	0	1	0	0	0	2	0	5/21/2015	20:30	21:05	35	EBB & TM	None	1.4	57.4	WMA

K2	K2_2015	1	0	0	0	0	0	1	0	0	2	0	5/21/2015	20:30	20:46	16	EBB & TM	None	0.8	56.8	WMA
K3	K3_2015	1	0	0	0	0	0	0	0	0	1	0	5/21/2015	20:30	22:50	140	EBB & TM	None	2.8	53.5	WPA
K4	K4_2015	1	0	0	0	0	1	0	0	0	2	0	5/21/2015	20:30	22:05	95	EBB & TM	None	2.2	53.1	WPA
K5	K5_2015	1	0	0	0	0	1	0	0	0	2	0	5/21/2015	20:30	21:56	86	EBB & TM	None	2.5	55.3	WPA
K6	K6_2015	1	0	1	0	0	1	0	0	0	3	0	5/21/2015	20:30	21:37	67	EBB & TM	None	2.3	54.7	WPA
K7	K7_2015	1	0	1	0	0	1	1	0	0	4	1	5/21/2015	20:30	23:00	150	EBB & TM	None	2.3	50.8	WPA
K8	K8_2015	1	0	1	0	0	0	0	0	0	2	0	5/21/2015	20:30	21:27	57	EBB & TM	None	2.8	62.2	WPA

2015
Visit 3

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A_1	A1_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	21:36	51	TE	None	4.2	68.3	WRP
A_10	A10_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	23:18	153	TE	None	4.2	68.4	Pit
A_11	A11_2015	1	0	0	0	0	1	0	0	0	2	0	5/27/2015	20:45	23:03	138	TE	None	2.7	66.4	Private
A_12	A12_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	22:08	83	TE	None	2.7	67.5	WPA
A_2	A2_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:27	102	TE	None	6.9	68.1	Pit
A_3	A3_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:50	125	TE	None	4	67.3	Pit
A_4	A4_2015	1	0	1	0	0	0	0	0	0	2	0	5/27/2015	20:45	23:25	160	TE	None	3.1	66.6	Pit
A_5	A5_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	22:19	94	TE	None	4.9	67.6	WMA
A_6	A6_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	21:47	62	TE	None	3.4	74	WMA
A_7	A7_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	22:33	108	TE	None	3.4	67.3	Private
A_8	A8_2015	1	0	1	0	0	1	1	0	0	4	1	5/27/2015	20:45	22:57	132	TE	None	5.2	69.8	Pit
A_9	A9_2015	1	0	0	0	0	1	0	0	0	2	0	5/27/2015	20:45	21:58	73	TE	None	4.5	69.6	WMA
B_1	B1_2015	1	0	0	0	0	0	0	0	0	1	0	5/25/2015	20:45	0:17	212	Monica	None	1.6	62.4	WRP
B_10	B10_2015	1	0	1	0	1	0	1	0	0	4	0	5/25/2015	20:45	23:42	177	Monica	None	2.1	62.3	WPA
B_2	B2_2015	1	0	0	0	0	0	1	0	0	2	0	5/25/2015	20:45	23:17	152	Monica	None	2.8	67.2	WRP
B_3	B3_2015	1	0	0	0	0	0	1	0	0	2	0	5/25/2015	20:45	23:07	142	Monica	None	3.1	69.1	WRP
B_4	B4_2015	0	0	0	0	0	0	0	0	0	0	0	5/25/2015	20:45	22:52	127	Monica	None	NA	NA	Private

B_5	B5_2015	0	0	0	0	0	0	0	0	0	0	0	5/25/2015	20:45	0:09	204	Monica	None	2.1	62.9	Pit
B_6	B6_2015	1	0	0	0	0	0	1	0	0	2	0	5/25/2015	20:45	22:41	116	Monica	None	3.4	69.1	Pit
B_7	B7_2015	1	0	1	0	0	0	1	0	0	3	0	5/25/2015	20:45	23:29	164	Monica	None	2.4	65	WMA
B_8	B8_2015	1	0	0	0	1	0	1	0	0	3	0	5/25/2015	20:45	23:56	191	Monica	None	1.7	63.1	WMA
B_9	B9_2015	1	0	0	0	1	0	0	0	0	2	0	5/25/2015	20:45	22:32	107	Monica	None	3.8	69.4	WMA
C_1	C1_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	NA	NA	DU	None	NA	NA	Private
C_10	C10_2015	0	0	0	0	0	1	0	0	0	1	0	5/26/2015	20:45	23:39	174	DU	None	4.6	56.2	WPA
C_11	C11_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	22:55	130	Du	None	2.4	56.1	Private
C_12	C12_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	23:18	153	DU	None	3.4	58.6	WRP
C_2	C2_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	23:00	135	DU	None	NA	NA	Pit
C_3	C3_2015	0	0	0	0	0	1	1	0	0	2	0	5/26/2015	20:45	22:34	109	DU	None	3.7	63.1	Pit
C_4	C4_2015	1	0	0	0	0	0	0	0	0	1	0	5/26/2015	20:45	22:05	80	DU	None	2	66.4	Private
C_5	C5_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	23:07	142	DU	None	3.8	55.6	WMA
C_6	C6_2015	0	0	0	0	0	1	1	0	0	2	0	5/26/2015	20:45	23:27	162	DU	None	2.4	57.6	WPA
C_7	C7_2015	1	0	1	0	0	1	0	0	0	3	0	5/26/2015	20:45	21:34	49	DU	None	3	63.1	WPA
C_8	C8_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:48	63	DU	None	2.5	58.1	Pit
C_9	C9_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	22:48	123	DU	None	4	58.4	Pit
D_1	D1_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:05	80	MH	None	2	67.6	Private
D_2	D2_2015	0	0	0	0	0	0	0	0	0	0	0	5/27/2015	20:45	21:33	48	MH	None	3.7	68.9	Pit
D_3	D3_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	22:29	104	MH	None	1.4	67.9	Pit
D_4	D4_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	21:22	37	MH	None	3.2	68.9	WMA
D_5	D5_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	23:15	150	MH	None	0	69	WMA
D_6	D6_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	21:51	66	MH	None	0	68.2	WRP
D_7	D7_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/27/2015	20:45	NA	NA	MH	NA	NA	NA	WRP
E_1	E1_2015	1	0	1	0	1	1	1	0	0	5	1	5/26/2015	20:45	21:18	33	BW	None	1	62.3	Private

E_10	E10_2015	1	0	1	0	0	1	1	0	0	4	1	5/26/2015	20:45	23:26	161	BW	None	1.7	58.6	WRP
E_11	E11_2015	1	0	1	0	0	0	1	0	0	3	0	5/26/2015	20:45	21:51	66	BW	None	0.7	63.1	WRP
E_12	E12_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	23:55	190	BW	None	3.4	55.4	WRP
E_13	E13_2015	1	0	1	0	1	1	1	0	0	5	1	5/26/2015	20:45	22:11	86	BW	None	1.8	60.6	WRP
E_2	E2_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	0:17	212	MH	None	3.2	57.2	WMA
E_3	E3_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	23:07	142	BW	None	1.3	60.5	Private
E_4	E4_2015	1	0	1	0	1	1	1	0	0	5	1	5/26/2015	20:45	22:58	133	BW	None	2	60	Pit
E_5	E5_2015	1	0	1	0	0	1	1	0	0	4	1	5/26/2015	20:45	21:31	46	BW	None	0	61.3	Pit
E_6	E6_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	0:21	216	BW	None	2.4	57.1	WMA
E_7	E7_2015	1	0	1	0	0	1	1	0	0	4	1	5/26/2015	20:45	23:18	153	BW	None	2.3	58.4	WRP
E_8	E8_2015	1	0	1	0	0	1	1	0	0	4	1	5/26/2015	20:45	23:38	173	BW	None	1.8	54.3	WRP
E_9	E9_2015	1	0	1	0	0	1	1	0	0	4	1	5/26/2015	20:45	0:07	202	BW	None	5.4	56.2	WRP
F_1	F1_2015	1	0	1	0	0	0	0	0	0	2	0	5/26/2017	20:45	23:04	139	JF	None	1.5	57.1	Private
F_10	F10_2015	1	1	1	0	0	0	1	0	0	4	0	5/26/2017	20:45	21:50	65	JF	None	2.2	66.3	WPA
F_11	F11_2015	1	1	1	0	0	0	0	0	0	3	0	5/26/2017	20:45	21:29	44	JF	None	2.3	66.5	WPA
F_12	F12_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2017	20:45	22:12	87	JF	None	1.3	61.3	WPA
F_13	F13_2015	1	1	0	0	0	0	0	0	0	2	0	5/26/2017	20:45	21:39	54	JF	None	2.3	66.5	WPA
F_2	F2_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2017	20:45	22:49	124	JF	None	1	57.9	Private
F_3	F3_2015	1	0	1	0	0	0	1	0	0	3	0	5/26/2017	20:45	22:57	132	JF	None	1.5	57.1	Private
F_4	F4_2015	1	0	1	0	0	0	0	0	0	2	0	5/26/2017	20:45	22:41	116	JF	None	0.9	57.9	Pit
F_5	F5_2015	1	0	1	0	0	0	1	0	0	3	0	5/26/2017	20:45	22:34	109	JF	None	2.1	58.5	WMA
F_6	F6_2015	1	0	0	0	0	0	0	0	0	1	0	5/26/2017	20:45	21:57	72	JF	None	0.02	61.4	WMA
F_7	F7_2015	1	1	1	0	0	0	1	0	0	4	0	5/26/2017	20:45	22:19	94	JF	None	0.6	60.8	WPA
F_8	F8_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2017	20:45	22:27	102	JF	None	0.6	59.5	WPA
F_9	F9_2015	1	0	0	0	0	0	0	0	0	1	0	5/26/2017	20:45	21:20	35	JF	None	1.3	67.1	WPA

G_1	G1_2015	1	0	0	0	0	0	0	0	1	2	0	5/27/2015	20:45	21:15	30	AE	None	2.9	70	WRP
G_10	G10_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:55	130	AE	None	1.2	65	WPA
G_11	G11_2015	1	0	1	0	0	0	0	0	0	2	0	5/27/2015	20:45	22:15	90	AE	None	2.1	67	WPA
G_2	G2_2015	0	0	0	0	0	0	0	0	1	1	0	5/27/2015	20:45	21:25	40	AE	None	2.9	69	Private
G_3	G3_2015	1	0	1	0	0	0	0	0	0	2	0	5/27/2015	20:45	21:35	50	AE	None	3	68	Pit
G_4	G4_2015	1	0	1	0	0	0	0	0	0	2	0	5/27/2015	20:45	21:45	60	AE	None	0.8	68	Pit
G_5	G5_2015	0	0	0	0	0	0	0	0	0	0	0	5/27/2015	20:45	21:55	70	AE	None	1	68	Pit
G_6	G6_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:25	100	AE	None	1.4	67	Pit
G_7	G7_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:35	110	AE	None	1.5	66	WPA
G_8	G8_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:45	120	AE	None	1.2	66	WPA
G_9	G9_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	22:05	80	AE	None	2.1	68	WPA
H_1	H1_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	23:13	148	MH	None	0.8	62.7	WRP
H_10	H10_2015	0	0	0	0	0	0	1	0	0	1	0	5/26/2015	20:45	22:48	123	MH	None	0	66.5	WRP
H_11	H11_2015	0	0	0	0	0	1	1	0	0	2	0	5/26/2015	20:45	22:00	75	MH	None	0.8	64.8	WRP
H_2	H2_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	21:46	61	MH	None	1.3	61.5	Private
H_3	H3_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	22:21	96	MH	None	0	65.7	Private
H_4	H4_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:23	38	MH	None	0.6	71.2	Private
H_5	H5_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:37	52	MH	None	1.5	63.4	Private
H_6	H6_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	23:02	137	MH	None	0	61.7	Private
H_7	H7_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	22:08	83	MH	None	1.7	59.2	WMA
H_8	H8_2015	1	0	0	0	0	0	0	0	0	1	0	5/26/2015	20:45	22:58	133	MH	None	0	61.7	WMA
H_9	H9_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	22:33	108	MH	None	0.7	64.3	WMA
I_1	I1_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	23:24	159	NB	None	1	56.5	Private
I_10	I10_2015	1	0	1	0	0	1	1	0	0	4	1	5/26/2015	20:45	22:04	79	NB	None	2.7	57.2	WPA
I_11	I11_2015	1	0	0	0	0	0	0	0	0	1	0	5/26/2015	20:45	23:38	173	NB	None	0	55.6	WRP

I_12	I12_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	22:18	93	NB	None	0	57.6	WRP
I_13	I13_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	22:41	116	NB	None	0	55.2	Private
I_14	I14_2015	0	0	0	0	0	1	0	0	0	1	0	5/26/2015	20:45	22:30	105	NB	None	0.8	57.2	Private
I_2	I2_2015	1	0	0	0	0	0	0	0	0	1	0	5/26/2015	20:45	23:47	182	NB	None	2	55	WMA
I_3	I3_2015	0	0	1	0	0	0	0	0	1	2	0	5/26/2015	20:45	22:54	129	NB	None	0	58.6	Pit
I_4	I4_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:44	59	NB	None	2.6	57.8	Pit
I_5	I5_2015	0	0	0	0	0	1	1	0	0	2	0	5/26/2015	20:45	23:04	139	NB	None	1.4	57	Pit
I_6	I6_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:15	30	NB	None	3.4	63	Pit
I_7	I7_2015	0	0	0	0	0	1	0	0	0	1	0	5/26/2015	20:45	23:14	149	NB	None	23	56.8	WMA
I_8	I8_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:55	70	NB	None	1.7	58.1	WMA
I_9	I9_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	21:33	48	NB	None	1.4	57.5	WMA
J_10	J10_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	0:03	198	MH	None	1.2	57.5	WRP
J_11	J11_2015	1	0	1	0	0	1	0	0	0	3	0	5/27/2015	20:45	21:53	68	BW	None	2.8	72.1	Private
J_12	J12_2015	1	0	0	0	0	1	0	0	0	2	0	5/26/2015	20:45	23:34	169	MH	None	1	64.4	Pit
J_13	J13_2015	1	0	1	0	0	1	1	0	0	4	1	5/27/2015	20:45	23:19	154	BW	None	0	69.8	WMA
J_14	J14_2015	1	0	0	0	0	1	1	0	0	3	0	5/27/2015	20:45	22:23	98	BW	None	3	67.6	WRP
J_2	J2_2015	1	0	1	0	0	1	1	0	0	4	1	5/27/2015	20:45	22:08	83	BW	None	4.6	68.4	WRP
J_3	J3_2015	0	0	0	0	0	0	0	0	0	0	0	5/26/2015	20:45	23:22	157	MH	None	NA	NA	WRP
J_4	J4_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	21:18	33	BW	None	4.9	69.8	Private
J_5	J5_2015	0	0	0	0	0	0	1	0	0	1	0	5/27/2015	20:45	21:45	60	BW	None	3.3	68.7	Pit
J_6	J6_2015	1	0	0	0	0	0	0	0	0	1	0	5/27/2015	20:45	22:40	115	BW	None	0	69.5	WMA
J_7	J7_2015	1	0	1	0	1	1	1	0	0	5	1	5/27/2015	20:45	22:59	134	BW	None	2.1	68	WMA
J_8	J8_2015	1	0	0	0	0	1	1	0	0	3	0	5/26/2015	20:45	23:49	184	MH	None	1.9	55	WMA
J_9	J9_2015	1	0	1	0	0	1	1	0	0	4	1	5/27/2015	20:45	22:47	122	BW	None	1.5	69.6	WPA
K_1	K1_2015	0	0	0	0	0	0	0	0	0	0	0	5/30/2015	20:45	23:26	161	EBB	None	0.9	56.7	WMA

K_2	K2_2015	0	0	0	0	0	0	0	0	0	0	0	5/30/2015	20:45	22:02	77	EBB	None	1.5	56.8	WMA
K_3	K3_2015	1	0	0	0	0	0	0	0	0	1	0	5/30/2015	20:45	21:52	67	EBB	None	0.6	62	WPA
K_4	K4_2015	0	0	0	0	0	0	0	0	0	0	0	5/30/2015	20:45	22:26	101	EBB	None	1.3	54.7	WPA
K_5	K5_2015	1	0	0	0	0	0	1	0	0	2	0	5/30/2015	20:45	22:42	117	EBB	None	1	57.7	WPA
K_6	K6_2015	1	0	0	0	0	0	0	0	0	1	0	5/30/2015	20:45	22:57	132	EBB	None	2.6	52.8	WPA
K_7	K7_2015	0	0	0	0	0	0	0	0	0	0	0	5/30/2015	20:45	21:40	55	EBB	None	0	60	WPA
K_8	K8_2015	1	0	0	0	1	1	0	0	0	3	0	5/30/2015	20:45	23:12	147	EBB	None	3.2	52.6	WPA

2015
Visit 4

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A_1	A1_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:19	94	TE	None	10.8	68.8	WRP
A_10	A10_2015	1	0	1	0	1	0	1	0	0	4	0	6/2/15	20:45	23:34	169	TE	None	6.2	67.5	Pit
A_11	A11_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	23:15	150	TE	None	9	67.8	Private
A_12	A12_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	22:31	106	TE	None	7.5	69	WPA
A_2	A2_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:48	123	TE	None	10.7	68.4	Pit
A_3	A3_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	23:06	141	TE	None	10.6	68.4	Pit
A_4	A4_2015	1	0	0	0	0	0	0	0	1	2	0	6/2/15	20:45	23:43	178	TE	None	5.9	67	Pit
A_5	A5_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	22:55	130	TE	None	13	68.7	WMA
A_6	A6_2015	1	0	0	0	1	0	0	0	0	2	0	6/2/15	20:45	22:09	84	TE	None	8.1	69	WMA
A_7	A7_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	22:40	115	TE	None	11.7	68.7	Private
A_8	A8_2015	1	0	0	0	0	0	1	0	0	2	0	6/2/15	20:45	23:24	159	TE	None	8	67.4	Pit
A_9	A9_2015	1	0	0	0	0	0	1	0	1	3	0	6/2/15	20:45	22:00	75	TE	None	6.2	69.3	WMA
B_1	B1_2015	1	0	0	0	0	0	0	0	0	1	0	6/1/15	20:45	22:21	96	Monica	None	3	69.8	WRP
B_10	B10_2015	1	0	1	0	1	0	1	0	0	4	0	6/1/15	20:45	22:47	122	Monica	None	5.6	67.8	WPA
B_2	B2_2015	1	0	0	0	0	0	0	0	0	1	0	6/1/15	20:45	22:32	107	Monica	None	3.4	68.3	WRP
B_3	B3_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	22:13	88	Monica	None	4.8	69.2	WRP
B_4	B4_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	21:50	65	Monica	None	NA	NA	Private

B_5	B5_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	23:19	154	Monica	None	5	68.1	Pit
B_6	B6_2015	1	0	0	0	0	0	1	0	0	2	0	6/1/15	20:45	22:04	79	Monica	None	5.5	70.1	Pit
B_7	B7_2015	1	0	0	0	1	0	1	0	0	3	0	6/1/15	20:45	22:40	115	Monica	None	4.5	69	WMA
B_8	B8_2015	1	0	0	0	1	0	1	0	0	3	0	6/1/15	20:45	23:08	143	Monica	None	5	58	WMA
B_9	B9_2015	1	0	0	0	0	0	0	0	0	1	0	6/1/15	20:45	23:27	162	Monica	None	5.8	69.8	WMA
C_1	C1_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6/2/15	20:45		NA	DU		NA	NA	Private
C_10	C10_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	23:42	177	DU	None	10.5	68.4	WPA
C_11	C11_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	22:54	129	DU	None	14	69.9	Private
C_12	C12_2015	1	0	1	0	0	1	0	0	0	3	0	6/2/15	20:45	23:16	151	DU	None	10.2	68.8	WRP
C_2	C2_2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6/2/15	20:45		NA	DU		NA	NA	Pit
C_3	C3_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	22:34	109	DU	None	11.6	71.7	Pit
C_4	C4_2015	1	0	1	0	0	0	0	0	0	2	0	6/2/15	20:45	22:10	85	DU	None	10	72.2	Private
C_5	C5_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	23:05	140	DU	None	7.3	69	WMA
C_6	C6_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	23:25	160	DU	None	8.6	68.3	WPA
C_7	C7_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	21:37	52	DU	None	12.3	73	WPA
C_8	C8_2015	1	0	1	0	1	1	0	0	0	4	0	6/2/15	20:45	21:50	65	DU	None	7.9	72.3	Pit
C_9	C9_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	22:48	123	DU	None	10.6	70.2	Pit
D_1	D1_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	22:28	103	TLG	None	9.4	74.7	Private
D_2	D2_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:01	76	TLG	None	9.4	74.5	Pit
D_3	D3_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	22:49	124	TLG	None	8.9	73.2	Pit
D_4	D4_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	21:48	63	TLG	None	9.9	75.2	WMA
D_5	D5_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	23:22	157	TLG	None	7.6	72.5	WMA
D_6	D6_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	22:16	91	TLG	None	12.1	75.4	WRP
D_7	D7_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	21:32	47	TLG	None	6	75.8	WRP
E_1	E1_2015	1	0	0	0	1	1	1	0	0	4	0	6/1/15	20:45	0:36	231	BW	None	7.7	63.1	Private

E_10	E10_2015	1	0	1	0	1	1	1	0	0	5	1	6/1/15	20:45	22:07	82	BW	None	6.3	66.4	WRP
E_10	E10_2015	1	0	0	0	0	1	0	0	0	2	0	6/1/15	20:45	22:40	115	BW	None	4.6	64.6	WRP
E_11	E11_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	0:12	207	BW	None	8.2	63.7	WRP
E_12	E12_2015	1	0	0	0	1	1	0	0	0	3	0	6/1/15	20:45	22:29	104	BW	None	5.4	65.8	WRP
E_13	E13_2015	~	0	1	0	1	1	0	0	0	3	0	6/1/15	20:45	23:57	192	BW	None	3.2	64.5	WMA
E_2	E2_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	22:17	92	BW	None	7.4	66.7	Private
E_3	E3_2015	1	0	0	0	1	1	0	0	0	3	0	6/1/15	20:45	23:05	140	BW	None	4.4	65	Pit
E_4	E4_2015	1	0	1	0	1	1	1	0	0	5	1	6/1/15	20:45	23:30	165	BW	None	6.1	64.5	Pit
E_5	E5_2015	1	0	0	0	1	1	1	0	0	4	0	6/1/15	20:45	0:20	215	BW	None	10	63.1	WMA
E_6	E6_2015	1	0	0	0	0	1	0	0	0	2	0	6/1/15	20:45	21:55	70	BW	None	3	68.1	WRP
E_7	E7_2015	1	0	0	0	1	1	0	0	0	3	0	6/1/15	20:45	22:54	129	BW	None	2.8	64.2	WRP
E_8	E8_2015	1	0	0	0	1	1	1	0	0	4	0	6/1/15	20:45	23:44	179	BW	None	5.4	64.5	WRP
F_1	F1_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	0:07	202	MH	None	7.7	69.7	Private
F_10	F10_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	22:22	97	MH	None	11.1	73.9	WPA
F_11	F11_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	21:42	57	MH	None	8.8	75	WPA
F_12	F12_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:38	113	MH	None	3	74	WPA
F_13	F13_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	21:30	45	MH	None	2.1	76.3	WPA
F_2	F2_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	23:44	179	MH	None	6.1	70.6	Private
F_3	F3_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	23:56	191	MH	None	6.6	70.8	Private
F_4	F4_2015	1	0	1	0	0	1	0	0	0	3	0	6/2/15	20:45	23:31	166	MH	None	6.4	70.5	Pit
F_5	F5_2015	0	0	0	0	0	1	1	0	0	2	0	6/2/15	20:45	23:19	154	MH	None	8.5	10.5	WMA
F_6	F6_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:12	87	MH	None	7.5	75.7	WMA
F_7	F7_2015	0	0	1	0	0	1	0	0	0	2	0	6/2/15	20:45	22:53	128	MH	None	6.2	70.6	WPA
F_8	F8_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	23:07	142	MH	None	8.5	69.6	WPA
F_9	F9_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	21:54	69	MH	None	6.9	74.6	WPA

G_1	G1_2015	1	0	1	0	0	0	0	0	0	2	0	6/8/15	20:45	21:50	65	AE	None	0.6	72	WRP
G_10	G10_2015	1	0	1	0	0	0	0	0	0	3	0	6/8/15	20:45	23:30	165	AE	None	1.7	69	WPA
G_11	G11_2015	1	0	1	0	0	0	0	0	0	2	0	6/8/15	20:45	22:50	125	AE	None	0.8	72	WPA
G_2	G2_2015	1	0	1	0	0	0	0	0	0	2	0	6/8/15	20:45	22:00	75	AE	None	0.6	73	Private
G_3	G3_2015	1	0	1	0	0	0	0	0	0	2	0	6/8/15	20:45	22:10	85	AE	None	0	71	Pit
G_4	G4_2015	1	0	1	0	0	0	1	0	0	3	0	6/8/15	20:45	22:20	95	AE	None	0	71	Pit
G_5	G5_2015	0	0	0	0	0	0	0	0	1	1	0	6/8/15	20:45	22:30	105	AE	None	0	71	Pit
G_6	G6_2015	1	0	1	0	0	1	0	0	1	4	0	6/8/15	20:45	23:00	135	AE	None	0	71	Pit
G_7	G7_2015	1	0	1	0	0	0	0	0	0	2	0	6/8/15	20:45	23:10	145	AE	None	2	67	WPA
G_8	G8_2015	1	0	1	0	0	0	0	0	0	2	0	6/8/15	20:45	23:20	155	AE	None	2	69	WPA
G_9	G9_2015	1	0	1	0	0	1	0	0	0	3	0	6/8/15	20:45	22:40	115	AE	None	0.7	72	WPA
H_1	H1_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	23:16	151	MH	None	4.4	65.8	WRP
H_10	H10_2015	1	0	0	0	0	1	1	0	0	3	0	6/1/15	20:45	22:46	121	MH	None	6	65.6	WRP
H_11	H11_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	22:01	76	MH	None	3.8	66.6	WRP
H_2	H2_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	21:50	65	MH	None	3.1	66.9	Private
H_3	H3_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	22:23	98	MH	None	1.7	68.9	Private
H_4	H4_2015	1	0	0	0	0	1	0	0	0	2	0	6/1/15	20:45	21:27	42	MH	None	4.5	67.6	Private
H_5	H5_2015	1	0	0	0	0	1	0	0	0	2	0	6/1/15	20:45	21:37	52	MH	None	3.8	67.6	Private
H_6	H6_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	23:00	135	MH	None	6.5	65.4	Private
H_7	H7_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	22:13	88	MH	None	5.1	67.7	WMA
H_8	H8_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	22:58	133	MH	None	4.7	65.7	WMA
H_9	H9_2015	1	0	0	0	0	1	1	0	0	3	0	6/1/15	20:45	22:36	111	MH	None	5.7	66.9	WMA
I_1	I1_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	23:20	155	NB	None	6.8	72.7	Private
I_10	I10_2015	1	0	1	0	0	1	0	0	0	3	0	6/2/15	20:45	22:03	78	NB	None	9.8	73.8	WPA
I_11	I11_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	23:32	167	NB	None	8.4	71.7	WRP

I_12	I12_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	22:13	88	NB	None	7.7	74	WRP
I_13	I13_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	22:37	112	NB	None	9.2	73.9	Private
I_14	I14_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:26	101	NB	None	9.3	73.8	Private
I_2	I2_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	23:42	177	NB	None	7.3	71.4	WMA
I_3	I3_2015	1	0	1	0	0	0	0	0	0	2	0	6/2/15	20:45	22:49	124	NB	None	9	73	Pit
I_4	I4_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	21:42	57	NB	None	4.9	74.9	Pit
I_5	I5_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	22:59	134	NB	None	7.9	73.1	Pit
I_6	I6_2015	1	0	0	0	0	0	0	0	0	1	0	6/2/15	20:45	21:15	30	NB	None	11.6	76.9	Pit
I_7	I7_2015	0	0	0	0	0	1	0	0	0	1	0	6/2/15	20:45	23:09	144	NB	None	4.5	73	WMA
I_8	I8_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	21:53	68	NB	None	9.3	74.4	WMA
I_9	I9_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	21:33	48	NB	None	8.8	75.1	WMA
J_10	J10_2015	1	0	0	0	0	1	1	0	0	3	0	6/1/15	20:45	0:07	202	MH	None	6.9	63.6	WRP
J_11	J11_2015	1	0	0	0	1	1	0	0	0	3	0	6/2/15	20:45	22:50	125	BW	None	8.5	73.1	Private
J_12	J12_2015	1	0	0	0	0	1	0	0	0	2	0	6/1/15	20:45	23:38	173	MH	None	1.6	66.8	Pit
J_13	J13_2015	0	0	1	0	0	1	0	0	0	2	0	6/2/15	20:45	21:23	38	BW	None	5	76.1	WMA
J_14	J14_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	22:14	89	BW	None	8.1	74.8	WRP
J_2	J2_2015	1	0	0	0	1	1	0	0	0	3	0	6/2/15	20:45	22:35	110	BW	None	5.5	73.9	WRP
J_3	J3_2015	0	0	0	0	0	0	0	0	0	0	0	6/1/15	20:45	23:28	163	MH	None	4.4	65.3	WRP
J_4	J4_2015	1	0	1	0	1	1	0	0	0	4	0	6/2/15	20:45	23:20	155	BW	None	8.2	72.3	Private
J_5	J5_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	23:00	135	BW	None	14.5	73.4	Pit
J_6	J6_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	22:00	75	BW	None	9.8	74.9	WMA
J_7	J7_2015	0	0	0	0	0	0	0	0	0	0	0	6/2/15	20:45	21:42	57	BW	None	9.7	75.8	WMA
J_8	J8_2015	0	0	0	0	0	1	0	0	0	1	0	6/1/15	20:45	23:53	188	MH	None	4.9	63.9	WMA
J_9	J9_2015	1	0	0	0	0	1	0	0	0	2	0	6/2/15	20:45	21:50	65	BW	None	7.9	75.1	WPA
K_1	K1_2015	1	0	1	0	0	1	1	0	0	4	1	6/7/15	20:45	21:34	49	EBB	None	0.9	73.5	WMA

K_2	K2_2015	1	0	0	0	0	0	0	0	0	1	0	6/7/15	20:45	22:48	123	EBB	None	0	66.7	WMA
K_3	K3_2015	0	0	0	0	0	0	0	0	0	0	0	6/7/15	20:45	22:58	133	EBB	None	0.8	65.2	WPA
K_4	K4_2015	1	0	1	0	0	1	0	0	0	3	0	6/7/15	20:45	22:29	104	EBB	None	0	66.4	WPA
K_5	K5_2015	1	0	1	0	0	1	1	0	0	4	1	6/7/15	20:45	22:18	93	EBB	None	1.9	67.4	WPA
K_6	K6_2015	1	0	1	0	0	1	1	0	0	4	1	6/7/15	20:45	22:00	75	EBB	None	1.6	68.2	WPA
K_7	K7_2015	1	0	1	0	0	1	1	0	0	4	1	6/7/15	20:45	23:11	146	EBB	None	1.3	67.2	WPA
K_8	K8_2015	1	0	1	0	1	0	1	0	0	4	0	6/7/15	20:45	21:49	64	EBB	None	0	72.8	WPA

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Visit 1

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A_1	A1_2016	1	0	0	0	0	1	1	0	0	3	0	5/2/16	20:26	21:00	34	MM	None	4.9	63.7	WRP
A_10	A10_2016	1	0	0	0	0	0	0	0	0	1	0	5/2/16	20:26	23:49	203	BW	None	2.7	52.9	Pit
A_11	A11_2016	1	0	1	0	0	0	1	0	0	3	0	5/2/16	20:26	0:00	214	MH	None	1.3	56.5	Private
A_12	A12_2016	1	0	0	0	0	0	1	0	0	2	0	5/2/16	20:26	22:56	150	NB	None	2.3	57.2	WPA
A_2	A2_2016	1	0	0	0	0	0	0	0	0	1	0	5/2/16	20:26	22:35	129	BW	None	3.8	53.1	Pit
A_3	A3_2016	1	0	1	0	0	1	1	0	0	4	1	5/2/16	20:26	23:14	168	NB	None	2.8	60.2	Pit
A_4	A4_2016	1	0	0	0	0	0	0	0	0	1	0	5/2/16	20:26	23:59	213	BW	None	1.8	47.9	Pit
A_5	A5_2016	0	0	0	0	0	0	0	0	0	0	0	5/2/16	20:26	22:45	139	MH	None	0	54.1	WMA
A_6	A6_2016	1	0	0	0	0	1	0	0	0	2	0	5/2/16	20:26	21:15	49	BW	None	2.3	47.7	WMA
A_7	A7_2016	1	0	0	0	0	0	1	0	0	2	0	5/2/16	20:26	22:22	116	MH	None	2.5	54.9	Private
A_8	A8_2016	1	0	0	0	0	1	1	0	0	3	0	5/2/16	20:26	23:35	189	MH	None	0	52.9	Pit
A_9	A9_2016	1	0	0	0	0	0	1	0	0	2	0	5/2/16	20:26	22:09	103	MH	None	1.8	55.7	WMA
B_1	B1_2016	1	0	0	0	0	1	1	0	0	3	0	5/7/16	20:26	22:52	146	MH	None	0	59	WRP
B_10	B10_2016	1	0	1	0	0	0	1	0	0	3	0	5/8/16	20:26	0:16	230	MH	None	2.1	53.4	WPA
B_2	B2_2016	1	0	0	0	0	0	1	0	0	2	0	5/7/16	20:26	22:34	128	BW	None	2.7	53.8	WRP
B_3	B3_2016	1	0	0	0	0	1	1	0	0	3	0	5/7/16	20:26	23:00	154	NB	None	3.1	64.5	WRP
B_4	B4_2016	1	0	0	0	0	0	1	0	0	2	0	5/7/16	20:26	23:32	186	MH	None	1.6	50.9	Private
B_5	B5_2016	1	0	0	0	0	0	0	0	0	1	0	5/7/16	20:26	23:49	203	BW	None	0.9	56	Pit

B_6	B6_2016	1	0	0	0	0	1	1	0	0	3	0	5/7/16	20:26	23:17	171	BW	None	0	57.2	Pit
B_7	B7_2016	1	0	0	0	0	0	0	0	0	1	0	5/8/16	20:26	0:06	220	MH	None	1.3	60.7	WMA
B_8	B8_2016	1	0	0	0	0	0	1	0	0	2	0	5/8/16	20:26	0:27	241	MH	None	2.2	56	WMA
B_9	B9_2016	1	0	0	0	0	0	0	0	0	1	0	5/8/16	20:26	0:46	260	MH	None	0	56.3	WMA
C_1	C1_2016	1	0	0	0	0	0	0	0	0	1	0	5/2/16	20:26	23:02	156	NB	None	2.7	69.5	Private
C_10	C10_2016	1	0	0	0	0	0	1	0	0	2	0	5/3/16	20:26	0:20	234	MH	None	0	61.2	WPA
C_11	C11_2016	1	0	0	0	0	0	0	0	0	1	0	5/2/16	20:26	23:32	186	BW	None	0	52	Private
C_12	C12_2016	0	0	0	0	0	0	0	0	0	0	0	5/2/16	20:26	0:00	214	MH	None	0	52.7	WRP
C_2	C2_2016	1	0	0	0	0	0	1	0	0	2	0	5/2/16	20:26	22:54	148	MH	None	1.5	55.5	Pit
C_3	C3_2016	1	0	0	0	0	1	1	0	0	3	0	5/3/16	20:26	22:40	134	BW	None	2.8	55.2	Pit
C_4	C4_2016	1	0	0	0	0	1	0	0	0	2	0	5/2/16	20:26	21:01	35	BW	None	1.2	54.8	Private
C_5	C5_2016	1	0	0	0	0	0	1	0	0	2	0	5/2/16	20:26	23:52	206	BW	None	2.4	46.4	WMA
C_6	C6_2016	1	0	0	0	1	0	0	0	0	2	0	5/3/16	20:26	0:08	222	MM	None	5.4	70	WPA
C_7	C7_2016	1	0	0	0	0	0	1	0	0	2	0	5/2/16	20:26	22:01	95	MLute	None	0.9	58	WPA
C_8	C8_2016	1	0	1	0	0	0	0	0	0	2	0	5/2/16	20:26	0:00	214	MH	None	0	63	Pit
C_9	C9_2016	0	0	0	0	0	0	0	0	0	0	0	5/2/16	20:26	23:22	176	BW	None	0	56.6	Pit
D_1	D1_2016	0	0	0	0	0	0	0	0	0	0	0	5/7/16	20:26	22:28	122	MH	None	0	66	Private
D_2	D2_2016	1	0	0	0	0	0	1	0	0	2	0	5/7/16	20:26	22:53	147	MH	None	1.2	54	Pit
D_3	D3_2016	1	0	0	0	0	0	0	0	0	1	0	5/7/16	20:26	22:05	99	MLute	None	1.3	58.7	Pit
D_4	D4_2016	1	0	0	0	0	1	1	0	0	3	0	5/7/16	20:26	23:04	158	NB	None	2.6	65.2	WMA
D_5	D5_2016	1	0	0	0	0	1	0	0	0	2	0	5/7/16	20:26	21:20	54	BW	None	1.6	50.5	WMA
D_6	D6_2016	0	0	0	0	0	0	1	0	0	1	0	5/7/16	20:26	22:40	134	BW	None	2.8	56.6	WRP
D_7	D7_2016	1	0	0	0	0	0	1	0	0	2	0	5/7/16	20:26	23:28	182	BW	None	1	62.4	WRP
E_1	E1_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	23:53	207	BW	None	1.5	49.9	Private
E_10	E10_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	21:56	90	MLute	None	0	64	WRP

E_11	E10_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	23:27	181	MH	None	0.6	53.2	WRP
E_12	E11_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	21:42	76	MLute	None	3.7	63	WRP
E_13	E12_2016	1	0	0	0	0	1	1	0	0	3	0	5/4/16	20:26	22:40	134	BW	None	1.9	54.8	WRP
E_2	E13_2016	1	0	0	0	0	1	0	0	0	2	0	5/4/16	20:26	21:14	48	BW	None	2.6	57.8	WMA
E_3	E2_2016	0	0	0	0	0	0	1	0	0	1	0	5/4/16	20:26	22:18	112	MH	None	1.4	59	Private
E_4	E3_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	22:30	124	BW	None	1.6	63.7	Pit
E_5	E4_2016	1	0	0	0	0	0	1	0	0	2	0	5/5/16	20:26	0:03	217	MH	None	1.4	51.1	Pit
E_6	E5_2016	1	0	1	0	0	0	0	0	0	2	0	5/4/16	20:26	20:56	30	MM	None	5.4	64.1	WMA
E_7	E6_2016	0	0	0	0	0	0	0	0	0	0	0	5/4/16	20:26	22:05	99	MH	None	2.7	51.3	WRP
E_8	E7_2016	1	1	0	0	0	0	1	0	0	3	0	5/4/16	20:26	22:54	148	MH	None	2.6	52.8	WRP
E_9	E8_2016	1	0	0	0	0	1	0	0	0	2	0	5/4/16	20:26	21:25	59	BW	None	0	51.5	WRP
F_1	F1_2016	0	0	0	0	0	0	0	0	0	0	0	5/3/16	20:26	23:21	175	MH	None	0.9	54	Private
F_10	F10_2016	1	0	0	0	1	1	1	0	0	4	0	5/3/16	20:26	21:37	71	DV/JD	None	7	63	WPA
F_11	F11_2016	1	0	0	0	0	1	0	0	0	2	0	5/3/16	20:26	21:24	58	BW	None	0.7	54.1	WPA
F_12	F12_2016	1	0	0	0	0	0	1	0	0	2	0	5/3/16	20:26	22:04	98	MLute	None	0.8	62	WPA
F_13	F13_2016	1	0	0	0	1	0	1	0	0	3	0	5/3/16	20:26	21:00	34	MM	None	3.2	64	WPA
F_2	F2_2016	1	0	0	0	0	1	1	0	0	3	0	5/3/16	20:26	23:02	156	NB	None	2.4	55.9	Private
F_3	F3_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	0:00	214	MH	None	0	55	Private
F_4	F4_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	22:50	144	MH	None	0	56	Pit
F_5	F5_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	22:36	130	BW	None	2.6	55.3	WMA
F_6	F6_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	21:49	83	MLute	None	0	64	WMA
F_7	F7_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	22:26	120	MH	None	2.4	55.3	WPA
F_8	F8_2016	0	0	0	0	0	0	0	0	0	0	0	5/3/16	20:26	22:15	109	MH	None	0.6	63.2	WPA
F_9	F9_2016	1	0	0	0	0	1	0	0	0	2	0	5/3/16	20:26	21:13	47	BW	None	0	56.6	WPA
G_1	G1_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	21:03	37	BW	None	0	62.5	WRP

G_10	G10_2016	1	0	0	0	0	1	0	0	0	2	0	5/3/16	20:26	21:41	75	DV/JD	None	6	66	WPA
G_11	G11_2016	1	0	0	0	0	1	1	0	0	3	0	5/3/16	20:26	23:21	175	BW	None	0	56.2	WPA
G_2	G2_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	21:17	51	BW	None	NA	NA	Private
G_3	G3_2016	1	0	0	0	0	0	1	0	0	2	0	5/3/16	20:26	22:30	124	BW	None	1.7	55.4	Pit
G_4	G4_2016	1	0	1	0	0	0	0	0	0	2	0	5/3/16	20:26	22:43	137	MH	None	3	50.5	Pit
G_5	G5_2016	1	0	0	0	0	0	0	0	0	1	0	5/3/16	20:26	22:58	152	NB	None	3	58.9	Pit
G_6	G6_2016	1	1	1	0	0	0	0	0	0	3	0	5/3/16	20:26	22:12	106	MH	None	2.5	55.8	Pit
G_7	G7_2016	1	0	0	0	0	0	1	0	0	2	0	5/3/16	20:26	21:57	91	MLute	None	0	59	WPA
G_8	G8_2016	1	0	0	0	0	1	0	0	0	3	0	5/3/16	20:26	21:31	65	DV/JD	None	6	63	WPA
G_9	G9_2016	1	0	0	0	0	1	1	0	0	3	0	5/3/16	20:26	23:12	166	NB	None	2.6	62.8	WPA
H_1	H1_2016	1	0	0	0	0	1	1	0	0	3	0	5/4/16	20:26	23:02	156	NB	None	3	65.2	WRP
H_10	H10_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	22:37	131	BW	None	4.7	55.1	WRP
H_11	H11_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	21:59	93	MLute	None	1.7	57	WRP
H_2	H2_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	21:48	82	MLute	None	0	60	Private
H_3	H3_2016	1	0	1	0	0	0	1	0	0	3	0	5/4/16	20:26	22:16	110	MH	None	4.6	56.9	Private
H_4	H4_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	21:28	62	DV/JD	None	7	67	Private
H_5	H5_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	21:41	75	DV/JD	None	5	63	Private
H_6	H6_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	22:55	149	NB	None	2.9	57.4	Private
H_7	H7_2016	0	0	0	0	0	0	0	0	0	0	0	5/4/16	20:26	22:07	101	MH	None	1.4	59.2	WMA
H_8	H8_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	22:48	142	MH	None	0	58.8	WMA
H_9	H9_2016	1	0	0	0	0	1	1	0	0	3	0	5/4/16	20:26	22:28	122	BW	None	3.2	58.9	WMA
I_1	I1_2016	1	0	0	0	0	0	0	0	0	1	0	5/5/16	20:26	23:09	163	NB	None	3	63.1	Private
I_10	I10_2016	1	0	0	0	0	0	0	0	0	1	0	5/5/16	20:26	21:47	81	MLute	None	1.6	52.5	WPA
I_11	I11_2016	1	0	0	0	0	0	1	0	0	2	0	5/5/16	20:26	23:24	178	BW	None	2.7	55.4	WRP
I_12	I12_2016	1	0	0	0	0	0	1	0	0	2	0	5/5/16	20:26	22:00	94	MLute	None	1	64	WRP

I_13	I13_2016	0	0	0	0	0	0	0	0	0	0	0	5/5/16	20:26	22:26	120	MH	None	2	59.5	Private
I_14	I14_2016	1	0	1	0	0	1	1	0	0	4	1	5/5/16	20:26	22:13	107	MH	None	4	58.9	Private
I_2	I2_2016	1	0	0	0	0	1	0	0	0	2	0	5/5/16	20:26	23:33	187	MH	None	0.9	49	WMA
I_3	I3_2016	1	0	0	0	0	1	1	0	0	3	0	5/5/16	20:26	22:39	133	BW	None	3.2	57.3	Pit
I_4	I4_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/5/16	20:26	NA	NA	BW	NA	NA	NA	Pit
I_5	I5_2016	1	0	0	0	0	0	0	0	0	1	0	5/5/16	20:26	22:49	143	MH	None	1.9	57.9	Pit
I_6	I6_2016	1	0	0	0	0	0	0	0	0	1	0	5/5/16	20:26	20:58	32	MM	None	5	64	Pit
I_7	I7_2016	1	0	1	0	0	1	1	0	0	4	1	5/5/16	20:26	23:00	154	NB	None	2.4	58.6	WMA
I_8	I8_2016	1	0	0	0	1	1	0	0	0	4	0	5/5/16	20:26	21:37	71	DV/JD	Drizzly	13	65	WMA
I_9	I9_2016	1	0	0	0	0	1	0	0	0	2	0	5/5/16	20:26	21:15	49	BW	None	0	55.9	WMA
J_10	J10_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	23:51	205	BW	None	0	52.4	WRP
J_11	J11_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	22:52	146	MH	None	1.3	54.5	Private
J_12	J12_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	23:22	176	BW	None	0.6	64.4	Pit
J_13	J13_2016	0	0	0	0	0	0	0	0	0	0	0	5/5/16	20:26	0:25	239	MM	None	5.2	65	WMA
J_14	J14_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	21:54	88	MLute	None	2	61	WRP
J_2	J2_2016	1	0	1	0	0	1	1	0	0	4	1	5/4/16	20:26	22:23	117	MH	None	3	56.6	WRP
J_3	J3_2016	1	0	0	0	0	0	0	0	0	1	0	5/4/16	20:26	23:14	168	NB	None	2	60.2	WRP
J_4	J4_2016	1	0	0	0	0	1	1	0	0	3	0	5/4/16	20:26	23:08	162	NB	None	3.9	60.2	Private
J_5	J5_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	22:43	137	MH	None	0.7	59.5	Pit
J_6	J6_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	21:41	75	MLute	None	3	52	WMA
J_7	J7_2016	1	0	0	0	0	1	0	0	0	2	0	5/4/16	20:26	21:16	50	BW	None	0.9	64.3	WMA
J_8	J8_2016	1	0	1	0	0	0	1	0	0	3	0	5/4/16	20:26	23:39	193	BW	None	0.6	57.7	WMA
J_9	J9_2016	0	0	0	0	0	0	0	0	0	0	0	5/4/16	20:26	21:29	63	DV/JD	None	13	62	WPA
K_1	K1_2016	1	0	1	0	0	0	0	0	0	2	0	5/5/16	20:26	1:18	292	MM	None	6.3	72.1	WMA
K_2	K2_2016	1	0	0	0	0	1	1	0	0	3	0	5/4/16	20:26	23:57	211	BW	None	0	57.6	WMA

K_3	K3_2016	1	0	1	0	1	0	0	0	0	3	0	5/5/16	20:26	0:07	221	MM	None	6.7	72	WPA
K_4	K4_2016	1	0	0	0	0	0	0	0	0	1	0	5/5/16	20:26	0:31	245	MM	None	4.3	64.1	WPA
K_5	K5_2016	1	0	1	0	1	1	0	0	0	4	0	5/5/16	20:26	0:43	257	MM	None	5.1	69.7	WPA
K_6	K6_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/5/16	20:26	NA	NA	MH	NA	NA	NA	WPA
K_7	K7_2016	1	0	0	0	0	0	1	0	0	2	0	5/4/16	20:26	23:41	195	BW	None	1.1	48.4	WPA
K_8	K8_2016	1	0	0	0	0	0	0	0	0	1	0	5/5/16	20:26	1:05	279	MH	None	1.2	56.1	WPA

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Visit 2

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A_1	A1_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	21:09	34	MH	None	3.6	52.9	WRP
A_10	A10_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	22:55	140	MH	None	1.0	54.5	Pit
A_11	A11_2016	1	0	0	0	0	1	1	0	0	3	0	5/14/16	20:35	22:35	120	MH	None	0.7	51.4	Private
A_12	A12_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	21:42	67	MH	None	1.7	53.1	WPA
A_2	A2_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	22:12	97	MH	None	0.0	47.2	Pit
A_3	A3_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	22:25	110	MH	None	0.6	55.4	Pit
A_4	A4_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	23:03	148	MH	None	0.9	49.4	Pit
A_5	A5_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	21:55	80	MH	None	0.0	54.4	WMA
A_6	A6_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	21:20	45	MH	None	2.6	48.3	WMA
A_7	A7_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	22:03	88	MH	None	1.7	52.7	Private
A_8	A8_2016	1	0	0	0	0	1	1	0	0	3	0	5/14/16	20:35	22:45	130	MH	None	1.6	48.4	Pit
A_9	A9_2016	0	0	0	0	0	0	1	0	0	1	0	5/14/16	20:35	21:31	56	MH	None	3.7	50.9	WMA
B_1	B1_2016	1	0	0	0	0	0	0	0	0	1	0	5/12/16	20:35	22:41	126	MM	None	5.0	69.8	WRP
B_10	B10_2016	1	0	1	0	0	0	0	0	0	2	0	5/13/16	20:35	0:32	237	MM	None	4.2	65.9	WPA
B_2	B2_2016	1	0	0	0	0	0	1	0	0	2	0	5/12/16	20:35	22:29	114	MM	None	5.1	70.0	WRP
B_3	B3_2016	1	0	0	0	1	0	0	0	0	2	0	5/12/16	20:35	22:55	140	MM	None	5.0	69.7	WRP
B_4	B4_2016	1	0	0	0	0	0	0	0	0	1	0	5/12/16	20:35	23:30	175	MM	None	4.7	66.9	Private
B_5	B5_2016	0	0	0	0	0	0	0	0	0	0	0	5/12/16	20:35	23:47	192	MM	None	4.9	66.6	Pit
B_6	B6_2016	1	0	1	0	1	0	1	0	0	4	0	5/12/16	20:35	23:17	162	MM	None	5.0	67.4	Pit

B_7	B7_2016	1	0	0	0	0	1	1	0	0	3	0	5/13/16	20:35	0:15	220	MM	None	4.4	66.6	WMA
B_8	B8_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	0:49	254	MM	None	4.0	63.4	WMA
B_9	B9_2016	1	0	0	0	0	1	0	0	0	2	0	5/13/16	20:35	1:10	275	MM	None	3.7	63.2	WMA
C_1	C1_2016	1	0	1	0	0	0	1	0	0	3	0	5/14/16	20:35	22:38	123	BW	None	0.0	49.8	Private
C_10	C10_2016	1	0	0	0	0	1	1	0	0	3	0	5/14/16	20:35	21:50	75	BW	None	1.1	52.1	WPA
C_11	C11_2016	1	0	0	0	0	1	1	0	0	3	0	5/14/16	20:35	22:10	95	BW	None	0.0	50.8	Private
C_12	C12_2016	1	0	0	0	0	1	1	0	0	3	0	5/14/16	20:35	21:33	58	BW	None	0.6	51.2	WRP
C_2	C2_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	22:53	138	BW	None	0.0	49.5	Pit
C_3	C3_2016	1	0	1	0	0	1	1	0	0	4	1	5/14/16	20:35	23:03	148	BW	None	0.8	52.0	Pit
C_4	C4_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	23:31	176	BW	None	0.0	54.2	Private
C_5	C5_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	21:48	73	BW	None	0.0	50.0	WMA
C_6	C6_2016	1	0	0	0	0	1	1	0	0	3	0	5/14/16	20:35	21:21	46	BW	None	0.0	56.3	WPA
C_7	C7_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	0:02	207	BW	None	1.8	42.5	WPA
C_8	C8_2016	1	0	1	0	0	0	0	0	0	2	0	5/14/16	20:35	23:50	195	BW	None	0.0	43.5	Pit
C_9	C9_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	22:21	106	BW	None	0.7	51.5	Pit
D_1	D1_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	22:24	109	DV/DJ	None	0.0	46.0	Private
D_2	D2_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	22:47	132	DV/DJ	None	0.0	46.0	Pit
D_3	D3_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	22:06	91	DV/DJ	None	1.0	60.0	Pit
D_4	D4_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	22:52	137	DV/DJ	None	0.0	45.0	WMA
D_5	D5_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	21:38	63	DV/DJ	None	1.0	54.0	WMA
D_6	D6_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	22:34	119	DV/DJ	None	0.0	46.0	WRP
D_7	D7_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	21:16	41	DV/DJ	None	1.0	54.0	WRP
E_1	E1_2016	1	0	0	0	0	1	0	0	0	2	0	5/11/16	20:35	23:40	185	MLute	None	4.0	57.0	Private
E_10	E10_2016	1	0	0	0	0	0	1	0	0	2	0	5/11/16	20:35	21:50	75	MLute	None	3.6	60.0	WRP
E_11	E10_2016	1	0	1	0	0	1	0	0	0	3	0	5/11/16	20:35	23:16	161	MLute	None	7.0	58.0	WRP

E_12	E11_2016	1	0	0	0	0	0	0	0	0	1	0	5/11/16	20:35	22:08	93	MLute	None	9.0	60.0	WRP
E_13	E12_2016	1	0	0	0	0	1	0	0	0	2	0	5/11/16	20:35	23:01	146	MLute	None	9.0	56.0	WRP
E_2	E13_2016	0	0	0	0	0	0	0	0	0	0	0	5/11/16	20:35	22:17	102	MLute	None	8.0	60.0	WMA
E_3	E2_2016	1	0	0	0	0	0	0	0	0	1	0	5/11/16	20:35	22:46	131	MLute	None	4.0	63.0	Private
E_4	E3_2016	1	0	0	0	0	0	0	0	0	1	0	5/11/16	20:35	22:54	139	MLute	None	9.0	58.0	Pit
E_5	E4_2016	1	0	1	0	0	0	0	0	0	2	0	5/11/16	20:35	23:33	178	MLute	None	4.0	60.0	Pit
E_6	E5_2016	1	0	0	0	0	1	0	0	0	2	0	5/11/16	20:35	22:25	110	MLute	None	1.8	60.0	WMA
E_7	E6_2016	1	0	0	0	0	0	0	0	0	1	0	5/11/16	20:35	21:57	82	MLute	None	5.0	58.0	WRP
E_8	E7_2016	1	0	0	0	0	0	0	0	0	1	0	5/11/16	20:35	21:38	63	MLute	None	3.0	58.0	WRP
E_9	E8_2016	1	0	0	0	0	0	0	0	0	1	0	5/11/16	20:35	22:33	118	MLute	None	9.0	57.0	WRP
F_10	F1_2016	1	0	1	0	0	1	1	0	0	4	1	5/12/16	20:35	21:46	71	MH	None	2.9	60.8	Private
F_11	F10_2016	1	0	0	0	0	0	0	0	0	1	0	5/12/16	20:35	21:54	79	MH	None	3.7	62.5	WPA
F_12	F11_2016	0	0	0	0	0	0	0	0	0	0	0	5/12/16	20:35	22:11	96	MH	None	2.3	63.5	WPA
F_12	F12_2016	0	0	0	0	0	0	0	0	0	0	0	5/12/16	20:35	23:30	175	MH	None	3.1	58.2	WPA
F_13	F13_2016	0	0	0	0	0	0	0	0	0	0	0	5/12/16	20:35	21:08	33	MH	None	0.0	72.8	WPA
F_2	F2_2016	0	0	0	0	0	0	0	0	0	0	0	5/12/16	20:35	23:18	163	MH	None	2.1	58.1	Private
F_3	F3_2016	1	0	1	0	0	0	1	0	0	3	0	5/12/16	20:35	23:09	154	MH	None	1.5	59.5	Private
F_4	F4_2016	1	0	1	0	0	1	1	0	0	4	1	5/12/16	20:35	23:00	145	MH	None	2.5	53.6	Pit
F_5	F5_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	22:47	132	MH	None	1.5	55.6	WMA
F_6	F6_2016	0	0	0	0	0	0	0	0	0	0	0	5/12/16	20:35	21:55	80	MH	None	0.0	66.0	WMA
F_7	F7_2016	1	0	1	0	0	1	1	0	0	4	1	5/12/16	20:35	22:35	120	MH	None	0.7	61.3	WPA
F_8	F8_2016	0	0	1	0	0	0	0	0	0	1	0	5/12/16	20:35	22:24	109	MH	None	1.5	55.2	WPA
F_9	F9_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	21:20	45	MH	None	1.9	59.6	WPA
G_1	G1_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	21:09	34	BW	None	2.0	49.0	WRP
G_10	G10_2016	0	0	0	0	0	0	0	0	0	0	0	5/15/16	20:35	21:43	68	BW	None	1.9	51.0	WPA

G_11	G11_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	23:24	169	BW	None	2.8	50.2	WPA
G_2	G2_2016	0	0	0	0	0	0	0	0	0	0	0	5/15/16	20:35	21:20	45	BW	Drizzly	1.0	50.3	Private
G_3	G3_2016	1	0	0	0	0	0	1	0	0	2	0	5/15/16	20:35	22:40	125	BW	None	1.8	48.6	Pit
G_4	G4_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	22:54	139	BW	None	2.1	49.5	Pit
G_5	G5_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	23:06	151	BW	None	1.2	48.9	Pit
G_6	G6_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	22:17	102	BW	None	2.1	48.8	Pit
G_7	G7_2016	1	0	0	0	0	0	0	0	0	1	0	5/15/16	20:35	22:01	86	BW	Light Rain	1.6	49.2	WPA
G_8	G8_2016	0	0	0	0	0	0	0	0	0	0	0	5/15/16	20:35	21:33	58	BW	Light Rain	2.7	49.0	WPA
G_9	G9_2016	1	0	0	0	0	0	1	0	0	2	0	5/15/16	20:35	23:15	160	BW	None	3.2	48.4	WPA
H_1	H1_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	22:52	137	MH	None	9.7	45.4	WRP
H_10	H10_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	22:20	105	MH	None	8.0	48.3	WRP
H_11	H11_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	21:47	72	MH	None	13.4	48.7	WRP
H_2	H2_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	21:38	63	MH	None	12.5	48.9	Private
H_3	H3_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	22:03	88	MH	None	7.5	47.3	Private
H_4	H4_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	21:18	43	MH	None	10.6	50.0	Private
H_5	H5_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	21:30	55	MH	None	10.9	49.6	Private
H_6	H6_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	22:43	128	MH	None	11.5	46.5	Private
H_7	H7_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	21:53	78	MH	None	10.0	47.6	WMA
H_8	H8_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	22:37	122	MH	None	9.0	46.3	WMA
H_9	H9_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	22:27	112	MH	None	10.5	46.3	WMA
I_1	I1_2016	1	0	0	0	0	0	1	0	0	2	0	5/12/16	20:35	23:05	150	NB	None	2.5	56.6	Private
I_10	I10_2016	1	0	1	0	0	1	1	0	0	4	1	5/12/16	20:35	21:49	74	NB	None	1.3	59.9	WPA
I_11	I11_2016	1	0	1	0	0	1	0	0	0	3	0	5/12/16	20:35	23:19	164	NB	None	3.3	58.2	WRP
I_12	I12_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	21:59	84	NB	None	0.7	57.7	WRP

I_13	I13_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	22:24	109	NB	None	3.0	57.4	Private
I_14	I14_2016	1	0	1	0	0	0	1	0	0	3	0	5/12/16	20:35	22:11	96	NB	None	0.0	59.4	Private
I_2	I2_2016	1	0	1	0	0	0	1	0	0	3	0	5/12/16	20:35	23:28	173	NB	None	1.8	58.8	WMA
I_3	I3_2016	1	0	0	0	0	0	0	0	0	1	0	5/12/16	20:35	22:36	121	NB	None	3.6	58.1	Pit
I_4	I4_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	21:29	54	NB	None	1.2	62.4	Pit
I_5	I5_2016	1	0	1	0	0	1	1	0	0	4	1	5/12/16	20:35	22:44	129	NB	None	3.5	56.6	Pit
I_6	I6_2016	1	0	0	0	0	1	0	0	0	2	0	5/12/16	20:35	21:05	30	NB	None	1.2	65.9	Pit
I_7	I7_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	22:55	140	NB	None	1.3	58.8	WMA
I_8	I8_2016	1	0	0	0	0	1	1	0	0	3	0	5/12/16	20:35	21:39	64	NB	None	0.8	61.3	WMA
I_9	I9_2016	1	0	0	0	0	1	0	0	0	2	0	5/12/16	20:35	21:20	45	NB	None	2.3	60.6	WMA
J_10	J10_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	23:42	187	MH	None	8.5	44.7	WRP
J_11	J11_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	0:28	233	BW	None	4.8	42.5	Private
J_12	J12_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	23:11	156	MH	None	7.3	47.0	Pit
J_13	J13_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	0:47	252	MH	None	5.7	41.8	WMA
J_14	J14_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	0:55	260	BW	None	9.1	42.1	WRP
J_2	J2_2016	1	0	0	0	0	0	0	0	0	1	0	5/14/16	20:35	0:41	246	BW	None	5.9	43.0	WRP
J_3	J3_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/13/16	20:35	NA	NA	BW	NA	NA	NA	WRP
J_4	J4_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	23:56	201	BW	None	6.2	43.0	Private
J_5	J5_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	0:20	225	BW	None	3.6	42.2	Pit
J_6	J6_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	0:27	232	MH	None	4.8	42.5	WMA
J_7	J7_2016	1	0	0	0	0	0	1	0	0	2	0	5/14/16	20:35	0:08	213	MH	None	5.1	44.2	WMA
J_8	J8_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	23:30	175	MH	None	5.7	44.1	WMA
J_9	J9_2016	0	0	0	0	0	0	0	0	0	0	0	5/14/16	20:35	0:17	222	MH	None	4.2	42.4	WPA
K_1	K1_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	21:29	54	BW	None	13.8	50.0	WMA
K_2	K2_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	23:03	148	BW	None	5.0	45.7	WMA

K_3	K3_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	23:11	156	BW	None	10.0	45.6	WPA
K_4	K4_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	22:23	108	BW	None	8.2	43.0	WPA
K_5	K5_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	22:11	96	BW	None	10.1	47.8	WPA
K_6	K6_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	21:56	81	BW	None	14.8	48.5	WPA
K_7	K7_2016	1	0	0	0	0	0	0	0	0	1	0	5/13/16	20:35	23:20	165	BW	None	5.0	46.0	WPA
K_8	K8_2016	0	0	0	0	0	0	0	0	0	0	0	5/13/16	20:35	21:42	67	BW	None	7.4	49.7	WPA

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Visit 3

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A_1	A1_2016	1	0	0	0	0	0	0	0	0	1	0	5/19/16	20:40	21:19	39	MH	None	7.7	61.3	WRP
A_10	A10_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	23:12	152	MH	None	2.9	54.5	Pit
A_11	A11_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	22:53	133	MH	None	2.4	53.8	Private
A_12	A12_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	21:56	76	MH	None	4.9	55	WPA
A_2	A2_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	22:20	100	MH	None	5.2	54.9	Pit
A_3	A3_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	22:42	122	MH	None	4.9	53.7	Pit
A_4	A4_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	23:21	161	MH	None	2	53.7	Pit
A_5	A5_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	22:35	115	MH	None	4.3	53.9	WMA
A_6	A6_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	21:34	54	MH	None	4.9	59.4	WMA
A_7	A7_2016	1	0	0	0	0	1	1	0	1	4	0	5/19/16	20:40	22:10	90	MH	None	3.8	57.2	Private
A_8	A8_2016	1	0	0	0	0	1	1	0	0	3	0	5/19/16	20:40	23:02	142	MH	None	4	54.5	Pit
A_9	A9_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	21:44	64	MH	None	9.2	58.1	WMA
B_1	B1_2016	1	0	1	0	0	0	0	0	0	2	0	5/22/16	20:40	0:22	222	MM	None	3.2	69.8	WRP
B_10	B10_2016	1	0	1	0	0	0	0	0	0	2	0	5/21/16	20:40	22:45	125	MM	None	2.4	72.9	WPA
B_2	B2_2016	1	0	0	0	0	0	1	0	0	2	0	5/22/16	20:40	0:43	243	MM	None	3.3	69.5	WRP
B_3	B3_2016	1	0	1	0	0	0	0	0	0	2	0	5/22/16	20:40	0:10	210	MM	None	3.4	70.2	WRP
B_4	B4_2016	1	0	0	0	0	0	0	0	0	1	0	5/21/16	20:40	23:29	169	MM	None	1.7	71.4	Private
B_5	B5_2016	0	0	0	0	0	0	0	0	0	0	0	5/21/16	20:40	23:13	153	MM	None	2	71.9	Pit
B_6	B6_2016	1	0	1	0	1	0	0	0	0	3	0	5/21/16	20:40	23:48	188	MM	None	2.4	71.3	Pit

B_7	B7_2016	1	0	1	0	0	0	1	0	0	3	0	5/21/16	20:40	22:59	139	MM	None	2.1	72.1	WMA
B_8	B8_2016	1	0	1	0	0	0	0	0	0	2	0	5/21/16	20:40	22:31	111	MM	None	2.5	73	WMA
B_9	B9_2016	1	0	1	0	0	0	1	0	0	3	0	5/21/16	20:40	22:17	97	MM	None	2.6	73.4	WMA
C_1	C1_2016	1	0	1	0	0	1	0	0	0	3	0	5/18/16	20:40	22:41	121	BW	None	0.8	63.5	Private
C_10	C10_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	23:11	151	BW	None	2	65.5	WPA
C_11	C11_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	22:02	82	BW	None	4.2	58.5	Private
C_12	C12_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	21:34	54	BW	None	2.3	60.4	WRP
C_2	C2_2016	1	0	1	0	0	0	0	0	0	2	0	5/18/16	20:40	22:28	108	BW	None	3.9	56.6	Pit
C_3	C3_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	22:55	135	BW	None	1.4	60.8	Pit
C_4	C4_2016	1	0	0	0	0	0	0	0	0	1	0	5/18/16	20:40	23:26	166	BW	None	1.8	57.2	Private
C_5	C5_2016	0	0	1	0	0	0	0	0	0	1	0	5/18/16	20:40	21:48	68	BW	None	3	57.7	WMA
C_6	C6_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	21:25	45	BW	None	2.3	59.8	WPA
C_7	C7_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	0:04	204	BW	None	0.8	53.9	WPA
C_8	C8_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	23:46	186	BW	None	4	55.5	Pit
C_9	C9_2016	1	0	1	0	0	1	1	0	0	4	1	5/18/16	20:40	22:12	92	BW	None	0.9	61.2	Pit
D_1	D1_2016	1	0	0	0	0	0	0	0	0	1	0	5/21/16	20:40	22:20	100	DV/JD	None	7	64	Private
D_2	D2_2016	1	0	0	0	0	1	0	0	0	2	0	5/21/16	20:40	22:42	122	DV/JD	None	9	63	Pit
D_3	D3_2016	1	0	0	0	0	1	1	0	0	4	0	5/21/16	20:40	22:00	80	DV/JD	None	7	65	Pit
D_4	D4_2016	1	0	0	0	0	0	0	0	0	2	0	5/21/16	20:40	22:50	130	DV/JD	None	8	64	WMA
D_5	D5_2016	1	0	0	0	0	1	0	0	1	4	0	5/21/16	20:40	21:35	55	DV/JD	None	8	65	WMA
D_6	D6_2016	1	0	0	0	0	1	0	0	0	3	0	5/21/16	20:40	22:30	110	DV/JD	None	8	64	WRP
D_7	D7_2016	0	0	0	0	0	0	0	0	0	0	0	5/21/16	20:40	21:10	30	DV/JD	None	12	64	WRP
E_1	E1_2016	1	0	1	0	1	0	0	0	0	3	0	5/19/16	20:40	0:00	200	MLute	None	1	56	Private
E_10	E10_2016	0	0	0	0	0	1	0	0	0	1	0	5/18/16	20:40	22:07	87	MLute	None	3	60	WRP
E_11	E10_2016	0	0	1	0	1	1	0	0	0	3	0	5/18/16	20:40	23:35	175	MLute	None	2	56	WRP

E_12	E11_2016	0	0	1	0	1	1	0	0	0	3	0	5/18/16	20:40	22:24	104	MLute	None	3	55	WRP
E_13	E12_2016	0	0	1	0	1	1	0	0	0	3	0	5/18/16	20:40	23:18	158	MLute	None	2	56	WRP
E_2	E13_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	22:23	103	MLute	None	3	55	WMA
E_3	E2_2016	1	0	1	0	0	0	0	0	0	2	0	5/18/16	20:40	22:59	139	MLute	None	4	57	Private
E_4	E3_2016	0	0	0	0	1	0	0	0	0	1	0	5/18/16	20:40	23:10	150	MLute	None	1	55	Pit
E_5	E4_2016	1	0	1	0	1	0	0	0	0	3	0	5/18/16	20:40	23:50	190	MLute	None	1	56	Pit
E_6	E5_2016	1	0	0	0	0	1	0	0	0	2	0	5/18/16	20:40	22:41	121	MLute	None	3	56	WMA
E_7	E6_2016	0	0	1	0	0	1	0	0	0	2	0	5/18/16	20:40	22:13	93	MLute	None	3	61	WRP
E_8	E7_2016	0	0	0	0	0	1	0	0	0	1	0	5/18/16	20:40	21:56	76	MLute	None	3	57	WRP
E_9	E8_2016	1	0	1	0	0	1	0	0	0	3	0	5/18/16	20:40	22:48	128	MLute	None	3	53	WRP
F_1	F1_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	23:26	166	MH	None	1.9	53.5	Private
F_10	F10_2016	1	0	1	0	0	1	0	0	0	3	0	5/18/16	20:40	21:58	78	MH	None	1	62.5	WPA
F_11	F11_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	21:29	49	MH	None	3.5	58	WPA
F_12	F12_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	22:10	90	MH	None	1.7	61.3	WPA
F_13	F13_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	21:19	39	MH	None	1.5	64.1	WPA
F_2	F2_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	23:08	148	MH	None	2.7	54.2	Private
F_3	F3_2016	0	0	1	0	0	0	0	0	0	1	0	5/18/16	20:40	23:17	157	MH	None	2.5	58.7	Private
F_4	F4_2016	1	0	0	0	0	1	0	0	0	2	0	5/18/16	20:40	22:58	138	MH	None	1.2	55	Pit
F_5	F5_2016	0	0	1	0	0	1	0	0	0	2	0	5/18/16	20:40	22:42	122	MH	None	2.1	59.5	WMA
F_6	F6_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	21:51	71	MH	None	1	59.7	WMA
F_7	F7_2016	1	0	0	0	0	1	1	0	0	3	0	5/18/16	20:40	22:30	110	MH	None	1.3	65.1	WPA
F_8	F8_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	22:21	101	MH	None	1.1	55.4	WPA
F_9	F9_2016	1	0	0	0	0	1	0	0	0	2	0	5/18/16	20:40	21:37	57	MH	None	1.6	57	WPA
G_1	G1_2016	1	0	0	0	0	0	0	0	0	1	0	5/19/16	20:40	21:12	32	BW	None	3	55.5	WRP
G_10	G10_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	21:48	68	BW	None	0.9	53.2	WPA

G_11	G11_2016	1	0	1	0	0	1	0	0	0	3	0	5/19/16	20:40	23:20	160	BW	None	6.8	53.4	WPA
G_2	G2_2016	1	0	0	0	0	0	0	0	0	1	0	5/19/16	20:40	21:24	44	BW	None	1.2	53.6	Private
G_3	G3_2016	1	0	0	0	0	0	1	0	0	2	0	5/19/16	20:40	22:34	114	BW	None	4.5	53.3	Pit
G_4	G4_2016	0	0	0	0	0	0	1	0	0	1	0	5/19/16	20:40	22:46	126	BW	None	4.5	53.5	Pit
G_5	G5_2016	1	0	0	0	0	0	0	0	0	1	0	5/19/16	20:40	22:57	137	BW	None	6.8	53.9	Pit
G_6	G6_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	22:24	104	BW	None	6.8	53.7	Pit
G_7	G7_2016	1	1	0	0	0	1	0	0	0	3	0	5/19/16	20:40	22:05	85	BW	None	5.4	54.1	WPA
G_8	G8_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	21:36	56	BW	None	2.3	53.1	WPA
G_9	G9_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	23:06	146	BW	None	5	53.6	WPA
H_1	H1_2016	0	0	0	0	0	0	0	0	0	0	0	5/17/16	20:40	22:51	131	MH	None	0	56	WRP
H_10	H10_2016	1	0	1	0	0	1	1	0	0	4	1	5/17/16	20:40	22:25	105	MH	None	0	60.6	WRP
H_11	H11_2016	1	0	0	0	0	0	0	0	0	1	0	5/17/16	20:40	21:53	73	MH	None	0	65.2	WRP
H_2	H2_2016	0	0	0	0	0	0	0	0	0	0	0	5/17/16	20:40	21:44	64	MH	None	0	66.2	Private
H_3	H3_2016	0	0	0	0	0	0	0	0	0	0	0	5/17/16	20:40	22:09	89	MH	None	0	58.9	Private
H_4	H4_2016	1	0	0	0	0	1	0	0	0	2	0	5/17/16	20:40	21:27	47	MH	None	0	66.2	Private
H_5	H5_2016	1	0	0	0	0	1	0	0	0	2	0	5/17/16	20:40	21:37	57	MH	None	1.2	58.9	Private
H_6	H6_2016	0	0	1	0	0	1	1	0	0	3	0	5/17/16	20:40	22:40	120	MH	None	0	59.2	Private
H_7	H7_2016	1	0	0	0	0	0	0	0	0	1	0	5/17/16	20:40	22:00	80	MH	None	0	64	WMA
H_8	H8_2016	1	0	0	0	0	1	0	0	0	2	0	5/17/16	20:40	22:34	114	MH	None	0	57.4	WMA
H_9	H9_2016	1	0	1	0	0	1	0	0	0	3	0	5/17/16	20:40	22:17	97	MH	None	0	58.9	WMA
I_1	I1_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	23:12	152	NB	None	4	54.1	Private
I_10	I10_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	21:58	78	NB	None	2.5		WPA
I_11	I11_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	23:26	166	NB	None	6.3	53.2	WRP
I_12	I12_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	22:09	89	NB	None	3.9		WRP
I_13	I13_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	22:32	112	NB	None	3.5	54.6	Private

I_14	I14_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	22:20	100	NB	None	4.4	53	Private
I_2	I2_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	23:36	176	NB	None	4.6	52.5	WMA
I_3	I3_2016	0	0	0	0	0	0	0	0	0	0	0	5/19/16	20:40	22:45	125	NB	None	4.6	56.6	Pit
I_4	I4_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	21:38	58	NB	None	2.3	58.1	Pit
I_5	I5_2016	1	0	0	0	0	1	1	0	0	3	0	5/19/16	20:40	22:54	134	NB	None	3.5	54.5	Pit
I_6	I6_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	21:12	32	NB	None	3.5	56.5	Pit
I_7	I7_2016	0	0	0	0	0	1	0	0	0	1	0	5/19/16	20:40	23:04	144	NB	None	3.9	54.8	WMA
I_8	I8_2016	1	0	1	0	0	1	0	0	0	3	0	5/19/16	20:40	21:48	68	NB	None	4.5	55.2	WMA
I_9	I9_2016	1	0	0	0	0	1	0	0	0	2	0	5/19/16	20:40	21:29	49	NB	None	4.5	53.2	WMA
J_10	J10_2016	1	0	0	0	0	1	0	0	0	2	0	5/17/16	20:40	23:36	176	MH	None	2.1	54.3	WRP
J_11	J11_2016	1	0	1	0	0	1	0	0	0	3	0	5/18/16	20:40	0:52	252	BW	None	1.4	53.1	Private
J_12	J12_2016	1	0	0	0	0	1	0	0	0	2	0	5/17/16	20:40	23:07	147	MH	None	0	55	Pit
J_13	J13_2016	1	0	0	0	0	0	0	0	0	1	0	5/18/16	20:40	0:31	231	MH	None	0	57.5	WMA
J_14	J14_2016	1	0	0	0	0	0	1	0	0	2	0	5/18/16	20:40	0:49	249	MH	None	0	60.8	WRP
J_2	J2_2016	1	0	1	0	0	0	1	0	0	3	0	5/18/16	20:40	1:07	267	BW	None	1.6	52.8	WRP
J_3	J3_2016	0	0	0	0	0	0	0	0	0	0	0	5/17/16	20:40	22:58	138	BW	None	0	61.1	WRP
J_4	J4_2016	1	0	0	0	0	1	0	0	0	2	0	5/18/16	20:40	0:23	223	BW	None	0	56.4	Private
J_5	J5_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	0:39	239	BW	None	1.4	49.1	Pit
J_6	J6_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	0:13	213	MH	None	0	58	WMA
J_7	J7_2016	1	0	1	0	0	1	0	0	0	3	0	5/17/16	20:40	23:55	195	MH	None	0	53	WMA
J_8	J8_2016	1	0	1	0	0	0	0	0	0	2	0	5/17/16	20:40	23:26	166	MH	None	0.6	60.4	WMA
J_9	J9_2016	0	0	0	0	0	0	0	0	0	0	0	5/18/16	20:40	0:04	204	MH	None	0	58.7	WPA
K_1	K1_2016	1	0	0	0	0	1	0	0	0	2	0	5/17/16	20:40	21:48	68	BW	None	2	57.2	WMA
K_2	K2_2016	1	0	0	0	0	0	0	0	0	1	0	5/17/16	20:40	23:44	184	BW	None	1.2	55	WMA
K_3	K3_2016	1	0	0	0	0	0	0	0	0	1	0	5/17/16	20:40	23:25	165	BW	None	1.2	54.9	WPA

K_4	K4_2016	1	0	1	0	0	1	0	0	0	3	0	5/17/16	20:40	22:54	134	BW	None	0	63.5	WPA
K_5	K5_2016	1	0	0	0	0	0	0	0	0	1	0	5/17/16	20:40	22:41	121	BW	None	0.9	58.1	WPA
K_6	K6_2016	1	0	0	0	0	0	0	0	0	1	0	5/17/16	20:40	22:23	103	BW	None	0	59.5	WPA
K_7	K7_2016	1	0	1	0	0	1	0	0	0	3	0	5/17/16	20:40	23:36	176	BW	None	0	58.4	WPA
K_8	K8_2016	0	0	0	0	0	0	0	0	0	0	0	5/17/16	20:40	22:10	90	BW	None	0.9	58.7	WPA

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Visit 4

Site ID	Site_Year	*Pseudacris maculata*	*Anaxyrus cognatus*	*Anaxyrus woodhousii*	*Spea bombifrons*	*Acris crepitans*	*Hyla chrysocelis*	*Lithobates blairi*	*Lithobates pipiens*	*Lithobates catesbeianus*	Richness	Community	Date	Sunset	Time	Minutes After Sunset	Observer	Precipitation	Wind (mph)	Air Temp (F)	Type
A_1	A1_2016	1	1	1	0	0	0	1	0	0	4	0	6/1/16	20:45	21:43	58	MH	None	0.0	79.4	WRP
A_10	A10_2016	1	0	1	0	0	1	0	0	0	3	0	6/1/16	20:45	23:51	186	MH	None	0.0	74.0	Pit
A_11	A11_2016	1	0	0	0	0	1	1	0	0	3	0	6/1/16	20:45	23:29	164	MH	None	0.0	67.3	Private
A_12	A12_2016	1	0	0	0	0	1	0	0	0	2	0	6/1/16	20:45	22:19	94	MH	None	0.0	73.9	WPA
A_2	A2_2016	0	0	0	0	0	0	0	0	0	0	0	6/1/16	20:45	22:48	123	MH	None	0.9	72.6	Pit
A_3	A3_2016	0	0	0	0	0	0	0	0	0	0	0	6/1/16	20:45	23:17	152	MH	None	0.0	69.8	Pit
A_4	A4_2016	0	0	0	0	0	0	0	0	0	0	0	6/1/16	20:45	0:00	195	MH	None	0.0	71.4	Pit
A_5	A5_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	23:04	139	MH	None	0.0	75.9	WMA
A_6	A6_2016	0	0	0	0	0	0	0	0	0	0	0	6/1/16	20:45	21:56	71	MH	None	0.0	78.2	WMA
A_7	A7_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	22:30	105	MH	None	0.0	74.0	Private
A_8	A8_2016	1	0	1	0	1	1	1	0	0	5	1	6/1/16	20:45	23:39	174	MH	None	0.0	70.3	Pit
A_9	A9_2016	0	1	1	0	1	0	1	0	1	5	0	6/1/16	20:45	22:05	80	MH	None	0.0	77.7	WMA
B_1	B1_2016	1	0	0	0	0	0	0	0	0	1	0	5/27/16	20:45	0:41	236	MM	None	4.6	62.9	WRP
B_10	B10_2016	1	0	1	0	0	0	0	0	0	2	0	5/26/16	20:45	23:28	163	MM	None	5.7	65.5	WPA
B_2	B2_2016	1	0	1	0	1	0	1	0	0	4	0	5/27/16	20:45	0:32	227	MM	None	5.0	63.0	WRP
B_3	B3_2016	1	0	1	0	0	0	0	0	0	2	0	5/27/16	20:45	0:59	254	MM	None	4.3	61.7	WRP
B_4	B4_2016	1	0	0	0	0	0	0	0	0	1	0	5/27/16	20:45	1:27	282	MM	None	4.3	61.5	Private
B_5	B5_2016	1	0	0	0	0	0	0	0	0	1	0	5/27/16	20:45	0:11	206	MM	None	5.4	63.2	Pit
B_6	B6_2016	1	0	1	0	1	0	1	0	1	5	0	5/27/16	20:45	1:15	270	MM	None	4.2	61.6	Pit

B_7	B7_2016	1	0	1	0	0	0	1	0	0	3	0	5/26/16	20:45	23:54	189	MM	None	5.9	64.1	WMA
B_8	B8_2016	1	0	1	0	0	1	0	0	0	3	0	5/26/16	20:45	23:03	138	MM	None	6.3	74.1	WMA
B_9	B9_2016	1	0	0	0	0	0	0	0	0	1	0	5/26/16	20:45	23:19	154	MM	None	6.0	74.2	WMA
C_1	C1_2016	1	0	1	0	0	0	0	0	0	2	0	5/30/16	20:45	22:45	120	BW	None	7.9	72.1	Private
C_10	C10_2016	1	0	0	0	0	1	1	0	0	3	0	5/30/16	20:45	21:20	35	BW	None	4.7	74.8	WPA
C_11	C11_2016	1	0	1	0	0	1	1	0	0	4	1	5/30/16	20:45	22:14	89	BW	None	5.0	72.1	Private
C_12	C12_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5/30/16	20:45	NA	NA	BW	NA	NA	NA	WRP
C_2	C2_2016	1	0	0	0	0	0	0	0	0	1	0	5/30/16	20:45	22:54	129	BW	None	8.1	71.7	Pit
C_3	C3_2016	1	0	1	0	0	1	1	0	0	4	1	5/30/16	20:45	23:05	140	BW	None	10.9	71.9	Pit
C_4	C4_2016	0	0	0	0	0	1	0	0	0	1	0	5/30/16	20:45	23:33	168	BW	None	10.8	70.8	Private
C_5	C5_2016	1	0	1	0	0	1	1	0	0	4	1	5/30/16	20:45	22:23	98	BW	None	6.1	72.4	WMA
C_6	C6_2016	1	0	1	0	1	1	0	0	0	4	0	5/30/16	20:45	21:40	55	BW	None	3.9	74.3	WPA
C_7	C7_2016	1	0	1	0	0	1	0	0	0	3	0	5/30/16	20:45	21:58	73	BW	None	3.9	73.1	WPA
C_8	C8_2016	1	0	1	0	0	1	0	0	0	3	0	5/30/16	20:45	23:54	189	BW	None	11.9	69.6	Pit
C_9	C9_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20:45	NA	NA	NA	NA	NA	NA	Pit
D_1	D1_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	22:33	108	BW	None	2.5	69.7	Private
D_2	D2_2016	1	0	0	0	0	0	0	0	0	1	0	6/1/16	20:45	21:56	71	BW	None	1.5	69.5	Pit
D_3	D3_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	23:00	135	BW	None	1.5	69.4	Pit
D_4	D4_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	21:45	60	BW	None	2.2	69.4	WMA
D_5	D5_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	23:30	165	BW	None	0.6	68.8	WMA
D_6	D6_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	22:24	99	BW	None	1.3	72.5	WRP
D_7	D7_2016	1	0	1	0	0	1	1	0	0	4	1	6/1/16	20:45	21:25	40	BW	None	2.7	70.2	WRP
E_1	E1_2016	0	0	1	0	1	1	1	0	0	4	0	6/3/16	20:45	0:00	195	BW	None	6.0	69.4	Private
E_10	E10_2016	1	0	1	0	0	1	1	0	0	4	1	6/2/16	20:45	22:09	84	BW	None	2.2	65.1	WRP
E_11	E10_2016	0	0	0	0	0	1	0	0	0	1	0	6/2/16	20:45	23:41	176	BW	None	3.0	68.8	WRP

E_12	E11_2016	1	0	0	0	0	1	0	0	0	2	0	6/2/16	20:45	21:23	38	BW	None	1.6	71.5	WRP
E_13	E12_2016	1	0	1	0	1	1	1	0	0	5	1	6/2/16	20:45	23:22	157	BW	None	3.1	66.2	WRP
E_2	E13_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	21:34	49	BW	None	2.5	70.2	WMA
E_3	E2_2016	1	0	1	0	0	1	0	0	0	3	0	6/2/16	20:45	23:02	137	BW	None	3.0	68.2	Private
E_4	E3_2016	1	0	1	0	1	1	1	0	0	5	1	6/2/16	20:45	23:13	148	BW	None	2.6	66.9	Pit
E_5	E4_2016	1	0	0	0	1	1	1	0	0	4	0	6/3/16	20:45	0:11	206	BW	None	2.2	67.6	Pit
E_6	E5_2016	1	0	1	0	0	1	1	0	0	4	1	6/2/16	20:45	21:47	62	BW	None	2.7	70.0	WMA
E_7	E6_2016	1	0	1	0	0	1	1	0	0	4	1	6/2/16	20:45	22:19	94	BW	None	2.2	67.2	WRP
E_8	E7_2016	1	0	0	0	0	1	1	0	0	3	0	6/2/16	20:45	22:33	108	BW	None	2.2	66.5	WRP
E_9	E8_2016	1	0	1	0	0	1	1	0	0	4	1	6/2/16	20:45	21:58	73	BW	None	1.8	70.0	WRP
F_1	F1_2016	1	0	1	0	0	1	0	0	0	3	0	6/2/16	20:45	23:34	169	MH	None	3.7	66.2	Private
F_10	F10_2016	1	0	0	0	0	1	1	0	0	3	0	6/2/16	20:45	22:00	75	MH	None	2.5	69.9	WPA
F_11	F11_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	21:48	63	MH	None	1.9	74.0	WPA
F_12	F12_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	NA	NA	MH	None	2.8	69.8	WPA
F_13	F13_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	21:26	41	MH	None	1.3	77.2	WPA
F_2	F2_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	23:15	150	MH	None	2.1	66.9	Private
F_3	F3_2016	1	0	1	0	0	1	0	0	0	3	0	6/2/16	20:45	23:24	159	MH	None	2.1	68.5	Private
F_4	F4_2016	1	0	1	0	0	1	1	0	0	4	1	6/2/16	20:45	23:05	140	MH	None	0.7	69.9	Pit
F_5	F5_2016	1	0	0	0	0	1	1	0	0	3	0	6/2/16	20:45	22:54	129	MH	None	2.5	69.8	WMA
F_6	F6_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	22:08	83	MH	None	0.9	69.8	WMA
F_7	F7_2016	1	0	1	0	0	1	1	0	0	4	1	6/2/16	20:45	22:43	118	MH	None	1.4	69.9	WPA
F_8	F8_2016	0	0	0	0	0	0	0	0	0	0	0	6/2/16	20:45	22:34	109	MH	None	1.2	67.1	WPA
F_9	F9_2016	1	0	1	0	0	1	0	0	0	3	0	6/2/16	20:45	21:38	53	MH	None	0.8	73.0	WPA
G_1	G1_2016	1	0	0	0	0	1	0	0	1	3	0	6/3/16	20:45	21:25	40	BW	None	3.2	71.8	WRP
G_10	G10_2016	1	0	1	0	0	1	0	0	0	3	0	6/3/16	20:45	21:58	73	BW	None	5.2	71.2	WPA

G_11	G11_2016	1	0	1	0	0	1	0	0	0	3	0	6/3/16	20:45	23:19	154	BW	None	0.6	70.2	WPA
G_2	G2_2016	1	0	0	0	0	1	1	0	0	3	0	6/3/16	20:45	21:35	50	BW	None	3.2	72.1	Private
G_3	G3_2016	1	0	1	0	0	1	1	0	0	4	1	6/3/16	20:45	22:39	114	BW	None	3.5	69.3	Pit
G_4	G4_2016	1	0	1	0	0	1	1	0	0	4	1	6/3/16	20:45	22:49	124	BW	None	4.7	71.2	Pit
G_5	G5_2016	0	0	0	0	0	0	0	0	0	0	0	6/3/16	20:45	22:57	132	BW	None	3.8	69.4	Pit
G_6	G6_2016	1	0	0	0	0	1	0	0	0	2	0	6/3/16	20:45	22:28	103	BW	None	5.8	70.3	Pit
G_7	G7_2016	1	0	0	0	0	1	1	0	1	4	0	6/3/16	20:45	22:17	92	BW	None	3.6	71.4	WPA
G_8	G8_2016	1	0	0	0	0	1	0	0	0	2	0	6/3/16	20:45	21:15	30	BW	None	6.5	70.8	WPA
G_9	G9_2016	1	0	0	0	0	1	1	0	1	4	0	6/3/16	20:45	23:09	144	BW	None	3.2	71.0	WPA
H_1	H1_2016	0	0	0	0	0	0	0	0	0	0	0	5/23/16	20:45	23:03	138	MH	None	2.8	67.1	WRP
H_10	H10_2016	1	0	1	0	0	1	1	0	0	4	1	5/23/16	20:45	22:36	111	MH	None	1.9	69.1	WRP
H_11	H11_2016	0	0	0	0	0	1	0	0	0	1	0	5/23/16	20:45	21:54	69	MH	None	7.6	70.2	WRP
H_2	H2_2016	0	0	0	0	0	0	0	0	0	0	0	5/23/16	20:45	21:42	57	MH	None	1.0	70.5	Private
H_3	H3_2016	0	0	0	0	0	0	0	0	0	0	0	5/23/16	20:45	22:13	88	MH	None	0.0	72.2	Private
H_4	H4_2016	1	0	0	0	0	1	0	0	0	2	0	5/23/16	20:45	21:19	34	MH	None	1.4	73.5	Private
H_5	H5_2016	0	0	0	0	0	1	0	0	0	1	0	5/23/16	20:45	21:33	48	MH	None	2.7	72.2	Private
H_6	H6_2016	1	0	0	0	0	1	0	0	0	2	0	5/23/16	20:45	22:55	130	MH	None	1.3	68.6	Private
H_7	H7_2016	1	0	0	0	0	1	0	0	0	2	0	5/23/16	20:45	22:01	76	MH	None	8.7	67.5	WMA
H_8	H8_2016	1	0	1	0	0	1	0	0	0	3	0	5/23/16	20:45	22:47	122	MH	None	1.9	71.1	WMA
H_9	H9_2016	0	0	1	0	0	1	0	0	0	2	0	5/23/16	20:45	22:27	102	MH	None	6.6	65.8	WMA
I_1	I1_2016	0	0	0	0	0	0	0	0	0	0	0	5/25/16	20:45	23:42	177	NB	None	9.2	62.4	Private
I_10	I10_2016	0	0	1	0	0	1	1	0	0	3	0	5/25/16	20:45	22:04	79	NB	None	0.0	75.0	WPA
I_11	I11_2016	1	0	0	0	0	0	0	0	0	1	0	5/25/16	20:45	23:55	190	NB	None	3.8	65.0	WRP
I_12	I12_2016	1	0	0	0	0	1	0	0	0	2	0	5/25/16	20:45	22:14	89	NB	None	0.0	72.0	WRP
I_13	I13_2016	1	0	0	0	0	1	0	0	0	2	0	5/25/16	20:45	22:36	111	NB	None	0.0	72.4	Private

I_14	I14_2016	0	0	0	0	0	1	0	0	0	1	0	5/25/16	20:45	22:26	101	NB	None	0.0	74.8	Private
I_2	I2_2016	0	0	1	0	0	0	0	0	0	1	0	5/25/16	20:45	0:04	199	NB	None	3.9	63.3	WMA
I_3	I3_2016	0	0	0	0	0	0	0	0	0	0	0	5/25/16	20:45	22:49	124	NB	None	0.0	73.8	Pit
I_4	I4_2016	1	0	1	0	0	1	1	0	0	4	1	5/25/16	20:45	21:43	58	NB	None	0.0	73.5	Pit
I_5	I5_2016	1	0	1	0	0	1	1	0	0	4	1	5/25/16	20:45	22:58	133	NB	None	3.1	68.1	Pit
I_6	I6_2016	1	0	0	0	0	1	1	0	0	3	0	5/25/16	20:45	21:17	32	NB	None	1.2	68.0	Pit
I_7	I7_2016	0	0	0	0	0	1	0	0	0	1	0	5/25/16	20:45	23:08	143	NB	None	8.7	68.3	WMA
I_8	I8_2016	1	0	1	0	0	1	0	0	0	3	0	5/25/16	20:45	21:52	67	NB	None	0.0	73.5	WMA
I_9	I9_2016	1	0	1	0	0	1	0	0	0	3	0	5/25/16	20:45	21:33	48	NB	None	0.0	68.2	WMA
J_10	J10_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20:45	NA	NA	NA	NA	NA	NA	WRP
J_11	J11_2016	1	0	1	0	0	1	0	0	0	3	0	5/24/16	20:45	0:21	216	BW	None	3.3	62.4	Private
J_12	J12_2016	0	0	0	0	0	1	0	0	0	1	0	5/23/16	20:45	23:20	155	MH	None	1.9	69.2	Pit
J_13	J13_2016	1	0	1	0	0	1	1	0	1	5	1	6/3/16	20:45	0:04	199	BW	None	1.4	65.9	WMA
J_14	J14_2016	1	0	1	0	0	1	1	0	0	4	1	6/3/16	20:45	0:25	220	BW	None	2.6	65.3	WRP
J_2	J2_2016	1	0	1	0	0	1	1	0	0	4	1	5/24/16	20:45	0:45	240	BW	None	6.4	64.6	WRP
J_3	J3_2016	0	0	0	0	0	0	0	0	0	0	0	5/23/16	20:45	23:11	146	MH	None	2.3	67.2	WRP
J_4	J4_2016	1	0	0	0	0	0	0	0	0	1	0	5/23/16	20:45	23:48	183	BW	None	3.2	63.4	Private
J_5	J5_2016	0	0	0	0	0	0	0	0	0	0	0	5/24/16	20:45	0:11	206	BW	None	4.5	63.7	Pit
J_6	J6_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20:45	NA	NA	NA	NA	NA	NA	WMA
J_7	J7_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20:45	NA	NA	NA	NA	NA	NA	WMA
J_8	J8_2016	1	0	1	0	0	1	1	0	0	4	1	5/23/16	20:45	23:35	170	BW	None	0.0	67.5	WMA
J_9	J9_2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20:45	NA	NA	NA	NA	NA	NA	WPA
K_1	K1_2016	1	0	0	0	0	1	0	0	0	2	0	5/23/16	20:45	21:19	34	BW	None	12.6	70.8	WMA
K_2	K2_2016	1	0	0	0	0	0	0	0	0	1	0	5/23/16	20:45	22:38	113	BW	None	2.0	69.8	WMA
K_3	K3_2016	1	0	0	0	0	1	0	0	0	2	0	5/23/16	20:45	22:56	131	BW	None	5.1	72.3	WPA

K_4	K4_2016	1	0	1	0	0	1	0	0	0	3	0	5/23/16	20:45	22:14	89	BW	None	10.1	68.9	WPA
K_5	K5_2016	1	0	1	0	0	0	0	0	0	2	0	5/23/16	20:45	21:58	73	BW	None	8.8	72.5	WPA
K_6	K6_2016	1	0	0	0	0	0	0	0	0	1	0	5/23/16	20:45	21:45	60	BW	None	9.9	70.1	WPA
K_7	K7_2016	1	0	1	0	0	1	0	0	0	3	0	5/23/16	20:45	23:04	139	BW	None	0.9	69.4	WPA
K_8	K8_2016	0	0	0	0	0	0	0	0	0	0	0	5/23/16	20:45	21:32	47	BW	None	8.4	69.8	WPA