CHANGE IN REFERENCE CONDITION WETLANDS AND ROAD DUST IMPACTS ON SPIDER MITES

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Increased disturbance from agriculture and the changing climate in the Prairie Pothole Region (PPR) of North Dakota may cause shifts in vegetation on wetland systems as well as increases in spider mite populations on soybeans. Part of this study focuses on wetlands functioning at the highest ecological state, or reference condition. Wetland plants serve as a good indicator for assessing wetland condition. The past and present Floristic Quality Index scores at each wetland site were significantly different ($p < 0.05$), indicating that vegetation at reference wetlands have declined in condition. Increased agriculture also leads to an increase in road dust on soybean fields, which increases the population of spider mites. Three separate experiments were completed on contained plaster arenas. These experiments produced mixed results. Spider mites produced more eggs on dusted arenas ($p < 0.05$) in experiment one while experiment two and three yielded the opposite result.

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PREFACE

This thesis contains two very different chapters funded through two different sources to pay for my schooling. The first chapter is a study that focuses on the change in reference condition wetlands in North Dakota over time. The second chapter is a study focused on the impacts of road dust and spider mites on soybeans.

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CHAPTER 1. CHANGE IN REFERENCE CONDITON WETLANDS

Introduction

Reference wetlands are defined as wetlands operating at the highest ecological function (Brinson et al. 1996). These wetlands, along with all others, are exposed to any number of stressors that can cause change over time. Anthropogenic and natural disturbances can impact wetlands by increasing sedimentation, chemicals and nutrients flowing into the system, and by altering the plant community through the introduction of nonnative species to the area (Miller et al. 2006). Wetland vegetation serves many ecological services including forage for domestic animals and wildlife, a source of critical habitat, structure and stability for the soil, and has the ability to uptake harmful nutrients and improve water quality (Fennessy et al. 1998). Reference condition wetlands and their plant communities are providing these ecological functions at the highest possible level. Wetlands with diverse native vegetation are more likely to be considered reference wetlands. However, these reference wetlands are not immune to habitat changes due to both natural and anthropogenic disturbances. Vegetation has proven to be one of the most sensitive features of wetland ecosystems; therefore, wetland plants are a good indicator for assessing wetland quality and change over time (Fennessy et al. 1998).

Wetland plant communities in the Prairie Pothole Region (PPR) evolved under a specific set of natural stressors, such as grazing by bison and other large ungulates and periodic fire (DeKeyser et al. 2003). When these wetlands are exposed to different anthropogenic disturbances (agriculture, urbanization, etc.) or lack of disturbance (idle wetlands) they are subject to change. Both highly disturbed and undisturbed wetlands are prone to declining plant community quality (DeKeyser et al. 2003). Therefore, monitoring these wetlands is crucial.

Monitoring and management of wetlands, including reference wetlands, is an ongoing struggle due to increased disturbance and change on both local and global scales. Various monitoring assessments aid in identifying and classifying reference condition wetlands including the Floristic Quality Index (FQI). The FQI is dependent on the abundance of native plant species within each wetland (TNGPFQAP, 2001). The assessment has proven to be an efficient tool to assess various wetland conditions across the country (Mushet et al. 2002; Wardrop et al. 2007; Paradeis et al. 2010; Hargiss et al. 2017).

Over half of wetland ecosystems in the world have been lost due to various disturbances (Moreno-Mateos et al. 2012). To compensate for these losses wetlands have been restored, replaced or created. However, the degree of success for these restored or created wetlands remains uncertain (Moreno-Mateos et al. 2012; Paradeis et al. 2010). Restored wetlands are often compared to reference wetlands to assess success or failure of the restoration (Moorhead 2013). Monitoring wetlands in reference condition is important because they are operating at the highest ecological function (Brinson and Rheinhardt 1996) and it can be assumed that if these wetlands are changing due to a variety of disturbances, so are wetlands of lower quality and function. Species richness, condition of wetlands soils, abundance and diversity of native plants and animals all reduce following a disturbance, and vegetation has been proven to be the slowest to recover (Moreno-Mateos et al. 2012). Assessing wetlands periodically and focusing on the changes occurring over time can help define the severity of the disturbances occurring. In order to do this effectively, it is estimated that at least 10 years need to have passed since the original assessment to truly observe change over time (Wilson and Nilsson 2009; Peng et al. 2010).

Fully functioning reference condition wetlands are also used as a comparison tool to test the function of other wetlands of different conditions (Brinson et al. 1996). Changes in wetlands can be assessed by comparing past and present satellite imagery (Ayanlande and Proske 2015; Lee and Yed 2009) or on site surveys of the plant community (DeKeyser et al. 2009). Assessing the past and present plant community at wetland sites can shed light on the possible changes occurring over time. Over the years, an increase in invasive species and decrease in species richness has been noticed in native prairie areas and reference wetlands across the United States (Kentula et al. 2004; DeKeyser et al. 2013). The plant communities at these reference wetland sites are changing over time as a result of many disturbances, therefore, it is important to monitor and manage them appropriately.

The PPR is one of the most wetland rich ecosystems in the world (Euliss et al. 1999). The assessment of reference condition wetlands in the PPR of North Dakota started in the mid 1990s and has continued since. Over the years, the climate has changed (IPCC 2013); as well as management regimes and general anthropogenic disturbances. Therefore, it is important to re-assess these sites to determine how the plant community of reference condition wetlands is responding. To date the authors are unaware of any prior studies in the PPR that have sought to estimate change over time at reference condition sites. The goal of this project is to re-assess reference wetlands across North Dakota to determine change over time. The specific objectives were to:

1) Analyze vegetation of four seasonal, four temporary and four semi-permanent reference condition wetlands in North Dakota; and
2) Look for trends in the data to determine change over time.

Literature Review

The wetland is considered one of the world's most unique ecosystems (Field et al. 2008). Wetlands serve as a transitional habitat to many different plant and animal species; aid in flood attenuation and can improve water quality by absorbing a variety of nutrients (Balcombe et al. 2005). North Dakota has an abundance of wetland habitats because the majority of the state is located within the Prairie Pothole Region (PPR). The PPR is a long stretch of land that was scoured out by glaciers, creating many shallow depressions, perfect for generating wetlands (Euliss et al. 1999). These PPR wetlands provide numerous ecological and economic services including habitat for many wetland dwelling species such as ducks. The entire PPR makes up only 10% of the continental breeding area for many duck species; however, this area produces about 50% of the entire duck population (Smith et al. 1964; Johnson et al. 2005). Each wetland in the PPR is located within a catchment basin. This catchment is defined as an area where rainfall accumulates and is outlined by the highest elevation points surrounding the basin (Mitsch and Gosselink 2007). Everything that occurs or changes within the catchment basin can impact the various parts and functions of a wetland (DeKeyser et al. 2009). Increased agricultural and anthropogenic disturbances in and around wetlands are major causes of wetland loss across the world (Johnston 2013; Rashford et al. 2016). North Dakota's original wetland area was around 2,000,000 hectares (5,000,000 acres), in 1984 this number dropped to 800,000 hectares (2,000,000 acres), resulting in a total wetland loss of 60% (Tiner 1984). A large percentage of the remaining wetlands in North Dakota are affected by various agricultural practices

Wetland Condition Assessments

Due to the extensive loss of wetlands and increased agricultural impact on remaining wetlands in North Dakota, it is important to monitor wetland condition. Since the implementation of the Clean Water Act in 1972, wetland assessment has been used to determine the condition of the Nation's wetlands (Hargiss et al. 2017). Assessing various aspects of wetland systems can help uncover the numerous gaps in the understanding of wetland condition. Brooks et al. (2004) defined wetland condition as the quality of the wetland as a function of various parameters. In recent years, measuring wetland condition has been defined as a multi-level approach (Mack 2006; USEPA 2016). Assessing the surrounding landscape (level 1), completing on-site checklists of various stressors (level 2), as well as intensely gathering quantitative data (level 3) can provide a well-rounded view of the wetland condition (Mack 2006; Stoddard et al. 2006; Hargiss et al. 2017). One example of an in-depth (level 3) assessment is the FQI. The FQI is a way to measure the quality of the plant communities in natural areas across the nation (Swink and Wilhelm 1979; TNPGPFQAP 2001; Hargiss et al. 2017) and has widely been used in wetlands (DeKeyser et al. 2003; McIndoe et al. 2008; Hargiss et al. 2017). It is dependent on the abundance of native plant species within each wetland and each native wetland plant species is assigned a coefficient of conservatism or C value (TNPGPFQAP 2001). C values are assigned a number from zero to ten, higher C values are awarded to conservative native species, lower C values are given to opportunistic native species, and introduced species are not given a C value. Conducting FQI assessments can be time consuming and costly in comparison to the Level 1 and 2 assessments (Hargiss et al. 2017). FQI assessments can take up a large portion of the day, while level 2 assessments can be completed on-site in less than an hour and level 1 assessments are usually completed from the office. Though time consuming, these in-depth assessments can give important information on the function and condition of wetland resources, as well as the possible influential disturbances (Hargiss et al. 2017). Over time, the advancement of technology has aided the assessment process with the creation of the

Geographic Information System (GIS) and satellite remote sensing. The use of these tools can aid in determining disturbances and possible change over time (Ayanlade and Proske 2015). Along with technology, reference condition wetlands play a huge roll in wetland assessment.

Reference Condition Wetlands

All ecological assessments need a benchmark to provide context for the results, reference condition provides the highest benchmark for wetland function (Brinson and Rheinhardt 1996; Hawkins et al. 2010). Most reference wetlands are located in areas with minimal anthropogenic disturbance (Brinson and Rheinhardt 1996). Therefore, regional reference condition sites are used to describe and measure the various aspects of other wetland systems (Hughes et al. 1986; Kentula et al. 1992). However, the term "reference condition" has many different meanings in various areas across the nation. In order to resolve the confusion between definitions, Stoddard et al. (2006) proposed the use of "reference condition for biological integrity" or RC(BI), when referring to environments of excellent condition and essentially un-impacted by humans. The addition of "biological integrity" was proposed to incorporate the main purpose of the Clean Water Act of 1972, "to restore and maintain the chemical, physical and biological integrity of the Nation's waters" (US Code title 33, chapter 26, subchapter 1, section 1251 (a)). The change in terminology to RC(BI), does not alter the original concept of reference condition. RC(BI) wetlands are still defined as wetlands functioning at the highest capacity with little to no human disturbance (Stoddard et al. 2006). However, in most areas in the United States, RC(BI) wetlands are scarce or non-existent. For example, due to the high amount of agriculture production in North Dakota, it is impossible to find wetlands with no human disturbance, therefore the standard RC(BI) definition does not fit. Stoddard et al. (2006) classified four other definitions to better describe highly functioning environmental conditions across a variety of landscapes.

These four conditions include: minimally disturbed condition (MDC), historical condition (HC), least disturbed condition (LDC), and best attainable condition (BAC) (Stoddard et al. 2006). MDC is defined as an environment absent of significant human disturbance with some natural variation. HC describes the condition of a specific environment at some point in history. In order to determine HC, it is important to define the condition of the environment pre-intensive agriculture and pre-settlement. LDC is defined as an environment with the best physical, chemical and biological conditions given in the current state of the landscape. LDC is described by analyzing data collected at various sites with a specific set of criteria defining what is best. Much of the nation, especially in the state of ND, has had heavy agriculture production including grazing by domestic livestock for many years. Therefore, LDC environments are considered to be the closest to reference condition in North Dakota. Lastly, Stoddard et al. (2006) describes BAC as the expected condition of least disturbed sites if found under proper management practices. BAC is confined by the terms of MDC and LDC, they will never be as good as MDC environments, or worse than LDC environments.

The use of regionally defined reference condition wetlands can help shed light on the various impacts effecting wetland systems. Gleason et al. (2008) surveyed the plant communities of cropped, restored and native prairie wetlands located on land under the U.S. Department of Agriculture Conservation Reserve and Wetland Reserve Programs. Cropped catchments were used as the baseline for assessing improvements, while native prairie wetlands were used as the upper benchmark to determine if specific restoration programs were preforming at their highest potential (Gleason et al. 2008). The EPA also used reference wetlands to compare wetland conditions across all 50 states in their 2011 and 2016 National Wetland Condition Assessment (USEPA 2016). Through this nationwide assessment they aimed to address the many gaps in biological condition and the physical, chemical and biological components of stress in various wetland systems (USEPA 2016). Using reference condition to help define possible disturbances and changes occurring in a specific area can promote possible changes in management regimes.

Wetland Change Over Time

Identifying the changes occurring over time at wetland sites can provide insight into the function and various processes that give structure to the surrounding landscape (Jager and Rohweder 2017). The use of satellite remote sensing and on-site assessments have been used to understand wetland landscapes, the effects of human activates and possible wetland change (Gulinck et al. 2001; Kentula et al. 2004; Shalaby and Tateishi 2007). Quantifying these changes is incredibly important for understanding the effects of urbanization and agriculture on wetland systems, as well as the effectiveness of management strategies (Kentula et al. 2004). When wetlands are exposed to disturbance, many aspects are subject to changes. Many wetlands located in urban areas have decreased cover of aquatic vegetation (Jager and Rohweder 2017) and degraded plant communities (Magee et al. 1999). The causes of these changes are thought to be the altered hydrological conditions, incoming invasive species and increased floodplain development (Jager and Rohweder 2017). Wetlands in both urban and agricultural environments are subject to both indirect (i.e. altered hydrology due to drainage) and direct (i.e. excavation) changes (Day et al. 2000). Day et al. (2000) concluded that there was no significant difference between direct and indirect wetland loss, and wetland loss is not due to one or the other, rather a complex mixture of the two.

The US Fish and Wildlife Service developed the National Wetland Inventory (NWI) to characterize and monitor the nation's wetlands (Wilen and Bates 1995). The NWI is a popular database for various studies focusing on wetland change over time. However, a study focusing on wetland change over a span of 16 years (1982-1998) found that 40% of wetlands previously identified in the NWI had been excavated or farmed (Kentula et al. 2004). Therefore, it is incredibly important that the NWI be regularly updated, as well as periodically assessing the wetlands to accurately account for the rapid changes occurring (Oslund et al. 2010). These changes can identify possible disturbances occurring in and around wetland systems.

Disturbances

Agriculture

In the Northern Great Plains alone, half of the land that surrounds wetlands is cropland (Gutenspergen et al. 2002). Cropland can have many impacts on wetland systems and functions, including altered hydrology. A study by Euliss and Mushet (1996) completed on temporary, seasonal and semi-permanent wetlands in the PPR assessed water level fluctuations on wetlands located on tilled lands compared to wetlands surrounded by undisturbed grassland. The study found that water levels in wetlands in tilled fields fluctuated about 14 centimeters (cm) while water levels on wetlands within grasslands only fluctuated about four cm (Euliss and Mushet 1996). Tillage reduces a wetlands natural ability to mitigate surface flow and can also alter ground water hydrology (Jordan et al. 2003). This fluctuation also disrupts the wetlands ability to transform and trap nutrients (Jordan et al. 2003). These changes can disturb the flora and fauna that inhabit the area. Studies have shown wetlands located adjacent to fields with herbicide applications or tillage can indirectly reduce overall plant species richness (Gutenspergen et al. 2002). Altered drainage, along with sediment and various nutrients it can transport, all have the ability to degrade wetlands (Jordan et al. 2003). Tile drainage is becoming an increasingly popular practice to remove excess surface water from fields (Smith et al. 2015). Some wetlands require surface runoff in order to recharge groundwater systems (Harbor 2007). Discharge of nutrients and sediment has increased due to increased fertilizer applications on many croplands (Jordan et al. 2003). These sources of nonpoint pollution could be eased if wetlands located near agriculture practices had the ability to cycle these nutrients. However, most wetlands located in or near agriculture practices are degraded in some way and cannot effectively trap and process the nutrients coming in (Gutenspergen et al. 2002). Many wetlands present in agricultural fields are completely converted to cropland as a result of drainage and tilling during the dry season (Stewart and Kantrud 1973; Knutsen and Euliss 2001).

Climate Change

Climate change is a major issue impacting landscapes all over the world, including wetlands in the PPR. Studies have shown that the average temperature throughout the United States has increased by 1.3 degrees Fahrenheit since the year 1850 and will continue to rise (Field et al. 2008). Some presume climate change is driven by the changes humans have made to the earth's surface over time. Urbanization and agriculture have been expanding at a rate so fast, the earth cannot account for all the alterations (IPCC 2013). A study completed on protected environments in Europe suggested that by the year 2080, 58% of the terrestrial plants in these areas will not be able to survive in the predicted future climatic conditions (Araujo et al. 2011). This overall warming also disrupts wetland habitats and functions.

Climate change has been shown to alter the way water cycles between lakes, rivers and the land (Erwin 2008; Field et al. 2008). Climate simulation models conducted by Johnson et al. (2010) concluded that all PPR wetland types had a decrease in seasonal water levels as a result of 2^{o} C and 4^{o} C temperature increases. Altered precipitation in the PPR, as a result of climate change, is expected to range from -5 to +10 percent of current conditions (IPCC 2013). However, a possible gain in precipitation will be offset by increased evapotranspiration rates from the predicted temperature increases (Ballard et al. 2014). Many wetlands rely on precipitation as a water source; this makes them incredibly vulnerable to climate change and urban developments (Winter 1999; Burkett and Kusler 2000). Wetlands have always had periods of flooding and drought, climate change can alter the severity and the timing of these conditions (Renton et al. 2015). Climate models completed by Renton et al. (2015) conclude that wetlands in the PPR will spend more time in dry conditions with low productivity. The altered hydrologic conditions can cause a shift in the plant community and the species that inhabit these wetlands (Bergkamp and Orlando 1999). It is possible that wetlands could naturally adapt to the changing climate over time; however, human disturbance is making this much more difficult (Day et al. 2008; Johnson et al. 2005).

Grazing and Idle Wetlands

Before human settlement, natural grazing by a variety of ungulates was common for many wetland and prairie systems in the PPR. Grazing by domesticated cattle has been and currently is a popular form of controlled disturbance in the PPR. However, the intensity and duration of cattle grazing can alter the plant communities present in various areas (Milchunas et al. 1988). When the intensity and duration increase, the plant communities are subject to overgrazing, and therefore a decrease in diversity (Milchunas et al. 1988; Foote and Hornung 2005). A moderate, controlled amount of grazing has shown to increase plant community diversity and productivity (Bakker and Ruyter 1981).

Many wetlands located on private or untouched land are at risk of becoming idle. Wetlands without any natural disturbances (i.e. grazing and periodic fire) decreases the retention of surface waters and the rate of nutrient turnover (Kantrud et al. 1989). The complete removal of grazing in some systems allowed taller grassland species to overgrow and outcompete shorter species (Belsky 1992). Belsky (1992) found that these shorter species eventually reduced in cover and were eliminated from the study area. Therefore, adequate grazing disturbance is pertinent to the success of various grassland and wetland systems.

Invasive Species

With warmer climates and limited rainfall, it is easier for invasive species to out-compete native vegetation (Etheridge et al. 1996; Badh et al. 2009). Over time, it is estimated that 50,000 nonnative species have been introduced to the US (Pimentel et al. 2004). One study showed that about 3% of the Earth's ice-free surface is covered by invasive species (Monney and Cleland 2001). The highly competitive nature of these species makes it more difficult for native vegetation to thrive. A study completed on wetlands showed invasive vegetation has a strong suppressive effect on native seedlings (Hager 2004). Once invasive vegetation is in place, the native seedlings have trouble establishing and cannot grow.

The aggressive spread of invasive species is also affecting the quality of many aquatic and terrestrial areas in the state of North Dakota (DeKeyser et al. 2013). Two of the most dominant upland invasive species across the Great Plains are Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*) (Cully et al. 2003).). It is believed natural prairie areas invaded by Kentucky bluegrass have a modified hydrology (Toledo et al. 2014), thus impacting the hydrology of wetlands in the Northern Great Plains. The invasion of hybrid cattail (*Typha x glauca*) and reed canarygrass (*Phalaris arundinacea*) in the wet meadow and shallow marsh zones have also been shown to disrupt the wetlands natural systems (Galatowitsch et al. 1999). Once these and other nonnative species are established in a wetland area, they slowly lower the quality of the wetland and can reduce the effectiveness of future restoration (Galatowitsch et al. 1999). Landscapes in highly disturbed systems (i.e. high amounts of invasive species) are more likely to have higher turbidity (Hanson et al. 2005). These turbid states have been shown to decrease the population of aquatic invertebrates, which, in turn, decreases many fish and wildlife species due to low food availability (Anteau and Afton 2008). The ecosystem alterations associated with wide spread invasions have the ability to create novel ecosystems. A novel ecosystem is defined as a species composition or abundance that has never occurred in a specific biome ever before. These new ecosystems can completely alter the functions of a wetland which can lead to degradation in plant communities among other disturbances (Hobbs et al., 2006).

Methods

Study Area

The study area for this project was the state of North Dakota. North Dakota was once home to an estimated 2,000,000 hectares (5,000,000 acres) of wetlands; however, due to a variety of disturbances, only about 800,000 hectares (2,000,000 acres) remain (Tiner 1984). Each reference condition wetland site sampled was located in the Missouri Coteau sub-ecoregion within the PPR. The Missouri Coteau is known for having extensive mixed grass prairie and is the most wetland rich sub-ecoregion within the PPR (Stewart and Kantrud 1971; Bryce et al. 1998; Dyke et al. 2015). The dominant land uses in this ecoregion include farming of small grain, corn, soybean and sunflowers; as well as, livestock ranching (Dyke et al. 2015).

Site Selection

Surveys conducted by the North Dakota Department of Health and the Environmental Protection Agency (EPA) between 1998 and 2004 sampled ten seasonal, nine temporary and five semi-permanent reference condition wetlands across the state. Therefore, the sample population of wetlands for this study was 24 reference condition wetlands that were sampled extensively for vegetation at least 10 years prior to 2016. Wetland locations were identified through past projects, Google Earth and ArcMap. Private landowners were first contacted by phone in early summer 2016. Phone numbers and home addresses were obtained by entering the section, township and range information on the North Dakota Recorders Information Network website (www.ndrin.com). Landowners were called three times over a one-week period, if no response was given, a letter was sent to their home address with an enclosed permission-to-access form and self-addressed stamped envelope. Of the five wetlands located on private land, no landowners gave permission to access their land. A total of 10 wetlands were located on public US Fish and Wildlife Service (USFWS) land. To access these wetlands, USFWS officials were contacted with information about the survey and potential survey dates. The remaining nine wetlands were located on public land owned by the state of North Dakota. A request of permission to access this land was submitted to the Department of North Dakota Trust Lands at least one month prior to the survey date. Once all sites were approved, a list of lessee information was provided and a letter was sent to their home addresses describing the project and informing them of the study and site visit. Of the 19 reference condition wetlands we received permission to survey, a total of 12, four temporary, four seasonal, and four semi-permanent, were randomly selected for sampling (Figure 1).

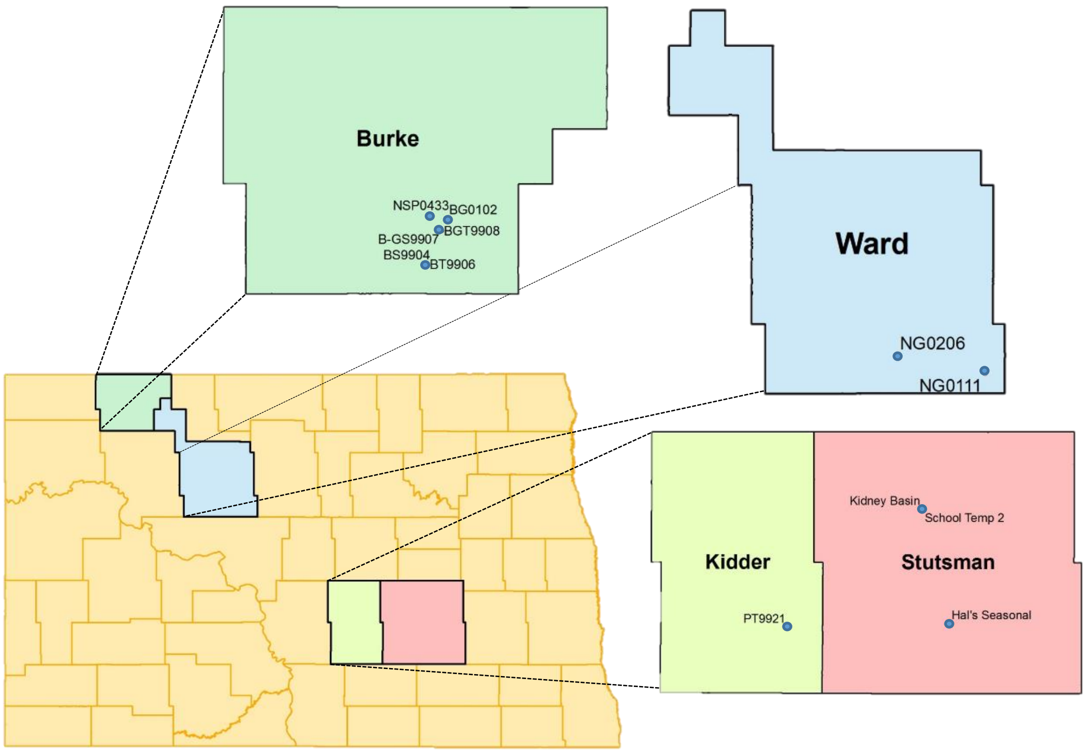


Figure 1.1. Location of the 12 final reference condition wetlands sampled.

Vegetation Sampling Methods

At each reference wetland, the plant community was assessed using a $1m^2$ quadrat method, similar to DeKeyser et al. (2003) and Hargiss et al. (2008) studies. Vegetation zones assessed for temporary wetlands consist of the low prairie and wet meadow zones (Stewart and Kantrud 1971). The low prairie zone is classified as the upland zone adjacent to the wetland and the line between the low prairie and wet meadow zone is the wetland boundary (Stewart and Kantrud 1971). Seasonal wetlands were sampled in the low prairie, wet meadow and shallow marsh zones; and semi-permanent wetlands the low prairie, wet meadow, shallow and deep marsh zones (Stewart and Kantrud 1971). The presence of each zone classifies the wetland type. Each quadrat was evenly distributed within each zone around the entire wetland using visual estimation. A total of eight quadrats were sampled in the low prairie zone, seven in the wet meadow, five in the shallow marsh, and five in the deep marsh zone. Within each quadrat, a list of primary species were identified and given a percent aerial cover. Additionally, presence of different species located between quadrats, or secondary species, were recorded to ensure that all species present within each zone and at the site were recorded. Both the primary and secondary species made up the complete species list at each site.

The complete past and present plant community species list from each site was ordinated and visualized using Nonmetric Multidimensional Scaling (NMS) in PC-ORD Version 7 (McCune and Mefford 2011). The NMS was run using a procedure based on meeting these conditions: “1) the final stress less than 20, 2) randomization test $p \leq 0.05$, and 3) a reduction of at least 5 points of stress with each additional axis” (Peck, 2016). The Relative Sorenson distance measure was used in the NMS analysis. A permutation ANOVA, or PERMANOVA, was used to compare past and present plant communities in PRIMER-E (Version 7) using PERMANOVA + (Anderson et al. 2008). The sites were treated as blocks to remove some of the variability due to differences in plant communities between sites. A Relative Sorenson distance measure was used in the PERMANOVA analysis. All percent data were arc-sine square root transformed before analysis.

The complete species list that was compiled over 10 years ago was sampled using a variety of methods (Appendix A). Past and present data sets were compared for percent cover and presence of native species, number of annual or perennial species, as well as the FQI score. The FQI is dependent on the abundance of native plant species within each wetland and each native wetland plant species is assigned a coefficient of conservatism or C value (TNPGPFQ 2011).   The equation used to determine the FQI is shown below:

$$FQI = average\ C\ value\ \times \sqrt{N}$$

N= Total number of native species

The FQI is a numerical way to define the condition of a wetland. It focuses on the vascular flora and assesses each site based on the floristic quality (TNPGPFQ 2011). Higher C values are awarded to conservative native species that would only be found on native dominated areas while lower C values are given to "weedy" and opportunistic native species (TNPGPFQ 2011). These C values along with the number of native species are used to calculate FQI, wetlands with higher FQI values are more likely to be considered reference wetlands (TNPGPFQ 2011). Two analyses were done on the FQI values. The first analysis was a paired t-test between past and present values of the 12 sites. One paired t-test used the FQI values from all the wetland zones, while the other used solely the wet meadow FQI values. The second analysis used the difference between present and past FQI values. By subtracting present values from past values, the change over time value was found; in this analysis negative values indicate that there was a decrease in FQI values over time. The calculated differences were then analyzed as a completely randomized ANOVA using PROC GLM in SAS® software (Version 9.4, SAS System for Windows, Cary, NC, USA) examining if the three wetland types (seasonal, temporary, and semi-permanent) were different in how FQI values changed over time.

Results and Discussion

Average C-Value

The average C-values for all zones were determined using C-values from both past and present species lists. C-values for species in all wetland zones decreased at all 12 sites (Table 1.1, p = 0.000011). The low prairie zone also had a significant decrease in C-value (Table 1.2, p = 0.0033). In the wet meadow zone only, C-values slightly decreased at seven of the 12 sites

(Table 1.3); however, the paired t-test did not indicate a significant difference ($p = 0.549$). By using the average C-value alone, one can get a better idea on what species are integrating into these wetland sites. If the average C-value goes down over time, there may be an increased number of non-native species or more opportunistic native species (C < 3) (TNPGPFQAP 2001). A study completed by Mushet et al. (2002) found that natural complex wetlands in North Dakota had the highest average C-values (3.4 - 4.7) when compared to restored wetlands. The average C-values in the current study, were similar to the findings of Mushet et al. (2002), with past and present average C-values on all 12 reference condition sites falling between 3.04 and 5.51.

A one-way ANOVA test for all zones among wetland classifications was significant ($F = 6.02$, $p = 0.0219$) and found that seasonal wetlands had less reduction in C-values than semi-permanent wetlands, while temporary wetlands were not different from the others. The one-way ANOVA test in the low prairie indicated similar siginificant differences ($F = 5.24$, $p = 0.031$) and found that seasonal wetlands had less reduction than semi-permanent, while temporary wetlands were not different from either. The wet meadow one-way ANOVA test among wetland classifications was significantly different ($F = 5.19$, $p = 0.0317$) with the seasoanl wetlands having a slight increase, while the temporary was significantly lower and the semi-permanent was not different from either.

Table 1.1.

Past, present and difference (Past – Present) in average C-value across all zones. Wetland types followed by a different letter in italics were significantly different ($p < 0.05$).

Wetland Classification	**Wetland ID**	**Past Avg. C value**	**Present Avg. C value**	**Difference**
Temporary (*AB*)	School Temp 2	4.22	3.95	-0.27
	PT9921	4.85	4.03	-0.82
	BGT9908	4.95	4.25	-0.7
	BT9906	5.68	5.09	-0.59
Seasonal (*A*)	BGS9907	4.71	4.26	-0.45
	BGS9904	5.32	4.96	-0.36
	Kidney Basin	4.42	3.93	-0.49
	Hal's Seasonal	3.51	3.31	-0.2
Semi-Permanent (*B*)	NSP0433	4.70	3.93	-0.77
	BG0102	5.01	4.07	-0.94
	NG0206	4.71	3.94	-0.77
	NG0111	4.86	4.19	-0.67

Table 1.2.

Past, present and difference (Past – Present) in average C-value for the low prairie zone. Wetland types followed by a different letter in italics were significantly different ($p < 0.05$).

Wetland Classification	**Site Name**	**Past Avg C value**	**Present Avg C value**	**Difference**
Temporary (*AB*)	School Temp 2	4.52	4.34	-0.18
	PT9921	4.82	4.26	-0.56
	BGT9908	5.12	4.69	-0.43
	BGT9906	6.02	5.3	-0.72
Seasonal (*A*)	BGS9907	5.02	5.51	0.49
	BGS9904	5.55	5.28	-0.27
	Kidney Basin	4.47	4.34	-0.13
	Hal's Seasonal	3.93	3.63	-0.30
Semi-Permanent (*B*)	NSP0433	4.96	4.52	-0.44
	BG0102	5.24	4.53	-0.71
	NG0206	5.28	4.31	-0.97
	NG0111	5.11	4.49	-0.62

Table 1.3.

Past, present and difference (Past – Present) in average C-value in the wet meadow zone. Wetland types followed by a different letter in italics were significantly different ($p < 0.05$).

Wetland Classification	Wetland ID	Past Avg. C value	Present Avg. C value	Difference
Temporary (*B*)	School Temp 2	3.82	3.04	-0.78
	PT9921	4.29	3.54	-0.75
	BGT9908	4.17	3.15	-1.02
	BT9906	4.42	4.40	-0.02
Seasonal (*A*)	BGS9907	4.04	4.31	0.27
	BGS9904	3.62	4.73	1.11
	Kidney Basin	3.63	3.89	0.26
	Hal's Seasonal	2.71	3.11	0.40
Semi-Permanent (*AB*)	NSP0433	3.41	3.98	0.57
	BG0102	4.40	4.00	-0.40
	NG0206	3.66	3.58	-0.08
	NG0111	4.84	3.82	-1.02

Floristic Quality Index

The FQI values were calculated using past and present plant species lists. The FQI is used to estimate the condition of a specific site based on the C-values of the plant species present (TNGPFQAP 2001). Eleven of the 12 sites had a decline in FQI scores for all zones combined between past and present samples (Table 1.4). The decreasing average C-value across all zones paralleled the results for the change in FQI score over time. A paired t-test between the past and present FQI scores found a significant decline for the combined wetland zones ($p = 0.0012$). A one-way ANOVA indicated seasonal wetlands having a a lower reduction in FQI when compared to semi-permanent wetlands, while temporary wetlands were not different from either. The low prairie zone alone also had significant decline (Table 1.5, $p = 0.00396$). A one-way ANOVA completed on the low prairie zone alone indicated that there was no difference in changes between wetland types (F = 1.55, p = 0.265). Therefore, the low prairie zone on all wetland types were declining. Many changes can occur on a landscape over the course of 10 years including climate change and invasive species to name a few. This study did not research the cause of change in reference wetlands just if there was a change. Wetland plant communities have been shown to decrease in condition due to changes in the surrounding landscape, and depending on wetland size, these changes can have large or small impacts (Magee et al. 1999; Jager and Rohweder 2017). The significant decrease in FQI values at all 12 sites indicates that these reference condition sites are losing highly conservative native species and gaining exotic species and this is happening across the landscape.

The difference between the FQI scores in the wet meadow zone indicated that seven of the 12 sites were declining in condition (Table 1.6). However, a paired t-test between past and present wet meadow FQI values found no significant differences (p = 0.58). In contrast, when all zones (low prairie, wet meadow, shallow and deep marsh) were combined and when the low prairie was separated out, the paired t-test resulted in a significant difference between past and present FQI scores (Table 1.4 and 1.5). Therefore, the minimal wet meadow changes did not counteract the changes occurring in the other zones. This indicates that the low prairie, shallow and deep marsh plant communities are contributing to the difference in past and present FQI values. This demonstrates the importance of measuring vegetation in all of these wetland zones; rather than just focusing on one or two zones, to get a full picture of what is happening at the wetland basin. Poptcheva et al. (2009) found that after 20 years, the vegetation present in various wet meadow systems subject to different management practices were not in equilibrium, and the floristic composition in the wet meadow of these wetlands was shifting toward higher amounts of non-native species. Our results of the overall wetland are similar to the findings of

Poptcheva et al. (2009) as the amount of non-native species are increasing; however, that study found the changes happening in the wet meadow zone, where the current study did not see significant changes in the wet meadow zone.

Table 1.4.

Past, present and the difference (Past - Present) in Floristic Quality Index (FQI) scores for all wetland zones. Wetland types followed by a different letter in italics were significantly different ($p < 0.05$).

Wetland Classification	**Site Name**	**Past FQI**	**Present FQI**	**Difference**
Temporary (*AB*)	School Temp 2	28.32	28.99	0.670
	PT9921	41.43	25.77	-15.66
	BGT9908	35.73	32.12	-3.61
	BGT9906	39.73	33.74	-5.99
Seasonal (*A*)	BGS9907	38.28	36.1	-2.18
	BGS9904	46.67	39.95	-6.72
	Kidney Basin	35.38	34.06	-1.32
	Hal's Seasonal	29.4	27.12	-2.28
Semi-Permanent (*B*)	NSP0433	45.76	37.11	-8.65
	BG0102	50.6	37.74	-12.86
	NG0206	50.3	35.22	-15.08
	NG0111	54.29	39.94	-14.35

The significant decrease in FQI scores and C-values across all reference wetlands in this study bring up the questions: is reference condition useful and should these results influence the way reference conditions wetlands are used as a management tool in the future? Stoddard et al. (2006) explains four other wetland condition definitions that may alter the definition of reference condition in some areas. Stoddard et al.'s (2006) definition of wetlands in the least disturbed condition could be considered “reference condition” in North Dakota due to the fact that it is almost impossible to find an area without any anthropogenic related disturbances.

Table 1.5.

Past, present and the difference (Past - Present) in Floristic Quality Index (FQI) scores for the low prairie zones. Wetland types followed by a different letter in italics were significantly different ($p < 0.05$).

Wetland Classification	**Site Name**	**Past FQI**	**Present FQI**	**Difference**
Temporary (A)	School Temp 2	25.15	29.76	4.61
	PT9921	39.75	25.19	-14.56
	BGT9908	29.84	30.4	0.56
	BGT9906	40.4	33.52	-6.88
Seasonal (A)	BGS9907	33.69	32.62	-1.07
	BGS9904	43.69	37.34	-6.35
	Kidney Basin	40.97	30.07	-10.9
	Hal's Seasonal	25.46	23.21	-2.25
Semi-Permanent (A)	NSP0433	36.12	31.96	-4.16
	BG0102	45.1	31.72	-13.38
	NG0206	46.92	31.71	-15.21
	NG0111	45.4	33.31	-12.09

Table 1.6.

Past, present and the difference (Past - Present) in Floristic Quality Index (FQI) scores for the wet meadow zones. Wetland types followed by a different letter in italics were significantly different ($p < 0.05$).

Wetland Classification	Site Name	Past FQI	Present FQI	Difference
Temporary (AB)	School Temp 2	17.91	15.49	-2.42
	PT9921	19.64	17.35	-2.29
	BGT9908	20.02	16.36	-3.66
	BGT9906	19.27	17.04	-2.23
Seasonal (A)	BGS9907	21.36	24.4	3.04
	BGS9904	19.84	23.67	3.83
	Kidney Basin	20.51	26.39	5.88
	Hal's Seasonal	14.36	18.91	4.55
Semi-Permanent (B)	NSP0433	21.30	26.08	4.78
	BG0102	28.82	25.61	-3.21
	NG0206	32.45	26.14	-6.31
	NG0111	37.77	25.33	-12.44

However, it is important to note that some disturbance (ex. fire and moderate grazing) on Upper Great Plains prairies are important to maintaining reference condition. Reference condition wetlands are slowly disappearing across the landscape and shifting into MDC, LDC, and BAC (Stoddard et al 2006). Recognizing the shift toward more highly disturbed conditions and acknowledging our reference condition or “best of the best” wetlands are also changing can result in more accurate management regimes and conservation.

Vegetation by Zone for All Sites

The NMS analysis of all wetland zones produced a final result with three dimensions which represented 86% of the variation (final stress = 10.73163, randomization test $p < 0.05$, final instability = 0.00000, number of iterations = 82, I = 0.6875, A = 0.3017) in the data (Peck 2016). Axis 1 represented 42.6% of the variation, axis 2 represented 25.2% of the variation, and axis 3 represented 18.1% of the variation (Figure 1.2 and 1.3).

A complete list of species with an $r > 0.5$ or $r < -0.5$ with axis one, two and three can be found in Table 1.7. Table 1.7 also includes C-values for all species, as well as an average C-value for each positive and negative axis. Positively associated species with axis one have a higher C-value (5.56) when compared to all other axes. While the negatively associated species with axis one have a lower C-value (3.08). However, axis one is mainly important for separating the sites. Axis two and three give more information about the source of changes occurring on each site. Species positively associated with axis two have a higher average C-value of 4.64, when compared to other axes. However, most of these successional vectors are going away from the positive end of axis two (Figure 1.2), therefore, losing conservative native species like *Carex xerantica* and *Sporobolus heterolepis*. This indicates that most sites are declining in condition across all wetland zones. Negatively correlated species along axis one and two include several annual, biennial and perennial introduced species such as *Cynoglossum officinale*, *Plantago major* and *Melilotus officinallis*.

Axis three only represents 18.1% of the variation in the data (Figure 1.3), so the species associated both positively and negatively with this axis do not hold as much weight as Axis one and two. Only one species was negatively associated with axis three, *Populus tremuloides*. Therefore, successional vectors directed toward the positive end of axis three indicate a slight increase in woody species. Only two of the 12 successional vectors were directed this way, PT9921 and School Temp 2 (Figure 1.3).

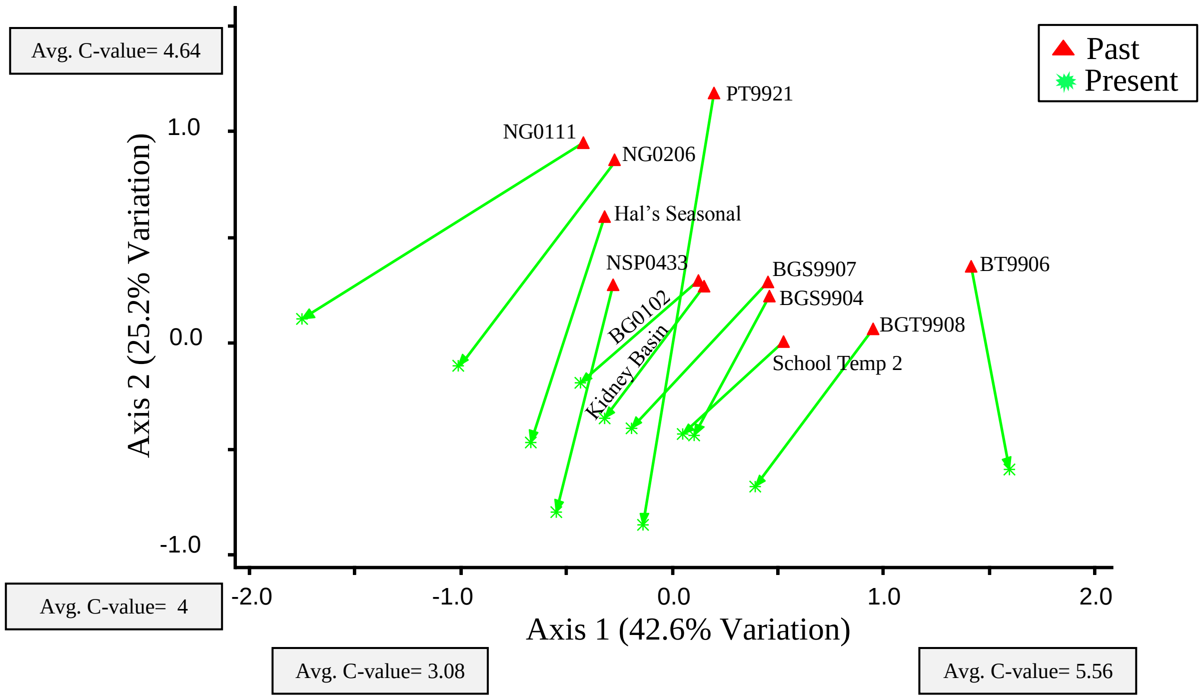


Figure 1.2. Nonmetric Multidimensional Scale (NMS) ordination of all zones (low prairie, wet meadow, shallow marsh and deep marsh) showing axis 1 and 2. Each pair of points represents one reference condition wetland site. The line connecting the two points represents the change over time. The PERMANOVA analysis found that past and present plant communities were significantly different ($p < 0.001$). Species found on each axis, along with their associated "r values" are listed in Table 1.7.

However, species positively associated with axis 3 included four introduced perennial and annual species and five species with a C-value < 3, resulting in an average C-value of 2 for this positive axis. Successional vectors directed toward the positive side of axis 3 indicate a decline in condition because of the lower average C-value associated with that end of the axis. Nine of the 12 wetland sites are clearly directed toward the lower C-values. Because of the low variation of axis 3, some successional vectors do not follow the trend that is occurring (PT9921, BT9906, and School Temp 2).

The NMS analysis of the low prairie zone compiled plant species lists produced a final result with three dimensions which represented 89% of the variation (final stress = 10.7552,

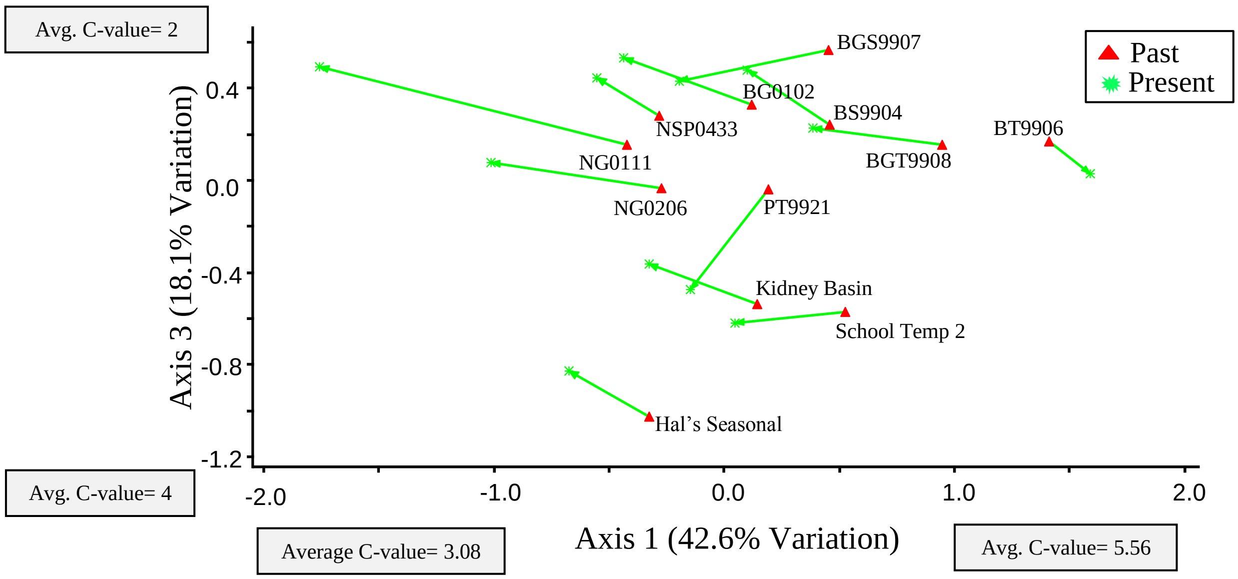


Figure 1.3. Nonmetric Multidimensional Scale (NMS) ordination of all zones (low prairie, wet meadow, shallow marsh and deep marsh) showing axis 1 and 3. Each pair of points represents one reference condition wetland site. The line connecting the two points represents the change over time. The PERMANOVA analysis found that past and present plant communities were significantly different ($p < 0.001$). Species found on each axis, along with their associated "r values" are listed in Table 1.7.

randomization test $p < 0.05$, final instability = 0.00000, number of iterations = 51, $I = 0.6845$, $A = 0.2805$) in the data (Peck 2016). Axis one represented 42.3% of the variation, axis two represented 32.4% of the variation, and axis three represented 13.4% of the variation (Figure 1.4 and 1.5) .

A complete list of species with an $r > 0.4$ or $r < -0.4$ with axis one, two and three can be found in Table 1.8. Table 1.8 also includes C-values for all species, as well as an average C-value for each positive and negative axis. Axis one is mainly used for spatially separating each site, while axis two and three indicates the sources of differences between each site. There were no low prairie species positively associated with axis one. Species negatively associated with axis one included a mix of annual, perennial and biannual oppourtunistic native species such as *Grindelia squarrosa* and *Pediomelum argophyllum*. Species along the positive end of axis two include a variety of annual and perennial native and introduced species, such as, *Melilotus officinalis*, *Medicago sativa* and *Echinochloa crus-galli*. Positive axis two has the lowest average C-value of 1.13, and 10 of the 12 sites are headed in this direction (Figure 1.4), indicating a loss of conservative species such as *Arnica fulgens* and *Camoanula rotundifolia*.

Table 1.7.

Plant species list for all zones along axis 1, 2 and 3. Introduced species are indicated with an asterisk (*) in the C-value column.

Axis 1 Positive	**r > 0.5**	**CC**	**Axis 2 Positive**	**r > 0.5**	**CC**
Artemisia ludoviciana	0.668	3	Achillea millefolium	0.817	3
Carex laeviconica	0.711	6	Elymus trachycaulus	0.652	6
Carex xerantica	0.529	10	Agrostis hyemalis	0.647	1
Galium boreale	0.523	4	Pascopyrum smithii	0.770	4
Rosa woodsii	0.554	5	Ambrosia psilostachya	0.581	2
Sporobolus heterolepis	0.538	10	Andropogon gerardii	0.809	5
Stachys palustris	0.614	3	Schizachyrium scoparium	0.726	6
Symphoricarpos occidentalis	0.720	3	Anemone canadensis	0.508	4
Vicia americana	0.503	6	Antennaria microphylla	0.556	7
Average CC (Axis 1 +)		**5.56**	Antennaria neglecta	0.693	5
Axis 1 Negative	**r < -0.5**	**CC**	Arabis hirsuta	0.538	7
Conyza canadensis	-0.518	0	Symphyotrichum ericoides	0.848	2
Cynoglossum officinale	-0.565	*	Symphyotrichum falcatum	0.771	4
Epilobium ciliatum	-0.518	3	Astragalus flexuosus	0.509	4
Juncus articulatus	-0.508	7	Calamagrostis stricta	0.632	5
Juncus torreyi	-0.636	2	Cirsium flodmanii	0.711	5
Myriophyllum spicatum	-0.615	3	Chenopodium rubrum	0.629	2
Plantago major	-0.533	*	Carex brevior	0.612	4
Potamogeton crispus	-0.540	*	Dalea purpurea	0.514	8
Stuckenia pectinata	-0.503	0	Distichlis spicata	0.542	2
Puccinellia nuttalliana	-0.518	4	Elaeagnus commutata	0.503	5
Salix bebbiana	-0.518	8	Eleocharis macrostachya	0.668	4
Salix eriocephala	-0.518	5	Vulpia octoflora	0.569	0
Oligoneuron album	-0.518	8	Galium boreale	0.528	4
Average CC (Axis 1 -)		**3.08**	Hordeum jubatum	0.518	0

r > or < 0.5 = correlation coefficient
CC= Coefficient of Conservatism

Table 1.7.

Plant species list for all zones along axis 1, 2 and 3. Introduced species are indicated with an asterisk (*) in the C-value column (continued).

Axis 2 Positive (cont.)	**r < 0.5**	**CC**
Juncus arcticus	0.833	5
Juncus interior	0.568	5
Lobelia spicata	0.622	6
Muhlenbergia asperifolia	0.520	2
Muhlenbergia richardsonis	0.600	10
Panicum virgatum	0.561	5
Polygala verticillata	0.541	8
Potamogeton gramineus	0.580	6
Pediomelum argophyllum	0.606	4
Ratibida columnifera	0.519	3
Rudbeckia hirta	0.700	5
Packera pseudaurea	0.597	5
Solidago mollis	0.730	6
Hesperostipa spartea	0.640	8
Taraxacum officinale	0.651	*
Utricularia macrorhiza	0.527	2
Viola pedatifida	0.570	8
Zigadenus elegans	0.580	8
Average CC (Axis 2 +)		**4.64**
Axis 2 Negative	**r > 0.5**	**CC**
Symphyotrichum lanceolatum	-0.506	4
Melilotus officinalis	-0.551	*
Potentilla arguta	-0.511	8
Average C-value (Axis 2 -)		**4.00**

Axis 3 Positive	**r > 0.5**	**CC**
Alopecurus aequalis	0.548	2
Ambrosia psilostachya	0.564	2
Bidens cernua	0.527	3
Bidens frondosa	0.670	1
Boltonia asteroides	0.579	3
Chenopodium glaucum	0.621	*
Carex vulpinoidea	0.641	2
Glyceria grandis	0.556	4
Helianthus maximilianii	0.655	5
Lotus unifoliolatus	0.514	3
Medicago lupulina	0.558	*
Plantago major	0.517	*
Polygonum lapathifolium	0.504	1
Pediomelum argophyllum	0.520	4
Rumex salicifolius	0.632	1
Setaria pumila	0.613	*
Sparganium eurycarpum	0.538	4
Vernonia fasciculata	0.686	3
Xanthium strumarium	0.612	0
Average CC (Axis 3 +)		**2.00**
Axis 3 Negative	**r > 0.5**	**CC**
Populus tremuloides	-0.521	4
Average CC Axis 3 -)		**4.00**

r > or < 0.5 = correlation coefficient
CC= Coefficient of Conservatism

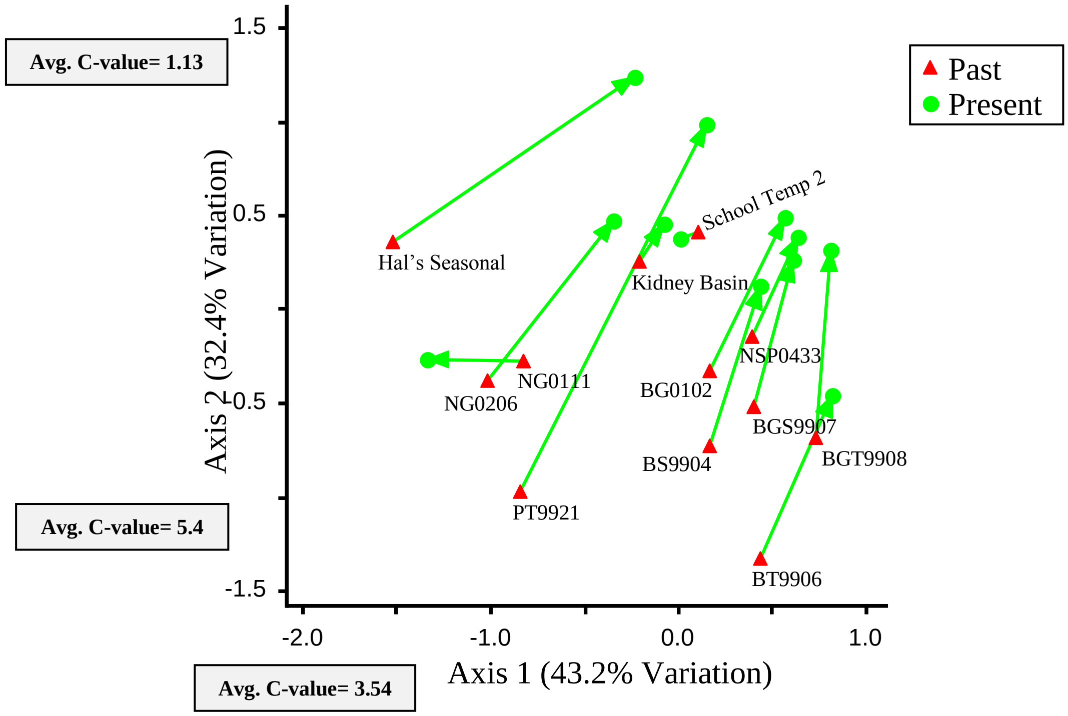


Figure 1.4. Nonmetric Multidimensional Scale (NMS) ordination of low prairie zone showing axis 1 and 2. Each pair of points represents one reference condition wetland site. The line connecting the two points represents the direction of change over time. The PERMANOVA analysis found that past and present plant communities were significantly different ($p < 0.001$) Species found on each axis, along with their associated "r values" are listed in Table 1.8.

However, species associated with the negative end of axis two has the highest C-value of 5.4, when compared to all other axes. Although, only two sites are directed toward this end of the axis with the higher average C-value, School Temp 2 and NG0111.

Axis three only accounts for 13.4% of the variation; therefore, the species and successional vectors associated with Figure 1.7 are not as important as axis one and two. Positively associated species with axis three include a mix of annual and perennial native and introduced species with an average C-value of 6. The negative side of axis three contains only one invasive species, Kentucky Bluegrass (*Poa pratensis*). *Poa pratensis* is one of the most common low prairie invasive species in the Great Plains (Cully et al. 2003). However, all sites seem to be directed away from the negative end of axis three. Therefore, *Poa pratensis* was not a main driving force in the decrease in condition in the low prairie zone mainly due to its dominating presence in the past and present plant communities.

In a study of North Dakota upland zones across the state DeKeyser et al. (2013), found that *Poa pratensis* and other invasive species were rapidly invading native upland zones as a result of climate change and other disturbances. Management of the upland zone can have major impacts on wetland condition (Renton et al. 2015). The low prairie zone is located adjacent to the wetland is considered the closest upland zone to the wetland; therefore, the upland zone can serve as a pathway for invasive species to migrate into wetland areas. The competitive nature of these invasive species reduces native plant cover (Hager 2004) and will have the most impact on the most conservative species (highest C value) as they are less able to grow in disturbed conditions. This explains the shift toward lower average C-values in the low prairie zone.

The NMS analysis of the wet meadow zone compiled plant species lists produced a final result with three dimensions which represented 82% of the variation (final stress = 12.13321, randomization test $p < 0.05$, final instability = 0.00000, number of iterations = 37, $I = 0.6455$, $A = 0.2231$) in the data (Peck 2016). Axis one represented 47.1% of the variation, axis two represented 18.8% of the variation, and axis three represented 16.5% of the variation (Figure 1.6 and 1.7).

A complete list of species with an $r > 0.4$ or $r < -0.4$ with axis one, two and three can found in Table 1.7. Table 1.7 also includes C-values for all species, as well as an average C-value for each positive and negative axis. Species positively associated with axis 1 include native perennials such as *Carex laeviconica, Sporobolus heterolepis*, and *Viola pedatifida*. Positive axis one has one of the highest average C-value amongst all axes (4.36). However, axis one is mainly used for spatially separating each site, while axis two and three indicate the sources of differences between each site. Also, the FQI scores for the wet meadow zone indicate that no significant changes were occurring; therefore, the successional vectors in Figures 1.6 and 1.7 show no obvious trend. Introduced and weedy native species associated with the positive end of axis two include annual species such as *Chenopodium glaucum*, *Potentilla norvegica*, and *Xanthium strumarium*. The positive end of axis two has a C-value of 2.14. Successional vectors in Figure 1.6 indicate a slight trend toward the positive end of axis two, indicating a loss of conservative native species such as *Dactylorhiza viridis*.

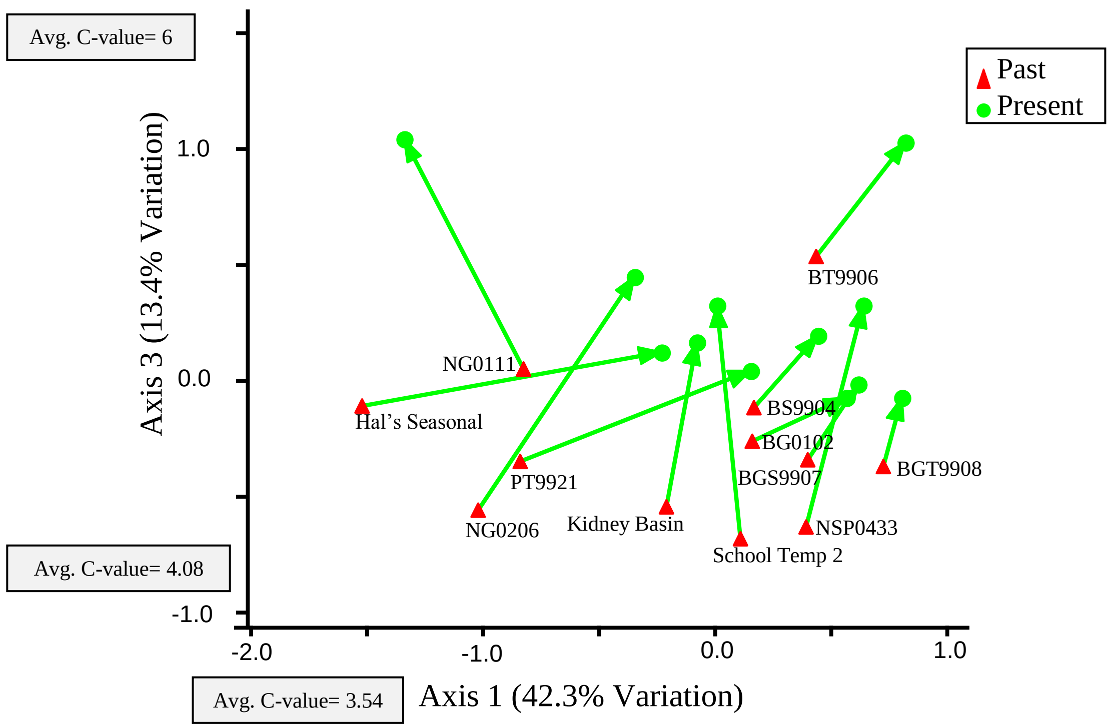


Figure 1.5. Nonmetric Multidimensional Scale (NMS) ordination of low prairie zone showing axis 1 and 3. Each pair of points represents one reference condition wetland site. The line connecting the two points represents the direction of change over time. The PERMANOVA analysis found that past and present plant communities were significantly different (p<0.001). Species found on each axis, along with their associated "r values" are listed in Table 1.8.

Table 1.8.

Plant species list for the low prairie along axis 1, 2, and 3. Introduced species are indicated with and asterisk (*) in the C-value column.

Axis 1 Negative	r < -0.4	CC
Achillea millefolium	-0.562	3
Agrostis scabra	-0.446	1
Pascopyrum smithii	-0.754	4
Ambrosia psilostachya	-0.773	2
Andropogon gerardii	-0.754	5
Schizachyrium scoparium	-0.703	6
Antennaria microphylla	-0.446	7
Antennaria neglecta	-0.435	5
Arctium minus	-0.423	*
Artemisia absinthium	-0.592	*
Symphyotrichum ericoides	-0.591	2
Boltonia asteroides	-0.480	3
Bouteloua gracilis	-0.405	7
Calamovilfa longifolia	-0.479	5
Cirsium flodmanii	-0.562	5
Carex brevior	-0.488	4
Carex vulpinoidea	-0.500	2
Cynoglossum officinale	-0.404	*
Dalea purpurea	-0.643	8
Distichlis spicata	-0.480	2
Erigeron strigosus	-0.610	3
Vulpia octoflora	-0.423	0
Grindelia squarrosa	-0.701	1
Hordeum jubatum	-0.654	0
Juncus interior	-0.605	5
Lobelia spicata	-0.644	6
Medicago lupulina	-0.732	*
Panicum virgatum	-0.599	5
Plantago major	-0.599	*
Polygala verticillata	-0.528	8
Pediomelum argophyllum	-0.720	4

Axis 1 Negative (cont.)	r < -0.4	CC
Ratibida columnifera	-0.822	3
Rudbeckia hirta	-0.664	5
Schoenoplectus acutus	-0.496	5
Setaria pumila	-0.463	*
Solidago mollis	-0.430	6
Oligoneuron album	-0.422	8
Hesperostipa spartea	-0.487	8
Taraxacum officinale	-0.505	*
Average C-value (Axis 1 -)		**3.54**
Axis 2 Positive	**r > 0.4**	**CC**
Ambrosia artemisiifolia	0.557	0
Apocynum cannabinum	0.418	4
Echinochloa crus-galli	0.431	*
Medicago sativa	0.413	*
Melilotus officinalis	0.527	*
Rorippa palustris	0.431	2
Vernonia fasciculata	0.411	3
Xanthium strumarium	0.431	0
Average C-value (Axis 2 +)		**1.13**
Axis 2 Negative	**r < -0.4**	**CC**
Achillea millefolium	-0.487	3
Elymus trachycaulus	-0.748	6
Anemone canadensis	-0.462	4
Arnica fulgens	-0.463	10
Artemisia ludoviciana	-0.516	3
Astragalus agrestis	-0.596	6
Symphyotrichum ericoides	-0.492	2
Symphyotrichum falcatum	-0.669	4
Calamagrostis stricta	-0.548	5
Campanula rotundifolia	-0.482	7
Chenopodium album	-0.443	*

r > or < 0.5 = Correlation coefficient
CC= Coefficient of Conservatism

Table 1.8.

Plant species list for the low prairie along axis 1, 2, and 3. Introduced species are indicated with and asterisk (*) in the C-value column (continued).

Axis 2 Negative (cont.)	r < -0.4	CC
Collomia linearis	-0.463	5
Comandra umbellata	-0.437	8
Carex laeviconica	-0.480	6
Carex praegracilis	-0.613	5
Carex xerantica	-0.542	10
Elaeagnus commutata	-0.498	5
Eleocharis erythropoda	-0.428	2
Equisetum laevigatum	-0.474	3
Galium boreale	-0.816	4
Helianthus nuttallii	-0.589	8
Heuchera richardsonii	-0.667	8
Juncus arcticus	-0.554	7
Liatris ligulistylis	-0.460	10
Muhlenbergia richardsonis	-0.531	10
Poa compressa*	-0.631	*
Potamogeton gramineus	-0.614	6
Rosa woodsii	-0.624	5
Packera pseudaurea	-0.484	5
Sisyrinchium campestre	-0.472	10
Sonchus arvensis	-0.597	*
Sporobolus heterolepis	-0.555	10
Stachys pilosa	-0.615	3
Stellaria longifolia	-0.466	8
Symphoricarpos occidentalis	-0.634	3
Taraxacum officinale	-0.403	*
Vicia americana	-0.606	6
Viola pedatifida	-0.551	8
Zigadenus elegans	-0.472	8
Zizia aurea	-0.518	8
Average C-value (Axis 2 -)		**5.4**

Axis 3 Positive	r > 0.4	CC
Agrimonia striata	0.454	5
Cynoglossum officinale	0.556	*
Juncus dudleyi	0.678	4
Potentilla arguta	0.481	8
Solidago ptarmicoides	0.479	8
Hesperostipa comata	0.462	6
Symphyotrichum laeve	0.522	5
Average C-value (Axis 3 +)		**6.00**
Axis 3 Negative	**r < -0.4**	**CC**
Anemone canadensis	-0.634	4
Symphyotrichum ericoides	-0.468	2
Calamagrostis stricta	-0.478	5
Carex brevior	-0.476	4
Glycyrrhiza lepidota	-0.617	2
Helianthus pauciflorus	-0.463	8
Juncus arcticus	-0.486	7
Poa palustris	-0.566	4
Poa pratensis	-0.672	*
Solidago altissima	-0.666	1
Solidago mollis	-0.420	6
Symphoricarpos occidentalis	-0.441	3
Thalictrum dasycarpum	-0.407	7
Average C-value (Axis 3 -)		**4.08**

r > or < 0.5 = Correlation coefficient
CC= Coefficient of Conservatism

Axis three only accounts for 16.5% of the variation; therefore, species and successional vectors in Figure 1.7 are not as important as axis one and two. Negative species on axis three include a mix of native perennial as well as introduced biannual and perennial species with an average C-value of 3.25. Species positively associated with axis three include only introduced perennial species, *Poa pratensis* and Quackgrass (*Elymus repens*); therefore the average C-value is 0. Vectors directed toward the positive end of axis three indicate an increase in these introduced species in the wet meadow zone. Both of these species are considered more common in upland zones, indicating the spread of invasive species into wet meadow areas. Bergkamp et al. (1999) found that wetlands are dependent on water levels. Various changes in precipitation and runoff can influence wetland hydrology, which alters water depth, temperature and other abiotic features, which affect the composition of wetland vegetation (Euliss et al. 2004). Therefore, this shift of upland species into the wet meadow zone could be caused by the natural shifts in water levels. Some opportunistic plants also shift to areas with a higher water content or areas higher in elevation in order to combat the rapidly changing climate (Pearson and Dawson 2003). The wet meadow is described as a band around the shallow marsh zone that can contain standing water at certain points in the year (Stewart and Kantrud 1971). Therefore, the wet meadow zone has more available water than the upland and low prairie zone, creating a buffer for plants to move up or down as it gets wetter or drier. The wet meadow zone does not contain any major invasive species. However, the more resilient opportunistic native species may migrate into this zone because they can survive in a variety of environments. These species have the ability to to outcompete native species and can change the composition of entire wetland zones (Etheridge et al 2006; Badh et al 2009). Successional vectors in Figure 1.7 do not show any certain trend toward one end of an axis or another. Therefore, axis three does not give much information about the overall change in condition of each wetland site.

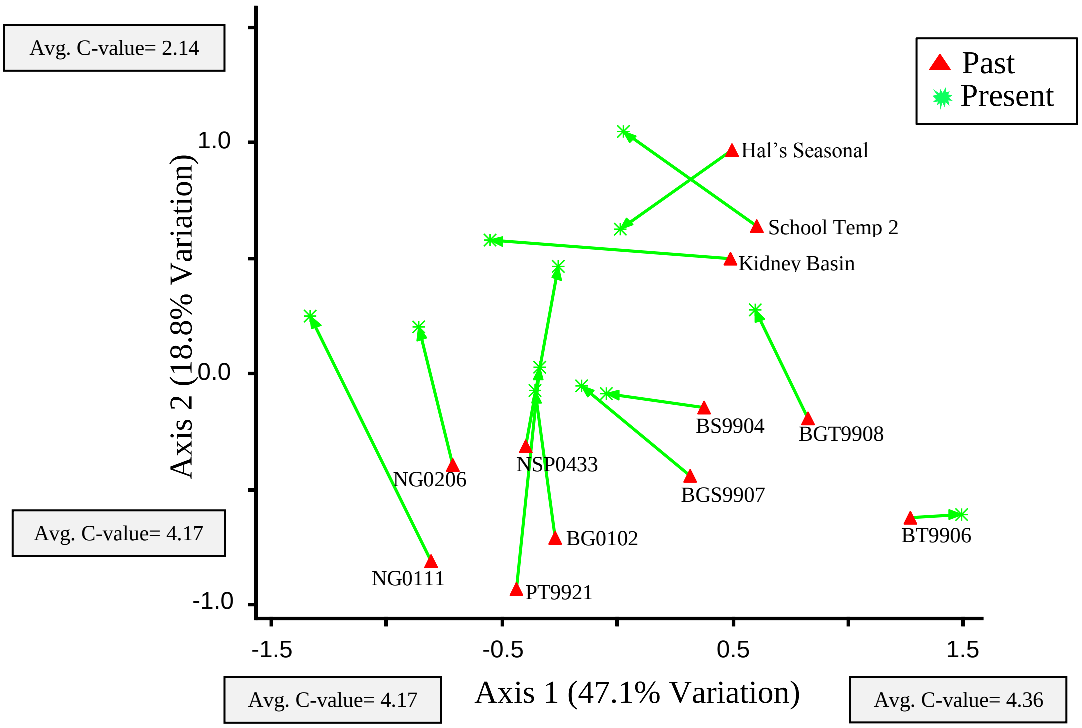


Figure 1.6. Nonmetric Multidimensional Scale (NMS) ordination of wet meadow species composition lists along axis 1 and 2. Each pair of points represents one reference condition wetland site. The line connecting the two points represents the direction of change over time. The PERMANOVA analysis found that past and present plant communities were significantly different ($p<0.001$). Species found on each axis, along with their associated "r values" are listed in Table 1.9.

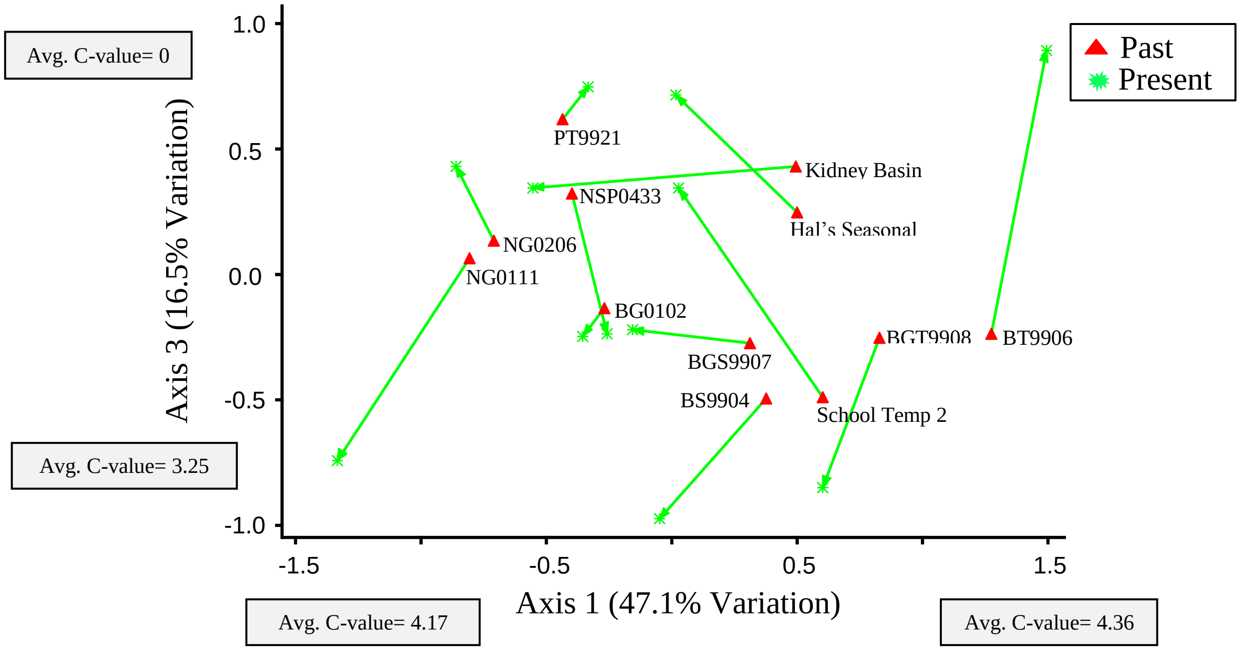


Figure 1.7. Nonmetric Multidimensional Scale (NMS) ordination of wet meadow species composition lists along axis 1 and 3. Each pair of points represents one reference condition wetland site. The line connecting the two points represents the direction of change over time. The PERMANOVA analysis found that past and present plant communities were significantly different ($p < 0.001$). Species found on each axis, along with their associated "r values" are listed in Table 1.9.

Table 1.9.

Plant species list for the wet meadow zone along axis 1, 2, and 3. Introduced species are indicated with an asterisk (*) in the C-value column.

Axis 1 Positive	**r > 0.4**	**CC**
Artemisia ludoviciana	0.507	3
Calamagrostis canadensis	0.416	5
Chenopodium album	0.409	*
Carex laeviconica	0.703	6
Erysimum cheiranthoides	0.466	*
Lysimachia hybrida	0.663	5
Rosa woodsii	0.461	5
Rumex crispus	0.576	*
Sporobolus heterolepis	0.448	10
Stachys palustris	0.507	3
Symphoricarpos occidentalis	0.554	3
Viola pedatifida	0.466	8
Average C-value (Axis 1 +)		**4.36**
Axis 1 Negative	**r < -0.4**	**CC**
Achillea millefolium	-0.531	3
Symphyotrichum ciliolatum	-0.416	8
Symphyotrichum ericoides	-0.587	4
Chenopodium rubrum	-0.487	2
Cirsium vulgare	-0.470	*
Carex praegracilis	-0.417	5
Carex sychnocephala	-0.416	7
Erigeron philadelphicus	-0.493	2
Erigeron strigosus	-0.416	3
Helianthus nuttallii	-0.409	8
Hordeum jubatum	-0.483	0
Juncus articulatus	-0.432	7
Juncus dudleyi	-0.486	4
Juncus torreyi	-0.485	2

Axis 1 Negative (cont.)	**r < -0.4**	**CC**
Liatris ligulistylis	-0.416	10
Medicago lupulina	-0.475	*
Muhlenbergia asperifolia	-0.406	2
Argentina anserina	-0.462	2
Puccinellia nuttalliana	-0.416	4
Ranunculus cymbalaria	-0.473	3
Salix bebbiana	-0.416	8
Schoenoplectus acutus	-0.408	5
Sisyrinchium campestre	-0.416	10
Solidago canadensis	-0.497	1
Average C-value (Axis 1 -)		**4.17**
Axis 2 Positive	**r > 0.4**	**CC**
Ambrosia artemisiifolia	0.467	0
Beckmannia syzigachne	0.427	1
Bidens frondosa	0.496	1
Boltonia asteroides	0.480	3
Chenopodium glaucum	0.484	*
Cirsium floodmanii	0.476	5
Helianthus maximilianii	0.407	5
Mentha arvensis	0.454	3
Oenothera biennis	0.460	0
Poa palustris	0.545	4
Polygonum pensylvanicum	0.407	0
Potentilla norvegica	0.587	0
Spartina pectinata	0.459	5
Vernonia fasciculata	0.633	3
Xanthium strumarium	0.404	0
Average C-value (Axis 2 +)		**2.14**

r > or < 0.5 = Correlation coefficient
CC= Coefficient of Conservatism

Table 1.9.

Plant species list for the wet meadow zone along axis 1, 2, and 3. Introduced species are indicated with an asterisk (*) in the C-value column (continued).

Axis 2 Negative	**r < -0.4**	**CC**
Symphyotrichum ericoides	-0.568	2
Calamagrostis stricta	-0.646	5
Chenopodium rubrum	-0.466	2
Carex praegracilis	-0.423	5
Equisetum laevigatum	-0.515	3
Euthamia graminifolia	-0.447	6
Dactylorhiza viridis	-0.417	10
Helianthus nuttallii	-0.423	8
Juncus arcticus	-0.562	5
Lobelia spicata	-0.467	6
Muhlenbergia asperifolia	-0.404	2
Ranunculus cymbalaria	-0.448	3
Salix petiolaris	-0.411	8
Packera pseudaurea	-0.564	5
Solidago canadensis	-0.506	1
Sonchus arvensis	-0.548	*
Triglochin maritima	-0.438	5
Average C-value (Axis 2 -)		**4.47**

Axis 3 Positive	**r > 0.4**	**CC**
Elymus repens	0.486	*
Poa pratensis	0.667	*
Average C-value (Axis 3 +)		**0**
Axis 3 Negative	**r < -0.4**	**CC**
Artemisia biennis	-0.485	*
Calamagrostis canadensis	-0.511	5
Cirsium arvense	-0.422	*
Conyza canadensis	-0.479	0
Carex sartwellii	-0.481	5
Epilobium ciliatum	-0.479	3
Juncus articulatus	-0.500	7
Polygonum amphibium	-0.551	6
Average C-value (Axis 3 -)		**3.25**

r > or < 0.5 = Correlation coefficient
CC= Coefficient of Conservatism

Conclusion

Over the course of 10 or more years, reference condition wetlands in North Dakota have declined in condition. The condition of all wetland zones significantly declined in FQI score and average C-value. The overall decline on all 12 sites was not driven by changes occurring in the wet meadow zone, nor was it due to one or two specific invasive species. This suggests that other disturbances were taking place and it is happening across the landscape causing a loss of highly conservative species. Though this study did not determine what was causing the change it is likely climate change, anthropogenic disturbance and invasive speices could all be factors.

Climate change and anthropogenic activity have been show to alter the vegetation and water cycling patterns of wetland systems in the PPR and the rest of the world. In some areas, these disturbances can create a community structure that has never been seen in that specific area.

The changes occurring in reference condition wetland plant communities across the landscape in North Dakota is alarming. These changes need to be documented not only in this region, but across the globe to determine what changes are happening and what are the precise mechanisms causing the change. This information is imperative to ensure proper conservation of these sites for the future and proper monitoring of change. The protection and proper management of these wetlands is vital to providing ecosystem services and maintaining species diversity. Proper management regimes for reference and other wetlands have the ability to improve habitat across the entire landscape.

Literature Cited

Anderson M, Gorley R, and Clarke K. 2008. PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. PRIMER-E: Plymouth, UK.

Anteau M and Afton A. 2008. Amphiod densities and indices of wetland quality across the Upper-Midwest, USA. Wetlands. 28: 184-196.

Araujo M, Alagador D, Cabeza M, Nogue´s-Bravo D, and Thuiller W. 2011. Climate change threatens European conservation areas. Ecology Letters. 14(5): 484–492

Ayanlade A and Proske U. 2015. Assessing wetland degradation and loss of ecosystem services in the Niger Delta, Nigeria. Marine and Freshwater Research.

Badh A, Akyuz A, Vocke G, and Mullins B. 2009. Impact of climate change on the growing seasons in select cities of North Dakota, United States of America. International Journal of Climate Change: Impacts and Responses. 1: 105-118.

Bakker J and Ruyter J. 1981. Effects of five years of grazing on a salt-marsh vegetation: A study with sequential mapping. Vegetatio. 44: 81-100.

Balcombe C, Anderson J, Ronald F, Rentch J, Grafton W, and Kordek W. 2005. A comparison of plant communities in mitigation and reference wetlands in the mid-Appellations. Wetlands. 25: 130-142.

Ballard T, Seager R, Smerdon J, Cook B, Ray AJ, Rajagopalan B, Kushnir Y, Nakamura J, and Henderson N. 2014. Hydroclimate variability and change in the Prairie Pothole Region, the "Duck Factory" of North America. Earth Interactions. 18: 1-28.

Belsky A. 1992. Effects of grazing, competition, disturbances and fire on species composition and diversity in grassland communities. Journal of Vegetation Science. 3: 187-200.

Bergkamp G and Orlando B. 1999. Wetlands and climate change. 22 pp.

Brinson M, and Rheinhardt R. 1996. The role of reference wetlands in functional assessment and mitigation. Ecological Applications. 6: 69-76.

Brooks R, Wardrop D, and Bishop J. 2004. Assessing wetland condition on a watershed basis in the mid-Atlantic region using synoptic land-cover maps. Environmental Monitoring and Assessment. 94: 9-22.

Bryce S, Omernik, J, Pater D, Ulmer M, Schaar J, Freeouf J, Johnson R, Kuck P, and Azevedo S. 1998. Ecoregions of North Dakota and South Dakota. (Two-sided color poster with map, descriptive text, summary tables, and photographs.) U.S. Geological Survey (scale 1:1,500,000). Reston, VA.

Burkett V and Kusler J. 2000. Climate change: Potential impacts and interactions in wetlands of the United States. Journal of the American Water Resources Association. 36: 313-320.

Cully A, Cully Jr J, and Hiebert R. 2003. Invasion of exotic plant species in tallgrass prairie fragments. Conservation Biology. 17: 990-998.

Day J, Britsch L, Hawes S, Shaffer G, Reed D, and Cahoon D. 2000. Pattern and process of land loss in the Mississippi Delta: A spatial and temporal analysis of wetland habitat change. Estuaries. 23: 425-438.

Day J, Christian R, Boesch D, Yanez-Arancibia A, Morris J et al. 2008. Consequences of climate change on the ecomorphology of coastal wetlands. *Estuaries and Coasts*. 31: 477-491.

DeKeyser E, Kirby D, and Ell M. 2003. An index of plant community integrity: Development of the methodology for assessing prairie wetland plant communities. Ecological Indicators. 3: 119-133.

DeKeyser E, Biondidni M, Kirby D and Hargiss C. 2009. Low prairie plant communities of wetlands as a function of disturbance: physical parameters. Ecological Indicators. 9:296-306.

DeKeyser E, Meehan M, Clamby G, and Krabbenhoft K. 2013. Cool season invasive grasses in Northern Great Plains natural areas. 33: 81-90.

Dyke S, Johnson S, and Isakson P. 2015. North Dakota state wildlife action plan. North Dakota Game and Fish Department. Bismarck, ND, USA.

Etheridge D, Steele L, Langenfelds R, Francey R, Barnola J, and Morgan V. 1996. Natural and anthropogenic changes in atmospheric CO2 over the last 1000 years from air in Antartic ice and firn. Journal of Geophysical Research. 101: 4115-4128.

Euliss N, and Mushet D. 1996. Water-level fluctuation in wetlands as a function of landscape condition in the prairie pothole region. Wetlands. 16: 587-593

Euliss N, Wrubleski D and Mushet D. 1999. Wetlands of the PPR: invertebrate species composition, ecology and management.

Euliss N, LaBaugh J, Fredrickson L, Mushet D, Laubhan M, Swanson G, Winter T, Rosenberry D, and Nelson R. 2004. The wetland continuum: A conceptual framework for interpreting biological studies. Wetlands. 24(2): 448-458.

Erwin L. 2008. Wetlands and global climate change: the role of wetland restoration in a changing world. *Wetlands Ecology and Management*. 17: 71-84.

Fennessy M, Gray M, Lopez R. et al. 1998,. An Ecological Assessment of Wetlands using Reference Sites. Vol. 1. *Final Report,* Ohio EPA Final Report to the U.S. EPA, State of Ohio Environmental Protection Agency, Division of Surface Water, Wetlands Division.

Field C, Boesch D, Chapin F, Gleick P, Janetos A, Lubchenco J, Overpeck J, Parmesan C, Root T, Running S, and Schneider S. 2008. Ecological Impacts of Climate Change. National Academies Press.

Foote A and Hornung C. 2005. Odonates as biological indicators of grazing effects on Canadian prairie wetlands. Ecological Entomology. 30: 273-283.

Galatowitsch S, Anderon N and Ascher P. 1999. Invasiveness in wetland plants in temperate North America. Wetlands. 19: 733-755.

Gleason R, Laubhan M, and Euliss N Jr. 2008. Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs: U.S. Geological Professional Paper 1745, 58 p.

Great Plains Flora Association. 1986. Flora of the Great Plains. University Press of Kansas. Lawrence, Kansas. 1402 pp.

Gulinck H, Mu´gica M, Delucio J, and Atauri J. 2001. A framework for comparative landscape analysis and evaluation based on land cover data, with an application in the Madrid region (Spain). Landscape and Urban Planning 55: 257–70.

Gutenspergen G, Peterson S, Leibowitz S, and Cowardin L. 2002. Indicators of wetland condition for the Priarie Pothole Region of the United States. Environmental Monitoring and Assessment. 78: 229-252.

Hager H. 2004. Competitive effect versus competitive response of invasive and native wetland plant speices. Oecologia. 139: 140-149.

Hanson M, Zimmer K, Butler M, Tangen B, Herwig B, and Euliss Jr N. 2005. Biotic interactions as determinants of ecosystem structure in prairie wetlands: An example using fish. Wetlands. 25: 764-775.

Harbor J. 2007. A practical method of estimating the impact of land-use change on surface runoff, groundwater recharge and wetland hydrology. Journal of the American Planning Association. 60: 95-108.

Hargiss C, DeKeyser E, Kirby D and Ell M. 2008. Regional assessment of wetland plant communities using the index of plant community integrity. *Ecological Indicators*. 3: 303-307.

Hargiss C, DeKeyser E, Norland J, and Ell M. 2017. Comparing tiers of a multi-tiered wetland assessment in the prairie pothole region. Wetlands Ecology Management.

Hawkins C, Olson J, and Hill R. 2010. The reference condition: predicting benchmarks for ecological and water quality assessments. Journal of the North American Benthological Society. 29: 312-343.

Hobbs R, Arico S, Aronson J, Baron J, Bridewater P, Cramer V, Epstien P et al. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography. 15: 1-7.

Hughes R, Larsen D, and Omernik J. 1986. Regional reference sites: a method fro assessing stream potentials. Environmental Management. 10(5): 629-635.

Intergovernmental Panel on Climate Change (IPCC). 2013. Climate Change 2013: The physical science basis. 1534 pp.

Jager N and Rohweder J. 2017. Changes in aquatic vegetation and floodplain land cover in the upper Mississippi and Illinois rivers (1989-2000-2010). Environmental Monitoring Assessment. 189: 77.

Johnson W, Millett B, Gilmanov T, Voldseth R, Guntenspergen G, and Naugle D. 2005. Vulnerability of Northern prairie wetlands to climate change. BioScience. 55: 863-872.

Johnson W, Werner B, Gutenspergen G, Voldseth R, Millett B, Naugle D, Tulbure M, Carroll R, Tracy J, and Olawksy C. 2010. Prairie wetland complexes as landscape functional units in a changing climate. BioScience. 60(2): 128-140.

Johnston C. 2013. Wetland losses due to row crop expansion in the Dakota Prairie Pothole Region. Wetlands. 33: 175-182.

Jordan T, Whigham D, Hofmockel K and, Pittek M. 2003. Nutrient and sediment removal by a restored wetland receiving agricultural runoff. Journal of Environmental Quality. 32: 1534-1547

Kantrud H, Krapu G, Swanson G. 1989. Prairie basin wetlands of the Dakotas: A community profile. Biological Report. 85.

Kentula M, Brooks R, Gwin S, Holland C, Sherman A, and Sifneos J. 1992. Wetlands. An approach to improving decision making in wetland restoration and creation.

Kentula M, Gwin S, and Pierson S. 2004. Tracking changes in wetlands with urbanization: Sixteen years of experience in Portland, Oregon, USA. Wetlands. 24: 734-743.

Knutsen G, and Euliss N. 2001. Wetland restoration in the Prairie Pothole Region of North America: A literature review. USGS/BRD/BSR-2001-006 Biological ScienceReport.

Larson G. 1993. Aquatic and wetland vascular plants of the Northern Great Plains. USDA Forest Service, General Technical Report RM-238. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO., 681 pp. + Ill.

Lee T, and Yed H. 2009. Applying remote sensing techniques to monitor shifting wetland vegetation: A case study of the Danshui river estuary mangrove communities. Ecological Engineers. 35: 487-496.

Mack J. 2006. Landscape as a predictor of wetland condition: an evaluation of the landscape development index (LDI) with a large reference wetlands dataset from Ohio. Environmental Monitoring and Assessment. 120: 221-241.

Magee T, Ernst T, Kentula M, and Dwire K. 1999. Floristic comparison of freshwater wetlands in an urbanizing environment. Wetlands. 19: 517-534.

McCune B and Mefford M. 2011. PC-ORD. Multivariate analysis of ecological data. Version 6. MjM Software, Gleneden Beach, Oregon, U.S.A.

McIndoe J, Rothrock P, and Reber R. 2008. Monitoring tallgrass prairie restoration performance using Floristic Quality Assessment. Proceedings of the Indiana Academy of Science. 117 (1): 16-28.

Milchunas D, Sala O, and Laurenroth W. 1988. A generalized model of the effects of grazing by large herbivores on grassland community structure. The American Naturalist. 132: 87-106.

Miller S, and Wardrop D. 2006. Adapting the floristic quality assessment index to indicate anthropogenic disturbance in central Pennsylvania wetlands. Ecological Indicators. 6: 313-326.

Mitsch W and Gosselink J. 2000. The value of wetlands: Importance of scale and landscape setting. Ecological Economics. 35: 25-33.

Monney H and Cleland E. 2001. The evolutionary impact of invasive species. Proceedings of the National Academy of Sciences. 98: 5446-5451.

Moorhead K. 2013. A realistic role for reference wetlands in restoration. Ecological Restoration. 31: 347-352.

Moreno-Mateos D, Power M, Comin F, and Yockteng R. 2012. Structural and functional loss in restored wetland ecosystems. PLoS Biology. 10(1).

Mushet D, Euliss N, and Shaffer T. 2002. Floristic quality assessment of one natural and three restored wetland complexes in North Dakota, USA. Wetlands. 22: 126-138.

Oslund F, Johnson R, and Hertel D. 2010. Assessing wetland changes in the Prairie Pothole Region of Minnesota from 1980 to 2007. Journal of Fish and Wildlife Management. 1(2): 131-135.

Paradeis B, DeKeyser E, and Kirby D. 2010. Evaluation of restored and native Prairie Pothole Region plant communities following an environmental gradient. Natural Areas Journal. 30: 294-304.

Pearson R and Dawson T. 2003. Predicting the impacts of climate change on the distrubition of species: Are bioclimate envelope models useful? Global Ecology and Biogeography. 12: 361-371.

Peck J. 2016. Multivariate analysis for ecologists: Step-by-step, second edition. MjM Software Design.

Peng G, ZhenGuo N, Xiao C, KuiYi Z, et al. 2010. China’s wetland change (1990-2000) determined by remote sensing. Science China Earth Science. 53: 1036-1042.

Pimentel D, Zuniga R and Morrison D. 2004. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics. 52: 273-288.

Poptcheva K, Schwartze P, Vogel A, Kleinebecker T, and Holzel N. 2009. Changes in wet meadow vegetation after 20 years of difference management in a field experiment (North-West Germany). Agriculture, Ecosystems and Environment. 134: 108-114.

Rashford B, Adams R, Wu J, Voldseth R et al. 2016. Impacts of climate change on land-use and wetland productivity in the Prairie Pothole Region of North America. Regional Environmental Change. 16: 515-526.

Reed P, Jr. 1988. National list of plant species that occur in wetlands: Northern Plains (Region 4). U.S. Department of the Interior, Fish and Wildlife Service. Washington, D.C. Biological Report 88(26.4).

Renton D, Mushet D, and DeKeyser E. 2015. Climate change and Prairie Pothole Wetlands – Mitigating water-level and hydroperiod effects through upland management: U.S. Geological Survey Scientific Investigation Report 2015–5004

Shalaby A and Tateishi R. 2007. Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. Applied Geography. 27: 28-41.

Smith, A, Stoudt J, and Gollop J. 1964. Prairie potholes and marshes. Waterfowl Tomorrow. 39-50.

Smith D, King K, Johnson, Francesconi W, Richards P, Dave Baker, and Sharpley A. 2015. Surface runoff and tile drainage transport of phosphorus in the Midwestern United States. Journal of Environmental Quality. 44: 495-502.

Stewart R and Kantrud H. 1971. Classification of natural ponds and lakes in the glaciated prairie region.

Stewart R and Kantrud H. 1973. Ecological distribution of breeding waterfowl populations in North Dakota. Journal of Wildlife Management. 37: 39-50.

Stoddard J, Larsen D, Hawkins C, Johnson R, and Norris R. 2006. Setting expectations for the ecological condition of streams: The concept of reference condition. Ecological Applications. 16: 1297-1276.

Swink F and Wilhelm G. 1979. Plants of the Chicago Region. Third ed., revised and expanded edition with keys. The Morton Arboretum, Lisle, IL.

Tiner R. 1984. Wetlands of the United States current status and recent trends. US Fish and Wildlife Service.

The Northern Prairie Great Plains Floristic Quality Assessment Panel (TNPGPTQAP). 2001. Coefficients of conservatism for the vascular flora of the Dakotas and adjacent grasslands: U.S.

Toledo D, Sanderson M, Spaeth K, Hendrickson J, and Printz J. 2014. Extent of Kentucky Bluegrass and Its Effect on Native Plant Species Diversity and Ecosystem Services in the Northern Great Plains of the United States. Invasive Plant Science and Management, 7(4):543-552.

USDA, NRCS. 2017. The PLANTS Database (http://plants.usda.gov, 19 June 2017). National Plant Data Team, Greensboro, NC 27401-4901 USA.

U.S. Environmental Protection Agency. 2016. National wetland condition assessment: 2011 technical report. Technical Report EPA 843-R-15-006.

Wardrop D, Kentula M, Jensen S, Stevens D, Hychka K, and Brooks R. 2007. Assessment of wetlands in the upper Juniata watershed in Pennsylvania, USA using the Hydrogeomorphic approach. Wetlands. 27: 432-445.

Wilen B and Bates M. 1995. The US Fish and Wildlife Service's National Wetlands Inventory project. Vegetatio. 118: 153-169.

Wilson S, and Nilsson C. 2009. Arctic alpine vegetation change over 20 years. Global Change Biology. 15: 1676-2684.

Winter T. 1999. The occurrence of wetlands within the concept of hydrologic landscapes. Specialty Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States. 235-239.

CHAPTER 2. ROAD DUST IMPACTS ON SPIDER MITES

Introduction

In order to manage arthropod pests within agricultural fields, it is important to have an understanding of the factors that contribute to their reproduction. Particulate matter (PM) is one factor that has received increased attention because of its impact on human health and plants (Grantz et al. 2003, TRS 2011). However, PM can also affect herbivorous arthropods that feed on affected plants.

PM is defined as a mixture of particles differing in origin, size and chemical composition that is generally divided into fine PM (0-2.5 μm) and coarse PM (2.5-10 μm) (Grantz et al. 2003). The physical and chemical characteristics of PM depend on the source from which it originates (Darley 1966, Shauer et al. 1996). For example, PM originating from cement factories is composed of various chemicals, such as chlorine (Cl) and calcium oxide (CaO), which cause it to have a more basic pH ($pH > 7$) (Darley 1966). However, most PM is composed of minerals and organic matter (Putaud et al. 2004) that originate from wind erosion, paved and unpaved roads, and construction (TRS 2011). Road dust, a specific kind of PM, is composed of both coarse and fine particles, and typically consists of a mixture of gravel (40-80%), sand (20-60%), and silt or clay (8-15%) (Woods 1960; Sanders and Addo 1993), although its chemical composition can be quite variable depending on its origin and particle size (Amato et al. 2009). Road dust can be of significant importance within agriculture systems (Prajapati and Tripathi 2008). Nearly 65% of all the roads in the United States are unpaved (Eaton et al. 1988), and traffic on gravel roads near agricultural areas can cause road dust to settle onto nearby crop plants (TRS 2011). A study focusing on dust dispersal found that particle size decreased as distance from the road increased (Farmer 1993), which suggests that fine materials can travel great distances and course material cannot travel far from their place of origin (Grantz et al. 2003, TRS 2011). However, particles with diameters of <10 μm can be transported for several thousand km by the wind (Zia-Khan et al. 2015). Therefore, plants near unpaved roads may be more heavily impacted by coarse particles, while fine particles have the potential to blanket large areas further away from the source of the dust.

There are multiple consequences once dust contacts a plant. Some of the most basic effects dust has on plants is related to it physically shading plant surfaces (Farmer 1993; Grantz et al. 2003), interfering with stomatal closure (Zia et al. 2013), and abrading leaf surfaces (Darley 1988), all of which can affect plant physiology and susceptibility to abiotic and biotic stressors (Grantz et al. 2003; Zia et al. 2013). The impact of dust on plant physiology depends on dust density on plant surfaces (Farmer 1993), with photosynthetic rate decreasing as dust load increases (Farmer 1993; Hirano et al. 1995). One study showed this relationship depended on the size of the dust particles, with an increase in the ratio of fine to course particles leading to a lower photosynthetic rate (Hirano et al. 1995). Hirano et al. (1995) also found that when cucumber plants were dusted when the stomata were open, the stomatal conductance, or the rate of CO_2 passing through the stomata, was significantly lower than control plants, and conductance decreased with particle size of the dust. Dust accumulation on leaf surfaces creates conditions similar to water stress (Zia-Khan et al. 2015), and plants under drought-like conditions are prone to serious long term effects such as decreased growth, development, reproduction, and yield (TRS 2011). In addition, stomatal blockage can increase leaf surface temperature, and vegetation with higher leaf surface temperatures can be more susceptible to drought (Farmer 1993). One study showed dust-covered cotton plants had canopy temperatures two to four °C higher than non-dusted plants (Eller 1977; Zia-Khan et al. 2015). Dust color can affect temperature changes independently of stomata, with darker colored dust increasing leaf surface temperatures more than light-colored dust (Hirano et al. 1995). Certain plant features such as rough or waxy leaf surfaces make the plant more susceptible to dust accumulation (Prajapati et al. 2008). Dust can abrade waxes on plant surfaces that protect against desiccation (Rai et al. 2010), and can also damage leaf tissue (Eveling 1972), all of which can make plants more susceptible to drought stress and reduce their longevity, growth, and reproduction (Farmer 1993).

The chemical composition of PM is also an important trait when considering effects of dust on plants. Dust from many roads is alkaline (Farmer 1993), and dust with a high pH can cause wilting and discoloration in a variety of plants (Darley 1966). Prajapati et al. (2008) suggests that cement dust and other dusts with high pH values (>9) can cause direct injury to leaf tissues, which is supported by a study that found obvious tissue damage on leaves exposed to cement-kiln dust (Darley 1966). Some dust is essentially chemically inert, containing no harmful chemicals or heavy metals (Subranmanyam and Roesli 2000), although other types of dust can contain environmental contaminants including heavy metals that are harmful to human and plant health (Raskin and Ensley 2000). Road dust acts as a "sink and source" for various pollutants, including eight heavy metals (As, Cd, Co, Cr, Pb, Cu, Zn, Mn and Ni) (Kexin et al. 2015). Some of these heavy metals can originate from brake pads, tires or other parts of vehicles (Apeagyei et al. 2010). The concentration of these heavy metals is directly related to the amount of traffic passing over the road (Apeagyei et al. 2010). The heavy metals are deposited with the road dust, and can cause earlier snowmelt, earlier flowering times for plants, and a decrease in mosses and lichens in ditch environments (Walker and Everett 1987; Santelmann and Gorham 1988). Dust can have a direct negative impact on the survival, growth, and reproduction of many plant species; however, dust can have other deleterious effects on plants due to indirect causes.

One way dust indirectly impacts plants is by affecting organisms that reside on exposed surfaces, such as herbivorous arthropods. Most herbivorous arthropods live on the surfaces of plant leaves (Helle and Sabelis 1985a), and dust can act as a physical barrier making it difficult for them to move around and establish colonies (Fleschner 1958, Glenn et al. 1999), and disrupting their settlement and feeding search patterns (Fleschner 1958). Conversely, dust can also aid in the establishment of herbivorous arthropods by providing hiding spaces from natural enemies (DeBach 1947) as well as reducing exposure to pesticide sprays and their residues (TRS 2011, Suzuki 2012). As mentioned previously, dust can increase leaf surface temperatures, which has major implications for arthropods, because they are poikilothermic (Gotoh et al. 2014). Dust can also cause the relative humidity of the leaf surface environment to fluctuate (Eller 1977; Zia-Khan et al. 2015), which is another abiotic factor important to the survival of small, soft-bodied arthropods (Ferro and Chapman 1984). Dust can not only affect herbivorous arthropods via physical and abiotic means, but can potentially impact arthropods indirectly via altering the quality of the host plant on which they feed. Plants exposed to dust are under physical stress and have altered physiology (White 1984; Price 1991), and plant stress has been linked with improved fitness and increased population density for numerous arthropod species (White 1984). Although dust may have various negative effects on the plant itself, these effects can create positive impacts for the herbivorous arthropods that feed on dusty plants.

Spider mites (Acari: Tetranychidae) are a common herbivorous arthropod that feed on a wide variety of host plants (Demirel and Cabuk 2008a, 2008b). Both adults and immatures have chelicerate mouthparts modified into needle-like stylets that help them penetrate and suck liquid out of individual plant cells (Helle and Sabelis 1985b). Spider mites can cause visible damage to soybean leaves and many other crops just 10 days after infestation (Haile 2003). As spider mite populations increase, infested leaves yellow, and can desiccate and die prematurely (Luedeling et al. 2009). Spider mites are a major problem in many agricultural and horticultural systems, and can cause significant yield loss (Haile 2003; Reddall et al. 2004). Part of the reason they are such important pests is because their populations can grow rapidly, especially under hot, dry, and dusty conditions (Helle and Sabelis 1985a).

For years, it has been noticed that spider mite infestations seem to occur more frequently, be more widespread, and be more severe under dusty conditions (DeBach 1947; Alstad and Edmunds 1982; Demirel and Cabuk 2008a, 2008b). The presence of dust can benefit spider mites in many ways. Dust can increase the temperature of the leaf surface (Zia-Khan et al. 2015). A study testing egg hatch rate in twospotted spider mites showed that more eggs hatched when subjected to low humidity and higher temperatures (Ferro and Chapman 1979; Vangansbeke et al. 2013). An infested leaf covered in dust also gives spider mites an “anchor” for their webbing (Holloway et al. 1943), and their webbing helps protect them from unfavorable abiotic conditions and natural enemies (Clotuche et al. 2011). Dust can also provide protection in the absence of webbing by creating hiding spaces from natural enemies, or enemy-free space (DeBach 1947). One study focusing on citrus mite populations on orchard trees found that pest mite populations were higher on talc treated trees versus control plants, even though there were predatory mites in both environments (DeBach 1947). Dusty substances were also thought to affect the predator’s physiology via desiccation, as well as reducing their ability to find food by acting as a physical deterrent (Felscher 1958). The decrease in natural enemies due to dust can promote mite infestations (Demirel and Cabuk 2008a, 2008b). However, some studies indicated that there was no correlation between the effects of dust on predators and pest mite populations (Oi and Barnes 1989). Instead, it is thought that the dust caused the plant to be more susceptible to drought, which increases mite outbreaks (Pringle et al. 2014). The development of spider mites and their offspring occurs faster on drought stressed plants (Nikolova et al. 2014). There are many potential reasons for spider mite success as a result of dusty conditions. Most studies use large scale methods such as field and greenhouse experiments to address these various hypotheses, very few have used smaller scale methods to focus on each possible hypothesis.

Because road dust has the potential to impact a large percentage of cropland, it is important to understand how it can affect herbivorous arthropods that feed on affected plants. The goal of this study was to examine effects of road dust on twospotted spider mites (*Tetranychus urticae* Koch), specifically short-term reproduction and the physical association of mites with dust particles under different environmental conditions. Our expectations were that mite reproduction would be higher on dusted arenas, and that more mites would be found in association with dust particles.

Materials and Methods

In order to address our objectives, we used short-duration lab experiments where arthropods were placed on dusted leaf discs in petri dish arenas. This allowed us to explore more direct effects of dust on arthropod biology and behavior while minimizing potential indirect effects of dust via altered host plant physiology or quality.

Arthropods used in experiments were twospotted spider mites (Acari: Tetranychidae, *Tetranychus urticae* Koch). Spider mites were reared on soybean plants (variety 16R09N, Peterson Farm Seed, Harwood, ND) located in thrips-proof cages (Model 44545F, MegaView Science Co., Taichung, Taiwan) under constant light at room temperature (~20 ± 2^{o}C, 40-60% RH) conditions. The spider mite colony was constantly monitored in order to maintain a healthy population, and old plants removed and new soybean plants added to the colony every week.

Immediately before the start of each experiment, two to three clean soybean plants were added to the colony. Mites used in experiments were taken from these new plants because they lacked extensive webbing and allowed us to remove mites more easily.

The same variety of soybeans was used for experimental leaf discs. Three to four seeds were planted in black plastic pots (10.16 cm x 10.16 cm x 8.89 cm) using Sungrow Professional Growing Mix (Sun Grow Horticulture, Agawam, MA). Soybeans were grown inside thrips-proof cages in an enclosed rearing room (25 ± 1^oC, 40-60% RH) under 16L:8D. Soybeans were allowed to grow for about two weeks, or until the first trifoliate was fully expanded (i.e., V1 growth stage). The first pair of fully expanded leaves (unifoliates) and trifoliate leaves were used in experiments. At the start of each experiment, leaves were removed from plants by hand and one circle, centered over the mid-vein and including a small portion of the stem, was excised using a leaf stamp. The leaf stamp was a section of aluminum pipe 3.81 cm in diameter with a sharpened edge.

The arenas used in each experiment were made from disposable polystyrene plastic Petri dishes (100 mm x 15 mm, VWR Manufacturing, Radnor, PA) partially filled with plaster (Plaster of Paris - Dry Mix, DAP, Baltimore, MD). The exact amount of plaster used varied by experiment. However, plaster was weighed to four decimal places on an analytical scale (Data Weighing Systems, Sartorius Balance 1412), placed in a plastic container (11.43 cm in diameter x 8.26 cm high), mixed with room temperature ($\sim 20^oC$) tap water with a spatula until smooth. Once mixed, the plaster was immediately transferred to Petri dishes by either a spatula or a 10 mL pipette (Pipette-Lite LTS L-10MLXLS, Rainin, Oakland, CA). Prior to experiments, dishes were allowed to dry for at least 48 hrs on a flat surface at room temperature ($\sim 20 \pm 2^oC$) or inside the incubator. Then the plaster was rehydrated with 10-15 mL of water (exact amount depends on experiment). After rehydration, one soybean leaf disc was placed in the center of the damp plaster. The edges and the severed petiole of the soybean leaf were covered with strips of toilet paper approximately 2.54 cm long and 0.64 cm wide by gently pressing down on toilet paper with a paintbrush moistened with water to ensure the leaf disc did not dry out.

Dust used in this experiment was a fractured ¾ inch gravel or Class Five gravel collected from outdoor piles at Aggregate Industries (Fargo, ND) using a shovel. All Aggregate Industries gravel is processed by a series of washing and screening operations, so it is free from any harmful chemicals. Gravel was then sifted with a 400-425 micrometer (µm) sieve to remove large particles and create a uniform texture. This mesh size was chosen based on results from Sanders et al. (1997). The dust was stored in a 2 gal bucket at room temperature ($20 \pm 5^{o}C$). The color of the dry sieved dust was classified as 10YR 5/3 using Munsell Soil Color Chart (2015, Munsell Color, Grand Rapids, MI). Samples of the sieved dust were sent to the North Dakota State University Soils Testing Lab to assess basic physical and chemical properties (Fargo, ND).

Dust was applied to experimental leaf discs by hand. First, dust was weighed (g) to four decimal places using an analytical scale (GH-300, A&D, San Jose, CA). The measured dust was then evenly distributed onto half of the soybean leaf disc by shaking the cup of dust directly over the leaf. To ensure no dust was applied to the non-dusted side of the leaf disc, a barrier was used to cover the non-dusted half of the leaf during dusting. The barrier was made of a piece of flexible plastic cut into a circle the size of the petri dish (100 mm in diameter) and then cut in half. The straight edge of the semi-circle was aligned with the mid-vein during dusting. Arenas were then examined under a dissecting microscope (Stemi 2000-C, Zeiss Manufacturing, Thornwood, NY) to ensure no dust particles had moved to the other side. If dust was present on the other side, a small paintbrush was used to move the dust to the dusted side. Control arenas did not receive any dust.

Once dust was applied, one adult female spider mite was transferred to the center of each leaf disc using a small paintbrush. The mite was observed under a dissecting microscope to ensure that it was uninjured in the transportation process, and then the Petri dish lid was put on. Arenas were then placed into an incubator (25 ± 1^{o}C, 50 ± 30 %RH, 12L:12D; Model 2015, Sheldon Manufacturing Inc., Cornelius, OR), with all arenas on the same shelf and their location randomized. A temperature / relative humidity meter (Onset HOBO U23 Pro v2, Bourne, MA) was placed inside the incubator and measurements were taken every 15 min during the duration of the experiments. Arenas were checked daily, which involved adding one mL of tap water to the plaster using a micropipette (Pipet-Lite LTS L-10XLS+, Rainin, Oakland, CA) to prevent the plaster and leaf discs from drying out. If a spider mite had wandered off the leaf or had died, the arena was removed from the incubator. At the end of the experiment, all arenas were examined under a dissecting microscope and the location of the adult female, number and location of offspring (eggs and juveniles, if applicable), and condition of the leaf recorded. Dust particles were gently moved aside with a paintbrush while searching the dusted side because eggs and juveniles were difficult to see in the dust.

Experiment 1: Effect of dust presence or absence on spider mite: mortality/absence, location of the eggs and adults, and reproduction

This experiment focused on the effect of the presence of dust on the short-term reproductive rate, location of the eggs and the adult mite and mortality of individual adult female spider mites. Experimental arenas were made by combining 40 g of plaster and 20 mL of water and adding 25 mL of this mixture to each Petri dish. Once fully dried, the petri dishes were pipetted with 15 mL of water at the start of the experiment. Dusted arenas (half-heavy dust) had 0.050 g of dust on one-half of the leaf disc while the other side of the leaf disc lacked dust. Control arenas were dust-free. The duration of this experiment was 4 to 5 days. This experiment was repeated five times, and each run had of 25 arenas (20 dusted, 5 control), with each arena considered to be a replicate.

Experiment 2: Effects of physical access to dust on spider mite: mortality/absence, location of the eggs and adults, and reproduction

This experiment consisted of 5 runs and each run had 1-4 replicates of each treatment. We did not use the different runs as an experimental variable because of the lack of replication within some runs. The focus of this experiment was to determine if physical access to the dust altered egg and adult mite location and reproduction. The use of barriers physically separated the mite from the dusted side of the area. Sham barriers were used to determine if the barrier had an effect on mite location or reproduction. Arenas were made by mixing 40 g of plaster and 40 grams of water and pipetting 25 mL of the mixture into each petri dish. Once the arenas had fully dried, they were given 15mL of water at the start of the experiment. A factorial design was used, with dust treatment crossed with barrier treatment. The dust treatment included non-dusted control arenas, half-light dust (0.025 g of dust on one half of the leaf disc), and half-heavy dust (0.050 g of dust on one half of the leaf disc). The barrier treatment consisted of arenas without barriers, and arenas with barriers. We also included a sham barrier treatment (half-light dust with a sham barrier) to explore potential effects of barrier presence on mite behavior and reproduction that were unrelated to dust. Barriers were made from of two strips of toilet paper (5.08 cm x 0.635 cm) rolled lengthwise. Strips were moistened with tap water and laid along the leaf midrib. The edges and ends of the barrier were pressed down with a wet paintbrush to ensure the mite couldn't pass under it. Once the barrier was in place, it was approximately 2 mm high. Sham barriers were made the same way, but instead of pressing the barrier onto the leaf, we left a gap for the mite to pass under. This experiment was replicated 12 times and each replication lasted 3 to 4 days.

At the end of each experiment, the temperature of each arena was measured using an infrared radiometer or IRT (MI-220; Apogee Instruments, Logan, UT). The IRT was attached to a ring stand and angled straight down over the center of the base. The base of the ring stand was covered with Styrofoam and the entire unit was enclosed with cardboard on three sides to reduce temperature fluctuation of the IRT. The IRT was left untouched for about 2 min to stabilize and the room temperature was recorded. Arenas were removed from the incubator one at a time to be measured. Once an arena was taken out, the Petri dish lid was removed and the arena was placed directly under the IRT with about 1 cm of space between the leaf and the bottom edge of the IRT. The temperature of the arena was recorded immediately after the temperature had stabilized (T0) and a subsequent temperature was taken at 1 min after (T1). This data was taken to calculate the rate of temperature change (T0-T1). This calculation more gave more information about the possible effect dust has on the rate of cooling in each area.

Experiment 3: Effects of dust and differing levels of humidity on spider mite: mortality/absence, location of the eggs and adults, and reproduction

The focus of this experiment was to identify if arenas with different plaster to water ratios had an effect on the location of the eggs, the location of the adult female and the amount of reproduction. Three separate arenas were made to achieve a low (25:55), medium (40:25) and high (55:25) plaster to water ratio. Once these plaster to water ratios were combined, 25 mL of the mixture was pipetted into a petri dish. Once fully dried, the arenas were weighed on a scale

(Data Weighing Systems, Sartorius Balance 1412) and recorded. At the start of each experiment, 7 to 8 mL of water was added to each arena using a pipette. This experiment consisted of 4 runs. Each run was composed of 12 arenas (four of each plaster to water ratio). Each plaster to water ratio was replicated 4 times within each run. . After four days, egg and mite location and reproduction were recorded. Once data was recorded, the leaf, along with all of the toilet paper, was removed and each plaster arena was reweighed. The water remaining within each arena was calculated by subtracting the final weight by the initial weight of the arena. Water change was calculated by taking the amount of water remaining in each arena subtracted by the initial water added (7 or 8 mL). At the end of each replication, temperatures of each arena were taken using the same methods used in experiment 2.

Statistical analysis

All data were analyzed using JMP Software Version 11 (SAS Software, 2013, Cary, NC). Histograms and Levene's test for equality of variance was used to assess the suitability of the data for parametric statistics. In each experiment, some arenas were excluded from all analyses. Reasons for exclusion were associated with arena malfunction (i.e. leaf drying out due to misalignment of dish lid, more than one adult mite on arena, arenas was dropped accidentally). Specifically, in experiment 1, one accidentally damaged arena was excluded from all analyses. In experiment 2, one arena was excluded because the mite had crossed the barrier. In experiment 3, 6 arenas were excluded. One arena in all 4 trials was an outlier, a lid of a petri dish had tipped off causing the leaf to dry out and two adult mites were present on one arena at the end of the experiment.

Mortality and Absence of Adult Female Spider Mites from Arenas

Adult mortality and absence on leaf arenas was monitored throughout the duration of each experiment. If a mite had died, the location (i.e. dusted or non-dusted side) was recorded. Many mites at the end of experiment 1 were missing, and presumably crossed the moist tissue paper barrier and left the arena. A chi-square analysis was used to determine if the incidence of dead + absent (missing) adult mites was related to the presence of dust on an arena, with dust treatment as the independent variable. This analysis was done for experiment 1, 2 and 3. In these analyses, dead and absent mites were combined. All arenas were used, including where mites did not reproduce. For experiment 2, two chi-square contingency analyses were completed: one focusing on the effects of dust on incidence of mortality / absence, and one focusing on the effect of the barrier.

Location of Adult Female Spider Mites

The location of each adult along with the location of each egg laid was recorded at the conclusion of each experiment. For this analysis, only experimental (i.e. dusted) arenas where the mite was alive and accounted for were used. Therefore, mites were either found on the dusted or non-dusted side, and assessing how frequently they were found on either side gives information about how the dust might be affecting the movement and settlement of adult mites. A one-way frequency distribution using the location of the mite (non-dusted or dusted side of the experimental arena) and two-sided chi-square test was used to test the hypothesis that the probability of finding the adult mite on the dusted or non-dusted side was not equal to 50 percent. This analysis was completed on experiment 1, 2 and 3.

Location of Spider Mite Eggs

The location of the eggs can also provide information about possible effects dust has on spider mite movement and behavior. The location of all the eggs, as well as which side had the most eggs were recorded at the end of each experiment. The location of the eggs on each experimental arena with dust was assessed using only arenas where the mite could choose the dusty or clean side of the arena (no barrier and sham barrier with dust only). Only arenas where the mite was alive and had reproduced were used in this analysis. If an arena had an equal number of eggs on both the dusted and non-dusted side, that arena was excluded from analysis. A one-way frequency distribution and two-sided chi-square test was used to test the hypothesis that the probability that the number of arenas with more eggs on the dusted (versus the non-dusted side) was not equal to 50 percent. This analysis was completed on experiments 1, 2 and 3.

Spider Mite Reproduction

The number of offspring (eggs and juveniles) on each arena were carefully counted and recorded at the end of each experiment. When assessing effects of dust on mite reproduction, we excluded arenas where the adult female did not lay any eggs. A chi-square analysis was used to determine if the incidence of arenas lacking eggs was related to the presence of dust on an arena, with dust treatment as the independent variable. Because experimental runs lasted for slightly different times, and eggs occasionally hatched, we used offspring per time period (per day for the first two experiments and per hour in the last experiment) as the dependent variable in analyses. For experiment 1 and 2, offspring produced per day was log x+1 transformed in order to meet the assumptions of parametric statistics.

In experiment 1, we used factorial ANOVA to determine if the presence of dust affected the number of offspring produced, with dust (presence, absence) and timing of the experimental trial (first thru fifth run) as the independent variables. We excluded arenas (n = 2) where mites never laid eggs and were alive at the end of the experiment, because this likely indicates the mites were injured during set-up or weren't adults. We analyzed the remaining data twice; once using data from all arenas (including those where mites were missing or dead), and again using data only from arenas where mites were alive at the end of the experiment. In addition, because the number of experimental arenas with dust was much higher than non-dusted control arenas, we used a non-parametric test (Wilcoxon/Kruskal-Wallis Method and Steel-Dwass Method) with dust treatment as the sole independent variable. To separate the effects of the different trials, Tukey's HSD posthoc test was used.

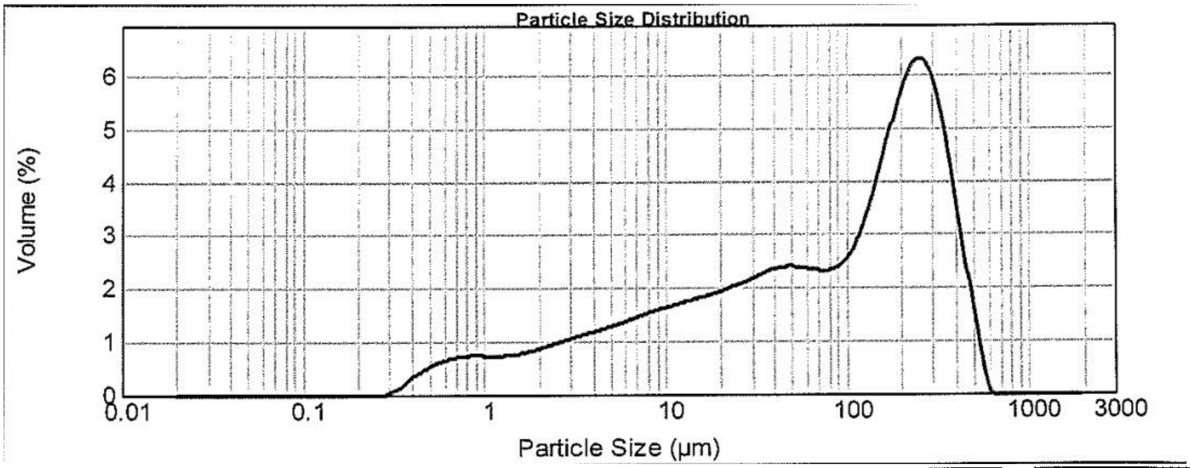
In experiment 2, we used factorial ANOVA to determine if the presence of dust and the barrier affected the number of offspring produced, with the dust and barrier treatments (present / absent) as independent variables. Arenas with sham barrier were not included in this analysis. Only one arena was excluded from analysis, because the barrier was not effective at containing the mite to the non-dusted side. In this experiment, two different dust amounts were used: half heavy (0.050 g) and half light (0.025 g), although for analysis we simply used the presence and absence of dust as the independent variable. To assess if the sham barrier had any effects on offspring production, an effects test was used where the barrier treatment was the independent variable. This analysis used both the half-heavy and half-light dusted arenas (i.e. arenas with dust present) with barriers present and sham barriers only.

In experiment 3, we initially wanted to use the plaster as the independent variable, because our assumption was that as plaster decreased, humidity within the experimental dishes would decrease. However, when we completed a regression analysis using the initial weight of the plaster as the independent variable and water change over the course of the experiment as the dependent variable, we found a non-linear relationship between the variables. Therefore, water change was used as the independent variable in subsequent analyses.

A Mixed model ANOVA was used to determine if the presence of dust affected the number of offspring produced, with the dust treatment and water change as independent variables. Six arenas were excluded from this analysis. One arena in each replication (4 arenas total) produced outliers when analyzing water change, therefore these arenas were not used in analyses. Two more arenas were also excluded, because the lid had tipped off one arena and caused the leaf to dry out and the other had two adult mites present at the end of the experiment. To analyze if change in temperature effected mite reproduction, an additional regression analysis was completed, with temperature change (T1-T0) as the independent variable and offspring per hour as the dependent variable.

Results

The NDSU Soil Testing Lab (Fargo, ND) classified the texture of the dust as a sandy loam, which is 72.8% sand (50 µm – 2000 µm), 20.9% silt (2 µm – 50 µm), and 6.3% clay (< 2 µm). Activation Laboratories Ltd. (Ancaster, ON) also analyzed the particle size. The abundance of particle sizes in the dust are show in Figure 2.1. Female spider mites are about 400 µm in length and their eggs are approximately 100 µm in diameter (Haile and Sabelis 1985). According to Figure 1, about half the dust was smaller than the size of an average female and larger than the average egg size. Both NDSU and Activation Laboratories conducted tests to determine basic properties of the dust. This dust is slightly alkaline (7.7 pH) and has relatively low concentrations of heavy metals (Table 2.1). The results from both labs outlining the basic physical and chemical properties, as well as the heavy metal composition, are described below in Table 2.1.



Size (µm)	Volume In %
0.020	0.00
0.031	0.00
0.048	0.00
0.076	0.00
0.118	0.00
0.183	

Size (µm)	Volume In %
0.183	0.00
0.285	0.50
0.444	1.66
0.691	2.09
1.076	2.13
1.675	

Size (µm)	Volume In %
1.675	2.54
2.609	3.11
4.062	3.69
6.325	4.35
9.848	4.96
15.334	

Size (µm)	Volume In %
15.334	5.50
23.876	6.27
37.176	6.86
57.885	6.75
90.131	8.30
140.341	

Size (µm)	Volume In %
140.341	14.20
218.520	17.50
340.251	9.17
529.794	0.42
824.925	0.00
1284.465	

Size (µm)	Volume In %
1284.465	0.00
2000.000	

Figure 2.1. Activation Laboratories (Ancaster, ON) results for the abundance of particle sizes found in the dust used in these experiments.

Table 2.1.

The basic chemical composition of the dust used in each experiment.

Parameter	Amount	Location Tested
pH	7.7	NDSU Soil Testing Lab
Nitrate Nitrogen (NO3-N)	2.27 kg/0.405 hectares (5 lbs/Acre)	NDSU Soil Testing Lab
Phosphorus (P)	2 ppm	NDSU Soil Testing Lab
Potassium (K)	52 ppm	NDSU Soil Testing Lab
Magnesium (Mg)	242 ppm	Actlabs
Sodium (Na)	22.4 ppm	NDSU Soil Testing Lab
Iron (Fe)	6.2 ppm	NDSU Soil Testing Lab
Chlorine (Cl)	111.08 kg/0.405 hectares (244.9 lbs/Acre)	NDSU Soil Testing Lab
Calcium (Ca)	4620 ppm	NDSU Soil Testing Lab
Ammonium-Nitrogen (NH4-N)	5.8 ppm	NDSU Soil Testing Lab
Soluble salts	0.43 mmhos/cm	NDSU Soil Testing Lab
Organic Matter (OM)	0.00004%	NDSU Soil Testing Lab
Sulfate-Sulfur (SO4-S)	7.26 kg/0.405 hectares (16 lbs/Acre)	NDSU Soil Testing Lab
Heavy Metals	**Amount**	**Location Tested**
Arsenic (As)	< 5 ppm	Actlabs
Copper (Cu)	1.62 ppm	NDSU Soil Testing Lab
Lead (Pb)	10 ppm	Actlabs
Cobalt (Co)	6 ppm	Actlabs
Nickle (Ni)	< 20 ppm	Actlabs
Manganese (Mn)	2.9 ppm	NDSU Soil Testing Lab
Zinc (Zn)	0.75 ppm	NDSU Soil Testing Lab
Chromium (Cr)	40 ppm	Actlabs

Effect of dust presence or absence on spider mite: mortality/absence, location of the eggs and adults, and reproduction

Incubator Environment

The HOBO unit was not utilized during the duration of experiment one. In order to get an idea of the environment during experiment one, the incubator was manually set for 25ºC and the HOBO was placed inside a few months after the completion of the experiment. The results are shown in Table 2.2. The average temperature for each run was lower than the manually programmed temperature. The RH% stayed relatively the same throughout the trial, excluding the outlying maximum.

Table 2.2.

Environmental data for experiment 1.

RUN	Avg temp (ºC)	Min temp (ºC)	Max temp (ºC)	Ave RH%	Min RH%	Max RH%
1	23.91	23.02	24.34	16.99	15.90	28.99

Did dust affect the incidence of adult mite mortality / absence from arenas?

On non-dusted control arenas, 48.0% of adult mites were found missing (n = 7) or dead (n = 5) (total 12 of 25 arenas), while on dusted arenas the incidence was 32.2% (dead n = 1, missing n = 31; total 32 of 99 arenas). However, the presence or absence of dust did not affect the number of adult mites missing or dead at the end of the experiment (Pearson χ^2 = 2.143, p = 0.143, Figure 2.2).

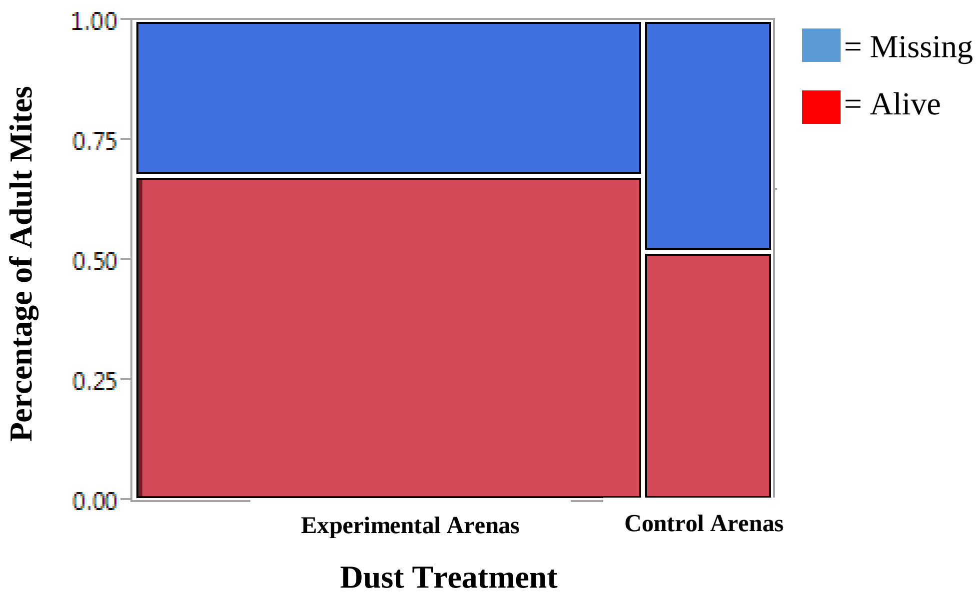


Figure 2.2. Percentage of adult mites found missing or dead at the end of experiment 1 on control and experimental arenas.

Were adult mites found more frequently on the dusted side of experimental arenas at the end of the experiment?

At the end of the experiment we found 63.2% of live adult female spider mites (43 of 68 arenas) on the dusted side of experimental arenas and 36.8% on the clean, non-dusted side (25 of 68 arenas). Live adult female mites were found on the dusted side of the experimental arenas more frequently than the non-dusted side (Pearson $\chi^2 = 4.765$, $p = 0.029$, Figure 2.3).

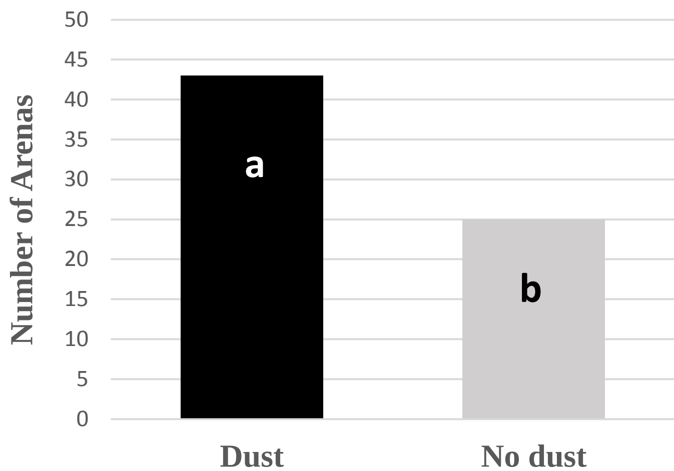


Figure 2.3. Total number of arenas where the adult mite was found on the dusted versus non-dusted side of experimental arenas. Groups with different letters indicate a significant difference ($p < 0.05$).

How frequently did the dusted side of experimental arenas have more eggs?

On experimental arenas where the mite reproduced and was alive at the end of the experiment, 58.8% of arenas had more eggs on the dusty side (40 of 68 arenas) and 41.2% of arenas had more eggs on the clean side (28 of 68 arenas), which was not significantly different ($\chi^2 = 2.118$, $p = 0.146$; Figure 2.4).

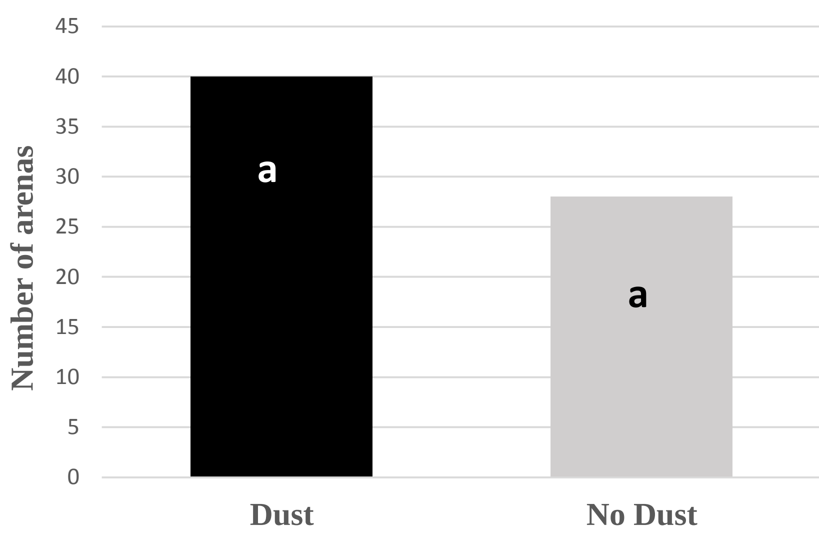


Figure 2.4. Total number of arenas where more eggs were found on the dusted versus non-sided side of experimental arenas. Groups with different letters indicate a significant difference ($p < 0.05$).

Did dust affect spider mite reproduction?

The number of arenas where mites didn't lay any eggs was relatively low (control, 3 of 25, 12.0%; dusted, 13 of 99, 13.1%), and was not impacted by the presence of dust (Pearson χ^2 = 0.023, p = 0.880, data not shown). When data from arenas where mites were missing or dead at the end of the experiment were used, only the timing of the experiment trial affected mite reproduction (*Trial* × *Treatment*, $df_{4,4}$, F = 1.475, p = 0.215; *Trial*, $df_{4,4}$, F = 3.216, p = 0.015; *Treatment*, $df_{1,4,}$ F = 1.780, p = 0.185; data not shown). However, when only assessing data from arenas where mites were alive at the end of the experiment (i.e., focusing solely on effects of dust on mite reproduction in the absence of effects on dust on mite mortality and emigration), positive effects of dust on the number of offspring per day (*Treatment*, $df_{1,4,}$ F = 5.202, p = 0.026; Fig. 2.5) was consistent across all trials (*Trial* × *Treatment*, $df_{4,4}$, F = 2.225, p = 0.075), although mite reproduction was higher in some trials versus others (*Trial*, $df_{4,4}$, F = 4.569, p = 0.003; Fig. 2.6).

Because sample size was imbalanced (99 experimental, 25 control arenas), we also assessed data from arenas where the mite reproduced and was alive at the end of the experiment using a nonparametric Wilcoxon/Kruskal-Wallis test. The results paralleled those of the parametric test and indicated that mites on dusted arenas produced more eggs per day than mites on control arenas (χ^2 = 4.155, p = 0.042), and that mite reproduction differed by experimental trial (χ^2 = 29.890, p < 0.0001).

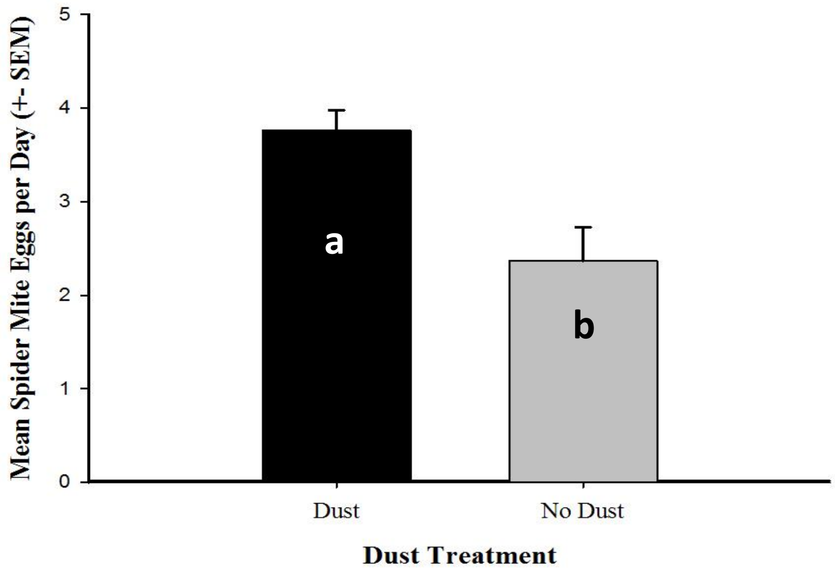


Figure 2.5. Mean eggs per day (±SEM) on dusted and non-dusted arenas. Groups with different letters indicate a significant difference ($p < 0.05$).

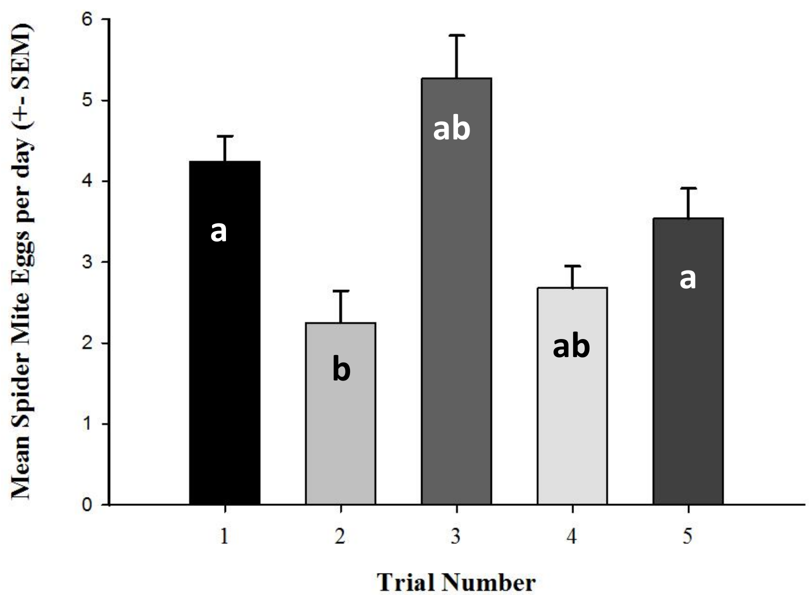


Figure 2.6. Mean eggs per day (±SEM) for each trial. Groups with different letters indicate a significant difference ($p < 0.05$).

Effects of physical access to dust on spider mite: mortality/absence, location of the eggs and adults, and reproduction

Incubator Environment

Experiment 2 was composed of 5 runs, and each run had 1-4 replicates of each treatment. The incubator environment for each run is shown in Table 2.3. The HOBO was removed from the incubator in reps 4 and 5; therefore, no data was available. Although the incubator was manually set for 25ºC, the average temperature for each run was higher than the manually programmed temperature. The RH% fluctuated about 4 – 10% during runs 1, 2 and 3.

Table 2.3.

Environmental data for runs (i.e., trials) 1 through 3 in experiment 2.

RUN	Avg temp (ºC)	Min temp (ºC)	Max temp (ºC)	Ave RH%	Min RH%	Max RH%
1	28.57	28.20	28.84	17.65	13.89	23.31
2	28.62	28.42	28.79	13.64	13.17	17.56
3	28.53	28.20	28.92	15.89	13.74	21.44
4	No Data	No Data	No Data	No Data	No Data	No Data
5	No Data	No Data	No Data	No Data	No Data	No Data

Did dust or barrier presence affect the incidence of adult mite mortality / absence from arenas?

This experiment had no dead mites; however, at the conclusion of the experiment, 39 out of a total 84 arenas had missing mites. On dusted arenas, 49.15% of adult mites were found missing or dead (29 of 59 arenas, Figure 2.7), while the incidence on non-dusted control arenas was 41.67% (10 of 24 arenas). However, dust did not have an effect on the incidence of mite mortality / absence (Pearson $\chi^2 = 0.384$, $p = 0.536$). The contingency analysis focusing on the effects of the barrier yielded a different result. On arenas with no barrier, 36.11% (13 of 36 arenas) of mites were absent, arenas with a sham barrier had 33.33% (4 of 12 arenas) of mites missing, and arenas with a barrier present had 62.86% (22 of 35 arenas) absent (Figure 2.8). Barrier treatment significantly affected the incidence of adult mite absence from arenas (Pearson $\chi^2 = 6.146$, $p = 0.046$). There was no difference in effects of the present barrier and the sham barrier (df_1, $F = 0.566$, $p = 0.457$).

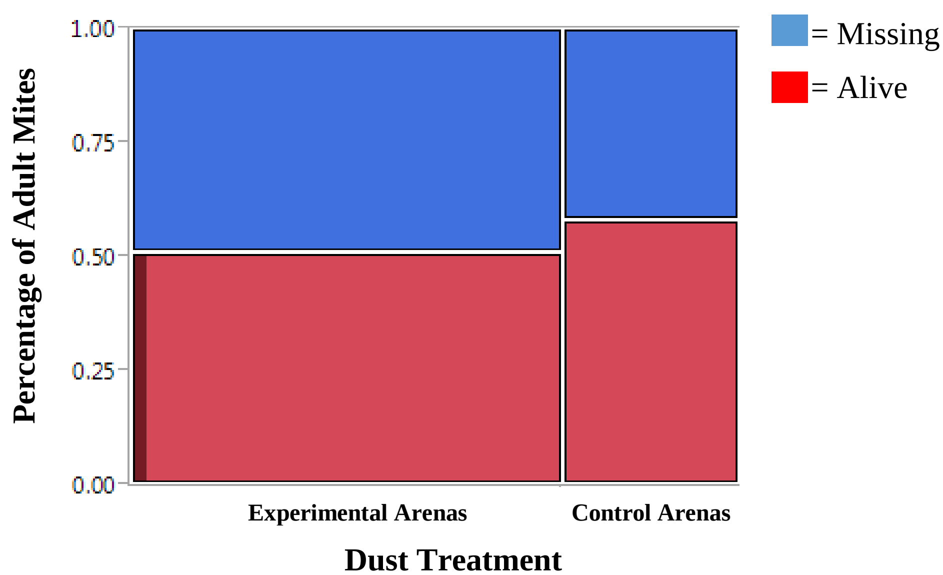


Figure 2.7. The effects of dust on the frequency of missing / dead adult mites at the end of experiment 2.

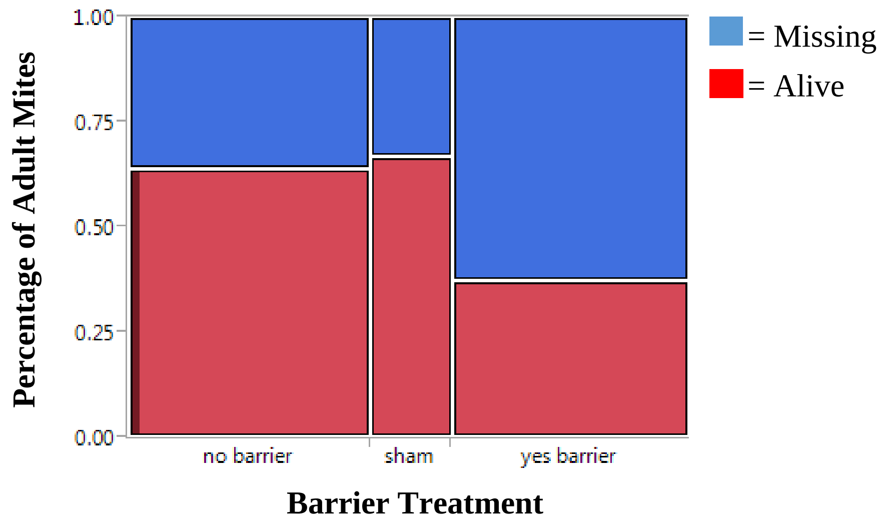


Figure 2.8. The effects of barrier treatment on the frequency of missing / dead adult mites at the end of experiment 2.

Were adult mites found more frequently on the dusted side of experimental arenas at the end of the experiment?

On experimental arenas receiving dust and lacking intact barriers (i.e., no barrier and sham barrier with dust only), 50.0% of the time live female adult mites were found on the non-dusted side of the arena (11 of 22 arenas), and 50.0% of the time eggs were found on the dusted side (11 of 22 arenas). These results were not significantly different ($\chi^2 < 0.001$, $p = 1.000$, Figure 2.9). This did not change if sham barriers were excluded, i.e., on experimental arenas receiving dust and lacking intact barriers, 42.9% of the time live female adult mites were found on the non-dusted side of the arena (6 of 14 arenas), and 57.1% of the time eggs were found on the dusted side (8 of 14 arenas), which was not significantly different ($\chi^2 = 0.286$, $p = 0.593$, data not shown).

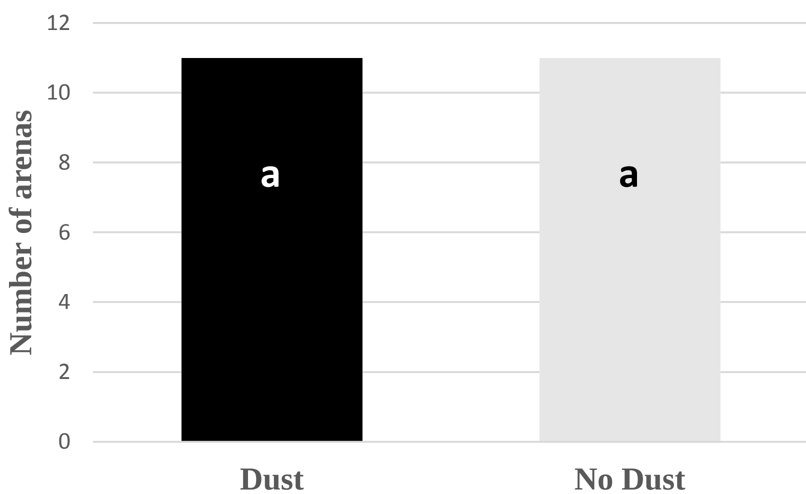


Figure 2.9. Total number of arenas where more adult mites were found on the dusted versus non-dusted side of experimental arenas. Groups with different letters indicate a significant difference ($p < 0.05$).

How frequently did the dusted side of experimental arenas have more eggs?

On experimental arenas receiving dust and lacking intact barriers (i.e., no barrier and sham barrier with dust only) where the mite reproduced and was alive at the end of the experiment, 66.7% of arenas had more eggs on the non-dusted side of the arena (14 of 21 arenas), and 33.3% of arenas had more eggs on the dusted side (7 of 21 arenas). Dust did not affect the frequency with which mites laid more eggs on dusted versus non-dusted sides of experimental arenas ($\chi^2 = 2.333$, $p = 0.127$, Figure 2.10).

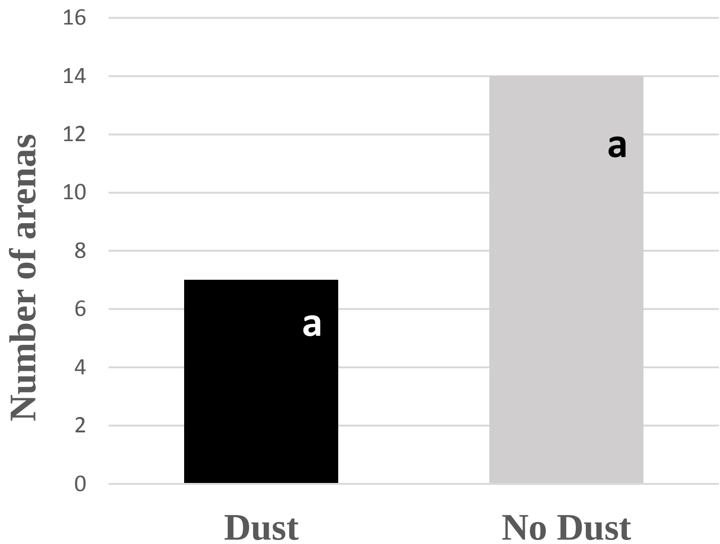


Figure 2.10. Total number of arenas where more eggs were found on the dusted versus non-dusted side of experimental arenas. Groups with different letters indicate a significant difference ($p < 0.05$).

This did not change if sham barriers were excluded, i.e., on experimental arenas receiving dust and lacking intact barriers, 53.9% of the time live female adult mites were found on the non-dusted side of the arena (7 of 13 arenas), and 46.1% of the time eggs were found on the dusted side (6 of 13 arenas), which was not significantly different ($\chi^2 = 0.077$, $p = 0.782$, data not shown).

Did dust or barrier treatment affect spider mite reproduction?

The number of arenas where mites didn't lay any eggs was relatively low for the control (control, 2 of 24 =8.3%) and higher for the dusted arenas (dusted, 14 of 60 = 23.3%). The barrier treatment may have affected the amount of reproduction as well, since the number of arenas where the mites did not lay eggs was moderately low across all treatment types (sham, 2 of 11 = 18.18%, barrier present, 9 of 36 = 25%, no barrier, 5 of 36 = 13.9%).

Using data from arenas with live, reproducing mites, neither dust (present, absent) nor barrier treatment (present, absent) impacted the total offspring per day (*Dust* × *Barrier*, $df_{2,2}$, F = 1.664, p = 0.206; *Dust*, $df_{1,1}$, F = 0.690, p = 0.509; *Barrier*, $df_{2,2}$, F = 0.322, p = 0.575; Figure 2.11). This didn't change if data from all arenas where mites had reproduced were used in the analysis (i.e., including arenas where mites were missing) (*Dust* × *Barrier*, $df_{2,2}$, F = 0.202, p = 0.818; *Dust*, $df_{1,1}$, F = 1.112, p = 0.335; *Barrier*, $df_{2,2}$, F = 3.327, p = 0.073; data not shown).

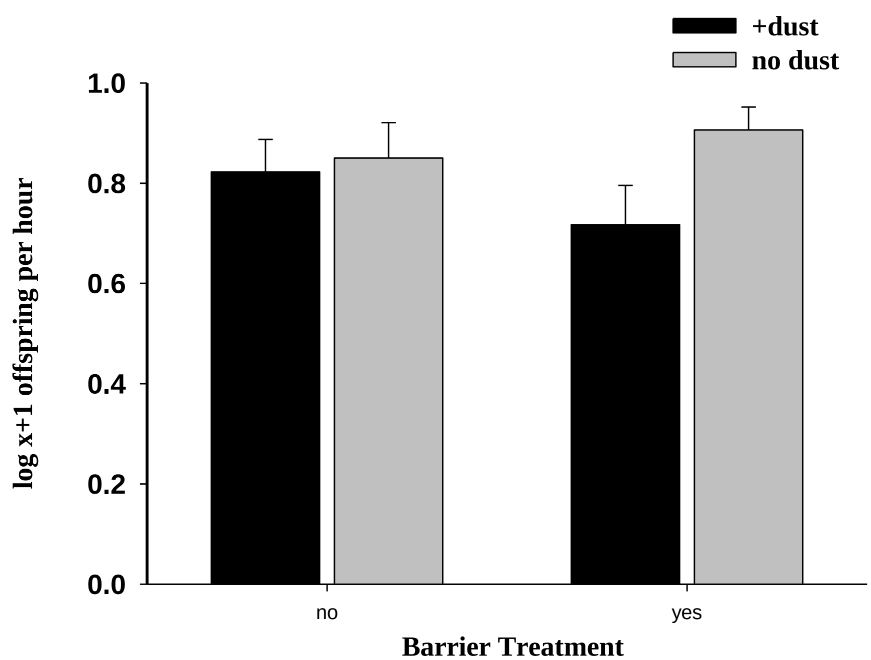


Figure 2.11. Effect of treatments on the amount of offspring per day (using data from arenas with live, reproducing mites).

The presence of the barrier could potentially alter arena humidity in addition to preventing mites from contacting dust. Therefore, in order to assess any effects of the barrier presence on mite reproduction, irrespective of dust, we compared mite reproduction on arenas with and without barriers where mites could contact the dust (i.e., half-light dusted arenas with the sham barrier versus half-light dusted arenas lacking barriers). Using data from arenas with live, reproducing mites, the sham barrier did not have an effect on the amount of spider mite reproduction (*Barrier*, t = 0.500, p = 0.625). This didn't change if data from all arenas where mites had reproduced were used in the analysis (i.e., including arenas where mites were missing) (*Barrier*, t = 0.880, p = 0.390).

Effects of dust and differing levels of humidity on spider mite: mortality/absence, location of the eggs and adults, and reproduction

Incubator Environment

Experiment 3 was composed of 4 runs, and the incubator environment across all runs is shown in Table 2.4. The incubator was manually set for 25ºC, and the average temperature for each run was relatively similar. The RH% fluctuated about 10 – 20 % during each trial.

Table 2.4.

Environmental data for runs (i.e., trials) 1 through 4 in experiment 3.

RUN	Ave temp (ºC)	Min temp (ºC)	Max temp (ºC)	Ave RH%	Min RH%	Max RH%
1	25.53	25.016	25.768	26.452	17.413	39.131
2	25.72	25.62	25.89	21.431	15.625	30.689
3	25.57	24.605	25.939	30.330	18.114	38.277
4	24.82	24.726	25.016	17.713	16.948	28.798

Relationships between the abiotic factors

The linear relationship between initial plaster weight and water change was non-significant (*Linear Fit*, R^2 = 0.0002, df_2, F = 0.0072, p = 0.9329). However, there was a binomial relationship between these two factors (*Polynomial Fit*, R^2 = 0.170, df_2, F = 3.998, p = 0.0263;

Figure 2.12). This indicated that arenas that had both low and high plaster to water ratios retained more water, and presumably had higher humidity, than arenas with medium plaster to water ratios.

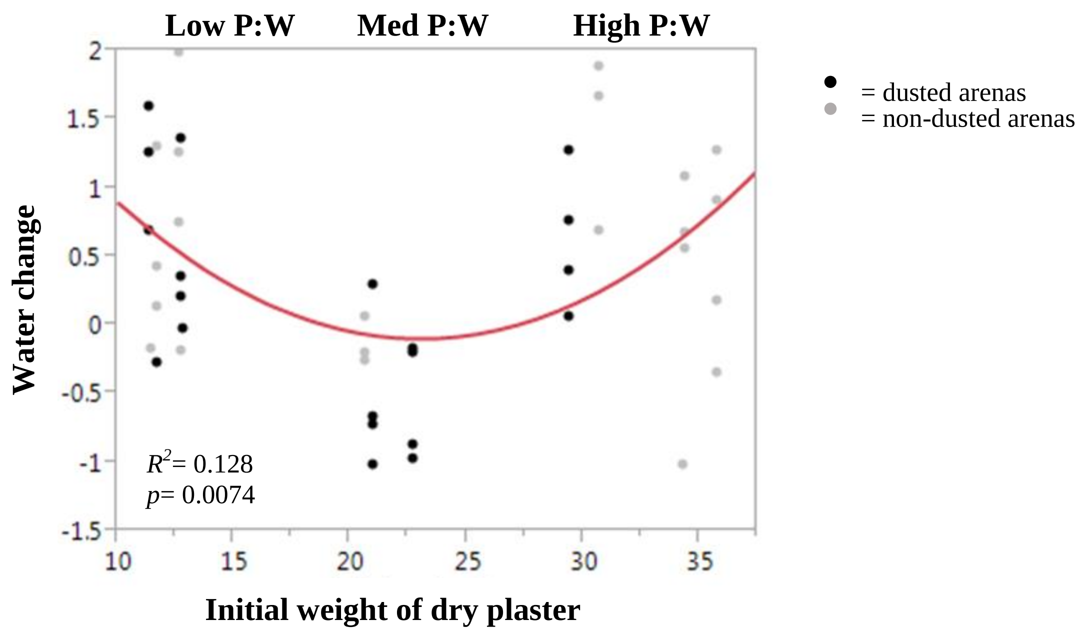


Figure 2.12. The relationship between water change and high, medium and low plaster to water ratios. Plaster to water ratios (P:W) are shown at the top of the graph.

There was no relationship between plaster weight and the difference in arena temperature immediately after they were removed from incubators and one minute later (i.e., temperature change, T0-T1) (adjusted R^2 = 0.017, t = -1.31, p = 0.198; data not shown). There was no effect of dust presence on water change (t = -1.65, p = 0.107; data not shown) or temperature change (t = -0.97, p = 0.340; data not shown).

However, there was a weak linear relationship between water change and temperature change (adjusted R^2 = 0.100, t = -2.36, p = 0.034). Arenas that retained water throughout the experiment (i.e., positive water change) cooled slower (i.e., had a smaller temperature change) when removed from the incubator (Fig. 2.13).

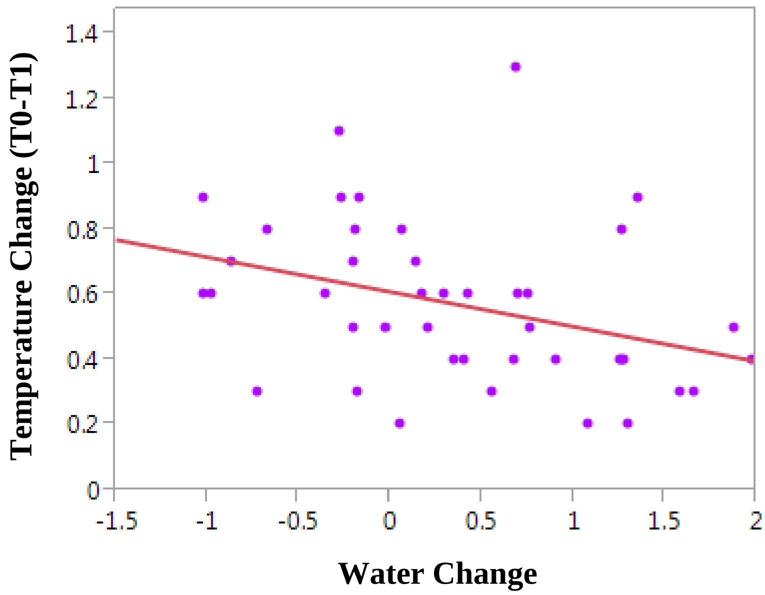


Figure 2.13. The relationship between water change and temperature change in each arena.

Did dust affect the incidence of adult mite mortality / absence from arenas?

This experiment had no dead mites, however, at the conclusion of this experiment on 11 out of 48 arenas (22.9%), mites were absent from the arena. On experimental arenas, including where mites had not reproduced, 25% of adult mites were found missing (5 of 20 arenas), while the non-dusted arenas had 22.7% (5 of 22 arenas). However, the presence of absence of dust did not affect the number of adult mites missing or dead at the end of experiment 2 (Pearson $\chi^2 = 0.03$, $p = 0.863$, Figure 2.14).

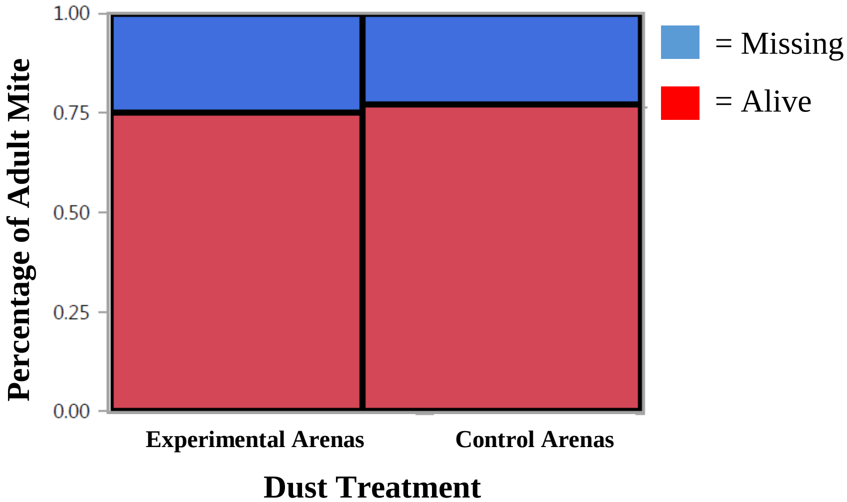


Figure 2.14. Percentage of adult mites found missing at the end of experiment 3 on control and experimental arenas.

Were adult mites found more frequently on the dusted side of experimental arenas at the end of the experiment?

At the end of the experiment, 80% of experimental arenas (12 of 15 arenas) had the live female spider mite on the dusted side of the arena, and 20% of arenas the mite was on the clean side (3 of 15 arenas). Live mites were found more frequently on the dusted side of experimental arenas (Pearson χ^2 = 5.400, p = 0.0201).

How frequently did the dusted side of experimental arenas have more eggs?

On experimental arenas with live mites that had reproduced, on 73.3% of experimental arenas, more eggs were located on the dusted side of the arenas (11 out of 15 arenas), whereas 26.7% (4 out of 15 arenas) had more eggs located on the clean side. There was a tendency for there to be more eggs on the dusty side of arenas (Pearson χ^2 = 3.267, p = 0.071, data not shown), which was significant if data from all arenas with reproducing mites were used (i.e. alive and missing/dead mites; out of 17 arenas, 13 arenas had more eggs on the dusty side compare to 4 arenas where more were on the clean side (Pearson χ^2 = 4.765, p = 0.029, Figure 2.15).

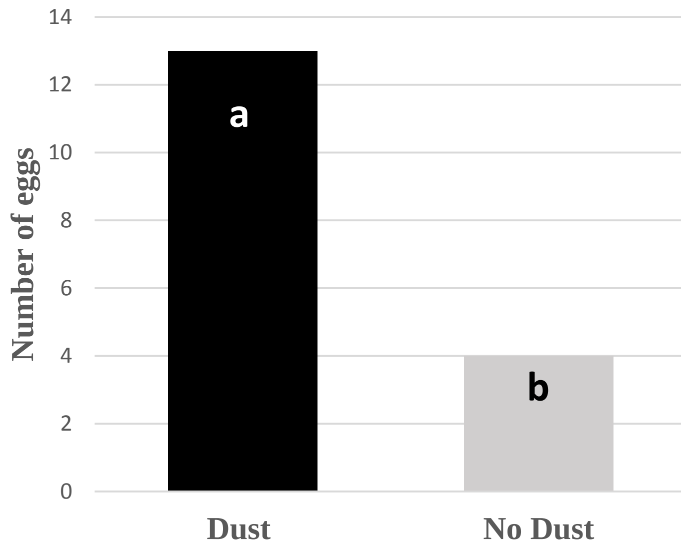


Figure 2.15. Total number of arenas where more eggs were found on the dusted versus non-dusted side of experimental arenas. Groups with different letters indicate a significant difference (p < 0.05).

Did dust and water change affect spider mite reproduction?

The number of arenas where mites didn't lay eggs was very low (non-dusted, 2 of 24, 8.3%; dusted, 1 of 24, 4.17%). When considering data from arenas with live mites that had reproduced, dust did not affect mite reproduction (*Dust*, $t = -1.14$, p = 0.265, Figure 2.16), although there was an inverse relationship between mite reproduction and water change (*Water Change*, t = -3.17, p = 0.0036), with offspring per hour decreasing as arenas retained an increasing amount of water (Figure 2.17). Results were similar when using data from arenas where mites had reproduced and were alive and missing (*Dust*, t = -1.05, p = 0.300, *Water Change*, t = -3.55, p = 0.001). Temperature change also had an effect on the amount of offspring produced (R^2 = 0.1503, p = 0.0078).

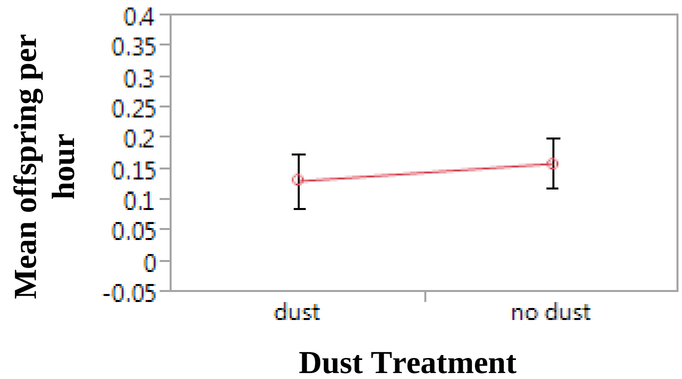


Figure 2.16. The relationship between the dust treatment and amount of offspring produced each hour using data from arenas with live mites that had reproduced.

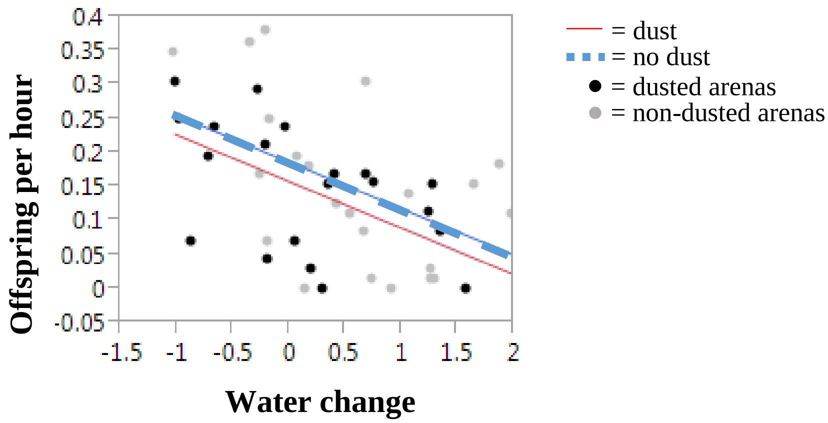


Figure 2.17. A regression plot showing the relationship between the amount of water change and the number of offspring per hour using data from arenas with live mites that had reproduced.

Discussion

These experiments were developed to narrow down the plausible effects of dust on spider mite populations on a smaller scale. Each experiment focused on various hypothesized effects of dust. Although not every experiment yielded significant results, results from experiment one indicated dust was having an effect on spider mite reproduction. Most of the studies focusing on dust and spider mites are larger scale experiments completed in the fields or in greenhouses. All three of these experiments were completed in manipulated, small-scale environments to pinpoint the effects of dust on spider mite populations. The results of these small scale experiments can help revise future large or small-scale experiments. Future experiments can focus on the physical effects of dust rather than the abiotic effects alone like we tried in experiments one and three. Dust effecting the mites behavior can open doors to further exploring the abiotic effects.

The effects of road dust can be widespread due to wind and increased traffic. Most road dust can act as a sink for heavy metals that originate from brake pads, tires and other parts of the car (Apeagyei et al. 2010). The amount of heavy metals present in road dust depends on the amount traffic passing over the road. The dust used in this experiment contains slight amounts of the heavy metals described in Kexin et al. (2015), such as As, Co, Cr, Pb, Cu, Zn, Mn and Ni. Considering our dust was collected from contained piles, the concentration of heavy metals is relatively low (Table 2.1). The dust used in these experiments had pH of 7.7. This value indicates that the dust has slightly basic or alkaline properties. Farmer (1993) found that road dust should have slightly alkaline properties with high calcium levels. Because this dust has a relatively neutral pH and low amounts of heavy metals, it does not cause injury or wilting to the soybean plants used in each experiment (Darley 1966; Prajapati et al 2008).

The texture of dust can be an important aspect when studying the effects on microscopic arthropods. The texture of the dust used is comparable to the typical mixture of sand, silt and clay found in road dust (Woods 1960; Sanders and Addo 1993). However, this dust has a lower clay content of 6.3%. The particle size does not matter when looking strictly at the amount of reproduction (Fukushima and Stafford 1969). However, the particle size has the ability affect the movement of arthropod species (Fleschner 1958). Female spider mites are about 400 µm in length and their eggs are approximately 100 µm in diameter (Helle and Sabelis 1985a). According to the particle size distribution graph produced by Activation Laboratories (Figure 2.1), more than half the dust used in these experiments was smaller than the size of an average female and the eggs. Fleschner (1958) and Glenn et al (1999) suggested that dust could act as a physical barrier, making it more difficult for insects to get around. Considering more adult mites were located on the dusted side of experimental arenas in experiment 1, this could mean there are other advantages to the dust. DeBach (1947) suggests that dust may provide a better establishment area with more hiding spaces and may offer more connections for their webbing (Holloway et al. 1943).

The incubator environment varied with each experiment. Experiment one had lower average temps (23.91ºC) and moderate RH (16.99%). Experiment two had the highest average temperatures (about 28ºC) and the lowest RH (about 15%) across all trials. Experiment three had moderate temperatures (about 25ºC) and the highest humidity (about 23.5%) across all trials. The varying environments can give clues to the effects dust has on the temperature and humidity of each arena. For instance, in experiment two, the dust had no effect on spider mite reproduction or establishment. This could be due to the higher temperatures and low humidity the mite was experiencing. Therefore, the dust did not provide any reasonable benefits so the entire arena was suitable habitat.

In all experiments, condensation collected on the lids of some arenas. If present, it was removed daily. Experiment one had varying amounts of condensation over the duration of the experiment. Dust has the ability to nullify the effects of high to moderate RH. In experiment one, there was significantly more reproduction on dusted arenas. This could be due to the dust cancelling out the effects of a slightly higher humidity. In experiment two, condensation appeared on arenas with a barrier or sham barrier present. Condensation accumulated above the barrier (i.e. on the petri dish lid) and around the barrier on the leaf. Spider mites prefer dry conditions (Helle and Sabelis 1985a). The condensation accumulated on arenas with a barrier could have been the cause of the significant amount of mites absent at the end of experiment two. In experiment three, the plaster to water ratios were created to manipulate different humidity ranges. Arenas with low plaster to water ratios had higher amounts of condensation on each petri dish lid. This experiment also had a higher environmental RH (about 23.5%) in the incubator. The highly humid environment could have nullified the effects of the dust

Fleschner (1958) found that dust could potentially affect an arthropod's physiology via desiccation or their ability of find food. On dusted arenas in experiments one and two, dust had no effect on the mortality or absence of adult spider mites. The dust was never the cause of the mite being absent, in fact, adult mites preferred to spend their time on the dusted side of arenas in experiments one and three. In experiment two, the barrier caused a significant number of mites to leave the arenas. With the permanent barrier in place, adult mites on these arenas had half the amount of space as mites on arenas without a barrier. This small space may have promoted them to find a more suitable habitat with ample feeding area.

Protection from possible predators and a variety of abiotic factors (i.e. high winds and rain) is also an important incentive to establish in dusty areas. Dust can provide anchors for webbing (Holloway et al. 1943) and webbing has been proven to protect arthropods and their eggs in stressful conditions (Helle and Sabelis 1985a). The location of the adult mite on experiment one and three showed that dusty conditions were preferred. Experiment two found no difference in adult mite location. Experiment two was created to analyze if the effects would be the same if the mite could not encounter the dust. The difference in results here indicates that contact with the dust may give the mites an incentive for establishment.

It was hypothesized that more eggs would be found on the dusted side due to the advantages of establishing in dust. Such as decrease in predators (DeBach 1947; Demirel and

Cabuk 2008a, 2008b), protection (Alstad and Edmunds 1982) and better microclimate (Pringle et al 2014). However, only experiment three supported this hypothesis. In experiments one and two, mites had no preference on where to lay their eggs. These results could be contradicting due to experimental set up or differing incubator environment. Experiment two had much higher average environment temperatures (~28 ºC**)** than experiment three (~25 ºC). While the RH% on experiment three was much higher (~23.5%) than experiment two (~15%). Experiment three had more eggs on the dusted side of experimental arenas; this could be due to the high humidity. Dust has been shown to increase leaf surface temperatures and decrease humidity (Eller 1977; Zia-Khan et al. 2015). All arthropods have an optimum temperature and humidity range needed to reproduce and survive (Briere et al 1999). The higher temperatures and varying humidity may be out of their optimum range.

Most research completed on spider mites focuses on increased populations due to the effects of dust. Our three small scale experiments yielded some different results. Experiment one had more reproduction on dusted arenas and paralleled the findings of several studies. Holloway et al (1942), DeBach (1947), and Demirel and Cabuk (2008a, 2008b), found that there were higher numbers of spider mites on crops with dusty substances. Dust had no effect on the amount of reproduction in experiment two. A study completed by Fukushima and Stafford (1969) suggests that sometimes road dust alone did not stimulate the mites to have a higher reproduction; rather other factors were influencing it as well. Experiment three gives a good example of the other possible factors that could be influencing mite reproduction. Dust can cause the humidity and temperature on the leaf surface to fluctuate (Eller 1977; Zia-Khan et al. 2015). This is an important abiotic factor to the survival of many herbivorous arthropods (Ferro and Chapman 1984). As the water change in each arena increased, so did the amount of reproduction.

This indicates that drier arenas (i.e. higher water change) had an increase in spider mite reproduction. Spider mites have been observed to thrive in hot, dry, dusty conditions (Helle and Sabelis 1985a). However, the dust in experiment 3 was not affecting the reproduction. Therefore, the abiotic effects, such as temperature, seem to take precedence over the effects of dust in the third experiment.

In conclusion, although the results from these experiments are not consistent, they do give more information on the effects of dust on spider mite populations. The behavior of spider mites and other arthropods is strongly influenced by abiotic conditions. Dust has the ability to alter these conditions to create a more suitable environment. These experiments outline the importance of including environmental conditions in experimental analysis. Each small-scale experiment completed had the ability to narrow the focus of the effects of dust. Some implications of these analyses is the difficulty of reproducing these results in the field or greenhouse. However, the results from these experiments can alter the way large scale experiments are designed to yield more accurate results.

Literature Cited

Alstad D and Edmunds G. 1982. Effects of air pollutants on insect populations. Annual Review of Entomology. 27: 369-384.

Amato F, Pandolfi M, Escrig A, Querol X, Alastuey A, Pey J, Perez N, and Hopke P. 2009. Quantifying road dust resuspension in urban environment by Multilinear Engine: A comparison with PMF2. Atmospheric Environment. 43: 2770-2780.

Angelova V, Ivanov K, and Ivanova R. 2007. Effect of chemical forms of Lead, Cadmium, and Zinc in polluted soils on their uptake by tobacco. Journal of Plant Nutrition. 27: 757-773.

Apeagyei E, Bank M, and Spengler J. 2011. Distribution of heavy metals in the road dust along an urban-rural gradient in Massachusetts. Atmospheric Environment. 45: 2310-2323.

Briere J, Pracros P, Le Roux A, and Pierre J. 1999. A novel rate model of temperature-dependant development for arthropods. Environmental Entomology. 28(1): 22-29.

Clotuche G, Mailleux A, Fernandez A, Deneubourg J, Detrain C, and Hance T. 2011. The formation of collective silk balls in the spider mite *Tetranychus urticae* Koch. PLoS One. 6(4): e18854.

Darley E. 1966. Studies of the effect of cement-kiln dust on vegetation. Journal of the Air Pollution Control Agency. 16: 145-150.

Demirel N and Cabuk F. 2008a. Population trends of two spotted spider mite on cotton nearby soil and asphalt roads. Journal of Entomology. 5: 122-127.

Demirel N and Cabuk F. 2008b. Evaluation population density of Tetranychus urticae Koch on cotton fields nearyby dirt and asphalt roads. Journal of Entomology. 5: 284-289.

DeBach P.1947. Predators, DDT, and citrus mite populations. Journal of Economic Entomology. Vol 40: 598-599.

Eaton R, Gerard S, and Gate D. 1988. Rating unsurfaced roads. Army Corps of Engineers, Cold Regions Res. And Engineering Lab. Hanover, N.H.

Eller BM. 1977. Road dust induced increase of leaf temperature. Environmental Pollution. 13: 99-107.

Eveling D. 1972. Similar effects of suspensions of copper oxychloride and kaolin on sprayed leaves. Annals of Applied Biologuy. 70: 245-249.
Farmer A. 1993. The effects of dust on vegetation – A review. Environmental Pollution. 79: 63-75.

Farmer A. 1993. The effects of dust on vegetation – A review. Evironmental Pollution. 79: 63-75.

Ferro D and Chapman R. 1979. Effects of different constant humidities and temperatures on twospotted spider mite egg hatch. Environmental Entomology. 701-705.

Fleschner C. 1958. The effect of orchard dust on the biological control of avocado pests. California Avocado Society Yearbook. 42: 94-98.

Glenn D, Puterka G, Vanderzwet T, Byers R, and Feldhake C. 1999. Hydrophobic particle films: A new paradign for suppression of arthropod pests and plant diseases.

Gotoh T, Saito M, Suzuki A and Nachman G. 2014. Effects of constant and variable temperatures on development and reproduction of the two-spotted spider mite *Tetranychus urticae*. 64: 465-478.

Grantz D, Garner J, and Johnson D. 2003. Ecological effects of particulate matter. Environment International. 29: 213-239.

Haile F and Higley L. 2003. Changes in soybean gas-exchange after moisture stress and spider mite injury. Physiological Ecology. 32: 433-440.

Helle W and Sabelis M. 1985a. Spider mites: Their biology, natural enemies and control. 1a.

Helle W and Sabelis M. 1985b. Spider mites: Their biology, natural enemies and control. 1b.

Hirano T, Kiyota M, and Aiga I. 1995. Physical effects of dust on leaf physiology of cucumber and kidney plants. Environmental Pollution. 89: 255-261.

Holloway J, Henderson C, and McBurnie H. 1942. Population increase of citrus read mite associate with the use of sprays containing inert granular residues. Journal of Economic Entomology. 35: 348-350.

Luedeling E, Zhang M, Bentley W, and Dharmasri L. 2009. Remote sensing of spider mite damage in California peach orchards. International Journal of Applied Earth Observation and Geoinformation. 11: 244-255.

Kexin L, Tao L, Lingqing W, Zhiping Y. 2015. Contamination and health risk assessment of heavy metals in road dust in Bayan Obo Mining Region in Inner Mongolia, North China. Journal of Geographical Sciences. 25: 1439-1451.

Nicklova I, Georgieva N, and Naydenova J. 2014. Development and reproduction of spider mites Tetranychus turkestani (Acari: Tetranychidae) under water deficit condition in soybeans. Pesticides Phytomedicine. 29(3): 187-195.

Oi D and Barnes M. 1989. Predation by the Western predatory mite on the pacific spider mite in the presence of road dust. Enviornmental Entomology. 18: 892-896.

Prajapati S and Tripathi B. 2008. Seasonal variation of leaf dust accumulation and pigment content in
plant species exposed to urban particulates pollution. Journal of Environmental Quality. 37: 865-875.

Price P. 1991. The plant vigor hypothesis and herbivore attack. Oikos. 62: 244-251.

Pringle K, Heunis J, and Villiers M. 2014. Does dust result in mite outbreaks in apple orchards? Journal of Applied Entomology. 138: 307-314.

Putaud J, Raes F, Dingenen R, Bruggemann E, et al. 2004. A European aerosol phenomenology – 2: chemical characteristics of particulate matter at kerbside, urban, rural and background sites in Europe. Atmospheric Environment. 38: 2579-2595.

Rai A, Kulshreshtha K, Srivastava P, and Mohanty C. 2010. Leaf surface structure alterations due to particulate pollution in some common plants. Environmentalist. 30: 18-23.

Raskin I and Ensley B. 2000. Phytoremediation of toxic metals: Using plants to clean up the environment. John Wiley and Sons. New York.

Reddall A, Sadras V, Wilson L, and Gregg P. 2004. Physiological responses of cotton to two-spotted spider mite damage. Crop Science. 44: 835-846.

Sanders T, and Addo J. 1993. Effectiveness and environmental impact of road dust suppressants.

Sanders, T., Addo, J., Ariniello, A. and Heiden, W. (1997). Relative Effectiveness of Road Dust Suppressants. Journal of Transportation Engineering 123(5), 393-397.

Shauer J, Rogge W, Hildemann L, Mazurek M, and Cass G. 1996. Source apportionment of airborne particulate matter using organic compounds as tracers. Atmospheric Environment. 30: 3837-3855.

Stantelmann M and Gorham E. 1988. The influence of airborne road dust on the chemistry of Sphagnum mosses. Journal of Ecology. 76: 1219-1231.

Suzuki T. 2012. Environmental engineering approaches toward sustainable management of spider mites. Insects. 3: 1126-1142.

Subramanyam B and Roesli R. 2000. Alternatives to pesticides in stored-product IPM. 321-380. http://link.springer.com/chapter/10.1007/978-1-4615-4353-4_12

Transport Research Support. 2011. Quantifying the impacts of vehicle generated dust: A comprehensive approach. Department for International Development. 1-72.

Vansebecke D, Schrijver L, Spranghers T, Audenaert J, Verhoeven R, Nguyen D et al. 2013. Alternating temperatures affect life table parameters of Phytoseiulus persimilis, Neoseiulus californicus (Acari: Phytoseiidae) and their prey Teranychus urticae (Acari: Tetranychidae). Experimental and Applied Acarology. 61: 285-298.

Walker D and Everett K. 1987. Road dust and its environmental impact on Alaskan taiga and tundra. Arctic and Alpine Research. 19: 479-489.

White T. 1984. The abundance of invertebrate herbivores in relation to the availability of Nitrogen in stressed food plants. Oecologia. 63: 90-105.

Woods, K.B. Highway Engineering Handbook, First Edition McGraw- Hill, 1960.

Zia S, Romano G, Spreer W, Sanchez C, Cairns J, Araus J, and Muller J. 2013. Infrared thermal imaging as a rapid tool for identifying water stress tolerant maize genotypes of different phenology. Journal of Agronomy and Crop Science. 199: 75-84.

Zia-Khan S, Spreer W, Pengnian Y et al. 2015. Effect of Dust Deposition on Stomatal Conductance and Leaf Temperature of Cotton in Northwest China. Water. 7: 116-131.

APPENDIX A. DIFFERENCE IN PAST AND PRESENT SAMPLING METHODS

Wetland Type	Wetland ID	Previous Vegetation Sampling Methods	2016 Vegetation Sampling Methods
Temporary	BT9906	15 quadrats in the low prairie, 15 quadrats in the wet meadow, list of secondary species (1999)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, presence and absence of secondary species
Temporary	BGT9908	15 quadrats in low prairie, 15 quadrats in the wet meadow, list of secondary species (1999)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, presence and absence of secondary species
Temporary	PT9921	15 quadrats in low prairie, 15 quadrats in the wet meadow, no secondary species (1999)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, presence and absence of secondary species
Temporary	School Temp 2	15 quadrats in low prairie, 15 quadrats in the wet meadow, no secondary species (1998)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, presence and absence of secondary species
Seasonal	Kidney Basin	15 quadrats in the low prairie, wet meadow and shallow marsh, no secondary species (1998)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow marsh, presence and absence of secondary species
Seasonal	Hal's Seasonal	15 quadrats in the low prairie, wet meadow and shallow marsh, no secondary species (1998)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow marsh, presence and absence of secondary species
Seasonal	BS9904	15 quadrats in the low prairie, wet meadow and shallow marsh, list of secondary species (1999)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow marsh, presence and absence of secondary species

Wetland Type	Wetland ID	Previous Vegetation Sampling Methods	2016 Vegetation Sampling Methods
Seasonal	BGS9907	15 quadrats in the low prairie, wet meadow and shallow marsh, list of secondary species (1999)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow marsh, presence and absence of secondary species
Semi-Permanent	NG0111	16 quadrats in the low prairie, 12 quadrats in the wet meadow, 8 quadrats in the shallow and deep marsh, presence and absence of secondary species (2001)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow and deep marsh, presence and absence of secondary species
Semi-Permanent	BG0102	16 quadrats in the low prairie, 12 quadrats in the wet meadow, 8 quadrats in the shallow and deep marsh, presence and absence of secondary species (2001)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow and deep marsh, presence and absence of secondary species
Semi-Permanent	NG0206	9 quadrats in the low prairie, 8 quadrats in the wet meadow, 5 quadrats in the shallow and deep marsh, presence and absence of secondary species (2002)	8 quadrats in the low prairie, 7 quadrats in the wet meadow, 5 in the shallow and deep marsh, presence and absence of secondary species

APPENDIX B. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE PT9921

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Amorpha canescens	Lead Plant	9	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Antennaria microphylla	Pink Pussy-toes	7	Native	P	UPL
Antennaria parvifolia	Pussy-toes	6	Native	P	UPL
Arabis hirsuta	Rock Cress	7	Native	B	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex aurea	Golden Sedge	8	Native	P	FACW
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex hallii	N/A	10	Native	P	FACW-
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Crepis runcinata	Hawk's-beard	8	Native	P	FAC
Distichlis spicata	Inland Saltgrass	2	Native	P	FACW
Eleocharis erythropoda	N/A	2	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Festuca octoflora	Sixweeks Fescue	0	Native	A	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Geum triflorum	Torch Flower	8	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Heuchera richardsonii	Alumroot	8	Native	P	FACU
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lepidium densiflorum	Peppergrass	0	Native	A	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Melilotus alba	White Sweet Clover	*	Introduced	A	UPL
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Panicum virgatum	Switchgrass	5	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygala verticillata	Whorled Milkwort	8	Native	A	UPL
Potamogeton gramineus	Variable Pondweed	6	Native	P	OBL
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ranunculus pensylvanicus	Bristly Crowfoot	4	Native	A	FACW+
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU
Schizachyrium scoparium	Little Bluestem	6	Native	P	UPL
Senecio pseudaureus	N/A	5	Native	P	FACU
Sisyrinchium campestre	White-eyed Grass	10	Native	P	UPL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stellaria longifolia	Long-leaved Stitchwort	8	Native	P	FACW
Stipa spartea	Porcupine-grass	8	Native	P	UPL
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Vicia americana	American Vetch	6	Native	P	UPL
Viola pedatifida	Prairie Violet	8	Native	P	FACU
Zigadenus elegans	White Camass	8	Native	P	FACU

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia artemisiifolia	Common Ragweed	0	Native	A	FACU
Amorpha canescens	Lead Plant	9	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Carex sartwellii	N/A	5	Native	P	FACW
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus maximiliani	Maximilian Sunflower	5	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Juncus balticus	Baltic Rush	5	Native	P	FACW
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Melilotus alba	White Sweet Clover	*	Introduced	A	UPL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Oxalis stricta	Yellow Wood Sorrel	0	Native	P	FACU
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Potentilla arguta	Tall Cinquefoil	8	Introduced	P	FACU
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex salicifolius	Willow-leaved Dock	1	Native	P	FACW
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX C. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE SCHOOL TEMP 2

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Amorpha canescens	Lead Plant	9	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Bidens frondosa	Beggar-ticks	1	Native	A	FACW
Boltonia asteroides	Violet Boltonia	3	Native	P	FACW
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis canadensis	Bluejoint	5	Native	P	FACW+
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Dichanthelium leibergii	Leiberg Dichanthelium	8	Native	P	FACU
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus maximilianii	Maximilian Sunflower	5	Native	P	FACU
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Lactuca tatarica	Blue Lettuce	1	Native	P	FACU
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Mentha arvensis	Field Mint	3	Native	P	FACW
Panicum virgatum	Switchgrass	5	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phleum pratense	Timothy	*	Introduced	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibium	Water Smartweed	6	Native	P	FACW
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rubus idaeus	Red Raspberry	5	Native	P	UPL
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Stipa viridula	Green Needlegrass	5	Native	P	UPL
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Urtica dioica	Stinging Nettle	0	Native	P	FACW
Vernonia fasciculata	Ironweed	3	Native	P	FAC
Viola pedatifida	Prairie Violet	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Agropyron smithii	Western Wheatgrass	4	Native	P	UPL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia artemisiifolia	Common Ragweed	0	Native	A	FACU
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Amorpha canescens	Lead Plant	9	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias syriaca	Common Milkweed	0	Native	P	UPL
Aster simplex	Panicled Aster	3	Native	P	FACW
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Cynoglossum officinale	Hound's Tongue	*	Introduced	B	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Fraxinus pennsylvanica	Red Ash, Green Ash	5	Native	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glyceria grandis	Tall Mannagrass	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus maximiliani	Maximilian Sunflower	5	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia racemosa	Marsh Muhly	4	Native	P	FACW
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU
Panicum virgatum	Switchgrass	5	Native	P	FAC
Phleum pratense	Timothy	*	Introduced	P	FACU
Plantago major	Common Plantain	*	Introduced	P	FAC
Poa palustris	Fowl Bluegrass	4	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygala verticillata	Whorled Milkwort	8	Native	A	UPL
Polygonum amphibium	Water Smartweed	6	Native	P	FACW
Polygonum aviculare	Knotweed	0	Native	A	FACU
Polygonum pensylvanicum	Pennsylvania Smartweed	0	Native	A	FACW
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Stipa spartea	Porcupine-grass	8	Native	P	UPL
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Vernonia fasciculata	Ironweed	3	Native	P	FAC
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX D. PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE BGT9908

PAST

Scientific Name[1]	**Common Name**	**C-Val[2]**	**Life[3]**	**Origin[4]**	**Ind[5]**
Achillea millefolium	Yarrow	3	Native	P	UPL
Agoseris glauca	False Dandelion	8	Native	P	FAC
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Astragalus canadensis	Canada Milk-vetch	5	Native	P	FACU
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis canadensis	Bluejoint	5	Native	P	FACW+
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Carex xerantica	N/A	10	Native	P	UPL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Comandra umbellata	N/A	8	Native	P	UPL
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis compressa	Flatstem Spikesedge	8	Native	P	FACW
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus lanceolatus	Thickspike Wheatgrass	7	Native	P	FAC
Elymus repens	Quackgrass	*	Introduced	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Heuchera richardsonii	Alumroot	8	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Mentha arvensis	Field Mint	3	Native	P	FACW
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibium	Water Smartweed	6	Native	P	FACW
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Prunus virginiana	Choke Cherry	4	Native	P	FACU-
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Salix petiolaris	Meadow Willow	8	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spiraea alba	Meadow-sweet	7	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Stellaria longifolia	Long-leaved Stitchwort	8	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Vicia americana	American Vetch	6	Native	P	UPL
Viola pedatifida	Prairie Violet	8	Native	P	FACU

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Agrimonia striata	Striate Agrimony	5	Native	P	FACU
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Astragalus canadensis	Canada Milk-vetch	5	Native	P	FACU
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis canadensis	Bluejoint	5	Native	P	FACW+
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Chenopodium album	Lamb's Quarters	*	Introduced	A	UPL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Conyza canadensis	Horseweed	0	Native	A	FACU
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Echinacea angustifolia	Purple Coneflower	7	Native	P	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Fragaria virginiana	Wild Strawberry	4	Native	P	FACU
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Melilotus alba	White Sweet Clover	*	Introduced	A	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum convolvulus	Wild Buckwheat	*	Introduced	A	FAC
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Prunus virginiana	Choke Cherry	4	Native	P	FACU-
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Rumex stenophyllus	N/A	*	Introduced	P	FACW+
Salix petiolaris	Meadow Willow	8	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spiraea alba	Meadow-sweet	7	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Teucrium canadense	American Germander	3	Native	P	FACW
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Thermopsis rhombifolia	Prairie Buck Bean	6	Native	P	UPL
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).
[3] Life-form – P = perennial, A = annual, B = biennial.
[4] Origin.
[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX E. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE BGT9906

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Arnica fulgens	Arnica	10	Native	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Bromus latiglumis	Ear-leaved Brome	8	Native	P	FACW
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Carex xerantica	N/A	10	Native	P	UPL
Chenopodium album	Lamb's Quarters	*	Introduced	A	UPL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Collomia linearis	Collomia	5	Native	A	FACU
Dichanthelium leibergii	Leiberg Dichanthelium	8	Native	P	FACU
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Fragaria virginiana	Wild Strawberry	4	Native	P	FACU
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Geum aleppicum	Yellow Avens	4	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Heuchera richardsonii	Alumroot	8	Native	P	FACU
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lilium philadelphicum	Wild Lily	8	Native	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum convolvulus	Wild Buckwheat	*	Introduced	A	FAC
Potamogeton gramineus	Variable Pondweed	6	Native	P	OBL
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex salicifolius	Willow-leaved Dock	1	Native	P	FACW
Salix petiolaris	Meadow Willow	8	Native	P	OBL
Senecio pseudaureus	N/A	5	Native	P	FACU
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Vicia americana	American Vetch	6	Native	P	UPL
Viola nuttallii	Nuttall's Violet	8	Native	P	UPL
Viola pedatifida	Prairie Violet	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL
Zizia aurea	Golden Alexanders	8	Native	P	FAC-

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agrostis scabra	Ticklegrass	1	Native	P	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Comandra umbellata	N/A	8	Native	P	UPL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex xerantica	N/A	10	Native	P	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Erysimum cheiranthoides	Wormseed Wallflower	*	Introduced	A	FACU
Fragaria virginiana	Wild Strawberry	4	Native	P	FACU
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Geum aleppicum	Yellow Avens	4	Native	P	FACU
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa comata	Needle-and-thread	6	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Juncus dudleyi	Dudley Rush	4	Native	P	FAC
Juncus interior	Inland Rush	5	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potamogeton gramineus	Variable Pondweed	6	Native	P	OBL

Scientific Name[1]	**Common Name**	**C-Val**[2]	**Life**[3]	**Origin**[4]	**Ind**[5]
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Teucrium canadense	American Germander	3	Native	P	FACW
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Vicia americana	American Vetch	6	Native	P	UPL
Viola pedatifida	Prairie Violet	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX F. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE BGS9907

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agropyron dasystachyum	Thickspike Wheatgrass	7	Native	P	FAC
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Alisma subcordatum	Common Water Plantain	2	Native	P	OBL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus repens	Quackgrass	*	Introduced	P	FAC
Elymus trachycaulus	Slender Wheatgrass	6	Native	P	FAC-
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erysimum inconspicuum	Smallflower Wallflower	7	Native	P	UPL
Eustoma grandiflorum	N/A	5	Native	A	FACW
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lemna minor	Duckweed	9	Native	P	OBL
Lemna trisulca	Star Duckweed	2	Native	P	OBL
Lepidium densiflorum	Peppergrass	0	Native	A	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lilium philadelphicum	Wild Lily	8	Native	P	FAC
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibium	Water Smartweed	6	Native	P	FACW
Populus tremuloides	Quaking aspen	4	Native	P	FAC
Potamogeton gramineus	Variable Pondweed	6	Native	P	OBL
Potamogeton pusillus	Baby Pondweed	2	Native	P	OBL
Argentina anserina	Silverweed	2	Native	P	OBL
Prunus virginiana	Choke Cherry	4	Native	P	FACU-
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Salix discolor	Pussy Willow	7	Native	P	FACW
Salix exigua	Sandbar Willow	3	Native	P	FACW+
Salix petiolaris	Meadow Willow	8	Native	P	OBL
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Scolochloa festucacea	Sprangletop	6	Native	P	OBL
Sisyrinchium campestre	White-eyed Grass	10	Native	P	UPL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Sparganium eurycarpum	Giant Burreed	4	Native	P	OBL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Thermopsis rhombifolia	Prairie Buck Bean	6	Native	P	UPL
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Vicia americana	American Vetch	6	Native	P	UPL
Zigadenus elegans	White Camass	8	Native	P	FACU

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Alisma gramineum	N/A	2	Native	P	OBL
Amelanchier alnifolia	Saskatoon Service-berry	6	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL
Atriplex subspicata	Spearscale	2	Native	A	FAC
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex hallii	N/A	10	Native	P	FACW-
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Carex sychnocephala	N/A	7	Native	P	FACW
Ceratophyllum demersum	Hornwort, Coontail	4	Native	P	OBL
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis compressa	Flatstem Spikesedge	8	Native	P	FACW
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lemna trisulca	Star Duckweed	2	Native	P	OBL
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Myriophyllum exalbescens	American Milfoil	3	Native	P	OBL
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Swamp Smartweed	0	Native	P	OBL
Populus tremuloides	Quaking aspen	4	Native	P	FAC
Potamogeton pectinatus	Sago Pondweed	0	Native	P	OBL
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Potentilla rivalis	Brook Conquefoil	3	Native	A	OBL
Ranunculus subrigidus	White Water Crowfoot	3	Native	P	OBL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Rumex stenophyllus	N/A	*	Introduced	P	FACW+
Sagittaria cuneata	Arrowhead	6	Native	P	OBL
Salix petiolaris	Meadow Willow	8	Native	P	OBL
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Sium suave	Water Parsnip	3	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliolatum	N/A	8	Native	P	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Typha latifolia	Broad-leaved Cattail	2	Native	P	OBL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Zigadenus elegans	White Camass	8	Native	P	FACU

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX G. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE BS9904

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agoseris glauca	False Dandelion	8	Native	P	FAC
Alisma subcordatum	Common Water Plantain	2	Native	P	OBL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Argentina anserina	Silverweed	2	Native	P	OBL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis canadensis	Bluejoint	5	Native	P	FACW+
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex aurea	Golden Sedge	8	Native	P	FACW
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Comandra umbellata	N/A	8	Native	P	UPL
Crepis runcinata	Hawk's-beard	8	Native	P	FAC
Deschampsia cespitosa	Tufted Hairgrass	9	Native	P	FACW
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis erythropoda	N/A	2	Native	P	OBL
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus caninus	Slender Wheatgrass	6	Native	P	FAC-
Elymus repens	Quackgrass	*	Introduced	P	FAC
Equisetum arvense	Field Horsetail	4	Native	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Euthamia graminifolia	N/A	6	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Gentiana affinis	Northern Gentian	10	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Heuchera richardsonii	Alumroot	8	Native	P	FACU
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lilium philadelphicum	Wild Lily	8	Native	P	FAC
Linum perenne	Blue Flax	6	Native	P	UPL
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Oxalis stricta	Yellow Wood Sorrel	0	Native	P	FACU
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa arida	Plains Bluegrass	6	Native	P	FAC
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Potamogeton gramineus	Variable Pondweed	6	Native	P	OBL
Potentilla argute	Tall Cinquefoil	8	Native	P	FACU
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ranunculus pensylvanicus	Bristly Crowfoot	4	Native	A	FACW+
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Scolochloa festucacea	Sprangletop	6	Native	P	OBL
Sisyrinchium campestre	White-eyed Grass	10	Native	P	UPL
Sium suave	Water Parsnip	3	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Sparganium eurycarpum	Giant Burreed	4	Native	P	OBL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Stellaria longifolia	Long-leaved Stitchwort	8	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Vicia americana	American Vetch	6	Native	P	UPL
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW
Zigadenus elegans	White Camass	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL
Zizia aurea	Golden Alexanders	8	Native	P	FAC-

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Agoseris glauca	False Dandelion	8	Native	P	FAC
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Agropyron smithii	Western Wheatgrass	4	Native	P	UPL
Alopecurus aequalis	Shortawn Foxtail	2	Native	P	OBL
Amelanchier alnifolia	Saskatoon Service-berry	6	Native	P	FACU
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Argentina anserina	Silverweed	2	Native	P	OBL
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis canadensis	Bluejoint	5	Native	P	FACW+
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex aurea	Golden Sedge	8	Native	P	FACW
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Comandra umbellata	N/A	8	Native	P	UPL
Deschampsia cespitosa	Tufted Hairgrass	9	Native	P	FACW
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis compressa	Flatstem Spikesedge	8	Native	P	FACW
Eleocharis compressa	Flatstem Spikesedge	8	Native	P	FACW
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Equisetum arvense	Field Horsetail	4	Native	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Geum aleppicum	Yellow Avens	4	Native	P	FACU
Glyceria grandis	Tall Mannagrass	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Heuchera richardsonii	Alumroot	8	Native	P	FACU
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lilium philadelphicum	Wild Lily	8	Native	P	FAC
Linum perenne	Blue Flax	6	Native	P	UPL
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Mentha arvensis	Field Mint	3	Native	P	FACW
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Sium suave	Water Parsnip	3	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Teucrium canadense	American Germander	3	Native	P	FACW
Thermopsis rhombifolia	Prairie Buck Bean	6	Native	P	UPL
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Zigadenus elegans	White Camass	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).
[3] Life-form – P = perennial, A = annual, B = biennial.
[4] Origin.
[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX H. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE KIDNEY BASIN

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Alisma subcordatum	Common Water Plantain	2	Native	P	OBL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Amorpha canescens	Lead Plant	9	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Astragalus canadensis	Canada Milk-vetch	5	Native	P	FACU
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bidens cernua	Nodding Beggar-ticks	3	Native	A	OBL
Bidens frondosa	Beggar-ticks	1	Native	A	FACW
Boltonia asteroides	Violet Boltonia	3	Native	P	FACW
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis canadensis	Bluejoint	5	Native	P	FACW+
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Carex vulpinoidea	Fox Sedge	2	Native	P	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Dichanthelium leibergii	Leiberg Dichanthelium	8	Native	P	FACU
Dichanthelium wilcoxianum	Wilcox Dichanthelium	8	Native	P	UPL
Eleocharis compressa	Flatstem Spikesedge	8	Native	P	FACW
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus repens	Quackgrass	*	Introduced	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Elymus trachycaulus	Slender Wheatgrass	6	Native	P	FAC-
Fragaria virginiana	Wild Strawberry	4	Native	P	FACU
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus maximilianii	Maximilian Sunflower	5	Native	P	FACU
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Lemna minor	Duckweed	9	Native	P	OBL
Lemna trisulca	Star Duckweed	2	Native	P	OBL
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lithospermum canescens	Hoary Puccoon	7	Native	P	UPL
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Lysimachia thyrsiflora	Tufted Loosestrife	7	Native	P	OBL
Mentha arvensis	Field Mint	3	Native	P	FACW
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Scutellaria galericulata	Marsh Skullcap	7	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sparganium eurycarpum	Giant Burreed	4	Native	P	OBL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Typha latifolia	Broad-leaved Cattail	2	Native	P	OBL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Viola pedatifida	Prairie Violet	8	Native	P	FACU

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Agropyron smithii	Western Wheatgrass	4	Native	P	UPL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Alopecurus aequalis	Shortawn Foxtail	2	Native	P	OBL
Ambrosia artemisiifolia	Common Ragweed	0	Native	A	FACU
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Amorpha canescens	Lead Plant	9	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Argentina anserina	Silverweed	2	Native	P	OBL
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias syriaca	Common Milkweed	0	Native	P	UPL
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex prairea	N/A	10	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Carex vulpinoidea	Fox Sedge	2	Native	P	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Elaeagnus commutata	Silverberry	5	Native	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Fraxinus pennsylvanica	Red Ash, Green Ash	5	Native	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glyceria grandis	Tall Mannagrass	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus maximilianii	Maximilian Sunflower	5	Native	P	FACU
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Juncus dudleyi	Dudley Rush	4	Native	P	FAC
Juncus interior	Inland Rush	5	Native	P	FACW
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Melilotus alba	White Sweet Clover	*	Introduced	A	UPL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU
Onosmodium molle	False Gromwell	7	Native	P	UPL
Plantago major	Common Plantain	*	Introduced	P	FAC
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum pensylvanicum	Pennsylvania Smartweed	0	Native	A	FACW
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Rumex mexicanus	Willow-leaved Dock	1	Native	P	FACW
Rumex stenophyllus	N/A	*	Introduced	P	FACW+
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Stipa viridula	Green Needlegrass	5	Native	P	UPL
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Teucrium canadense	American Germander	3	Native	P	FACW
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Verbena hastata	Blue Vervain	5	Native	P	FACW
Verbena hastata	Blue Vervain	5	Native	P	FACW
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX I. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE HAL'S SEASONAL

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Alisma subcordatum	Common Water Plantain	2	Native	P	OBL
Alopecurus aequalis	Shortawn Foxtail	2	Native	P	OBL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bidens cernua	Nodding Beggar-ticks	3	Native	A	OBL
Bidens frondosa	Beggar-ticks	1	Native	A	FACW
Boltonia asteroides	Violet Boltonia	3	Native	P	FACW
Calamovilfa longifolia	Prairie Sandreed	5	Native	P	UPL
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Carex vulpinoidea	Fox Sedge	2	Native	P	OBL
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Dalea purpurea	Purple Prairie Clover	8	Native	P	UPL
Distichlis spicata	Inland Saltgrass	2	Native	P	FACW
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Euphorbia glyptosperma	Ridge-seeded Spurge	0	Native	A	FACU
Glyceria grandis	Tall Mannagrass	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus annuus	Common Sunflower	0	Native	A	FACU
Helianthus maximilianii	Maximilian Sunflower	5	Native	P	FACU
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW
Lemna minor	Duckweed	9	Native	P	OBL
Lemna trisulca	Star Duckweed	2	Native	P	OBL
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lysimachia ciliata	Fringed loosestrife	6	Native	P	FACW
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Mentha arvensis	Field Mint	3	Native	P	FACW
Oxalis stricta	Yellow Wood Sorrel	0	Native	P	FACU
Panicum virgatum	Switchgrass	5	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Plantago major	Common Plantain	*	Introduced	P	FAC
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygala verticillata	Whorled Milkwort	8	Native	A	UPL
Polygonum lapathifolium	Pale Smartweed	1	Native	A	OBL
Potamogeton diversifolius	Water-thread Pondweed	4	Native	P	OBL
Potamogeton pusillus	Baby Pondweed	2	Native	P	OBL
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex salicifolius	Willow-leaved Dock	1	Native	P	FACW
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Setaria glauca	Yellow Foxtail	*	Introduced	A	FACU
Sium suave	Water Parsnip	3	Native	P	OBL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Sparganium eurycarpum	Giant Burreed	4	Native	P	OBL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Vernonia fasciculata	Ironweed	3	Native	P	FAC
Vicia americana	American Vetch	6	Native	P	UPL
Xanthium strumarium	Cocklebur	0	Native	A	FAC

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Alisma gramineum	N/A	2	Native	P	OBL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Alopecurus aequalis	Shortawn Foxtail	2	Native	P	OBL
Ambrosia artemisiifolia	Common Ragweed	0	Native	A	FACU
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Apocynum cannabinum	Indian Hemp Dogbane	4	Native	P	FAC
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias syriaca	Common Milkweed	0	Native	P	UPL
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bidens frondosa	Beggar-ticks	1	Native	A	FACW
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex athrostachya	N/A	7	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex vulpinoidea	Fox Sedge	2	Native	P	OBL
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Echinochloa crusgalli	Barnyard Grass	*	Introduced	A	FACW
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus repens	Quackgrass	*	Introduced	P	FAC
Fraxinus pennsylvanica	Red Ash, Green Ash	5	Native	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glyceria grandis	Tall Mannagrass	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus maximilianii	Maximilian Sunflower	5	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus torreyi	Torrey's Rush	2	Native	P	FACW
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Lysimachia hybrida	Loosestrife	5	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Medicago sativa	Alfalfa	*	Introduced	P	UPL
Melilotus alba	White Sweet Clover	*	Introduced	A	UPL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Orthocarpus luteus	Owl Clover	6	Native	A	FACU
Panicum virgatum	Switchgrass	5	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Plantago major	Common Plantain	*	Introduced	P	FAC
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum erectum	Erect Knotweed	0	Native	A	OBL
Polygonum lapathifolium	Pale Smartweed	1	Native	A	OBL
Polygonum pensylvanicum	Pennsylvania Smartweed	0	Native	A	FACW
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex mexicanus	Willow-leaved Dock	1	Native	P	FACW
Schoenoplectus pungens	N/A	4	Native	P	OBL
Scirpus acutus	Hard-stem Bulrush	5	Native	P	OBL
Setaria glauca	Yellow Foxtail	*	Introduced	A	FACU
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Sparganium eurycarpum	Giant Burreed	4	Native	P	OBL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Vernonia fasciculata	Ironweed	3	Native	P	FAC
Xanthium strumarium	Cocklebur	0	Native	A	FAC

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).
[3] Life-form – P = perennial, A = annual, B = biennial.
[4] Origin.
[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX J. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE BG0102

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Bluegrass species	3	Native	P	UPL
Agoseris glauca	False Dandelion	8	Native	P	FAC
Agropyron caninum	Slender Wheatgrass	6	Native	P	FAC-
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Cudweed sage	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Argentina anserina	Silverweed	2	Native	P	OBL
Artemisia frigida	Prairie Sagewort	4	Native	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Astragalus canadensis	Canada Milk-vetch	5	Native	P	FACU
Astragalus flexuosus	Pliant Milk-vetch	4	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Bromus latiglumis	Ear-leaved Brome	8	Native	P	FACW
Calamagrostis stricta	N/A	5	Native	P	FACW+
Calamovilfa longifolia	Prairie Sandreed	5	Native	P	UPL
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex species	Sedge	7	Native	P	FAC
Carex xerantica	N/A	10	Native	P	UPL
Cicuta maculata	Common Water Hemlock	4	Native	P	OBL
Cirsium arvense	Canada thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Comandra umbellata	N/A	8	Native	P	UPL
Crepis runcinata	Hawk's-beard	8	Native	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Dalea purpurea	Purple Prairie Clover	8	Native	P	UPL
Echinacea angustifolia	Purple Coneflower	7	Native	P	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis palustris	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Equisetum arvense	Field Horsetail	4	Native	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erigeron glabellus	N/A	7	Native	B	FACW
Euphorbia esula	Leafy Spurge	*	Introduced	P	UPL
Euthamia graminifolia	N/A	6	Native	P	FACW
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Habenaria viridis	Long-bracted Orchid	10	Native	P	OBL
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Heuchera richardsonii	Alumroot	8	Native	P	FACU
Hieracium umbellatum	N/A	6	Native	P	FACW
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus alpinoarticulatus	N/A	7	Native	P	OBL
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW
Juncus nodosus	Knotted Rush	7	Native	P	OBL
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lilium philadelphicum	Wild Lily	8	Native	P	FAC
Linum perenne	Blue Flax	6	Native	P	UPL
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Mirabilis hirsuta	Hairy Four-O'Clock	4	Native	P	UPL
Muhlenbergia asperifolia	Scratchgrass	2	Native	P	FACW
Muhlenbergia racemosa	Marsh Muhly	4	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Panicum virgatum	Switchgrass	5	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum coccineum	Swamp Smartweed	0	Native	P	OBL
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Prunus americana	Wild Plum	4	Native	P	UPL
Prunus virginiana	Choke Cherry	4	Native	P	FACU-
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL
Scolochloa festucacea	Sprangletop	6	Native	P	OBL
Senecio pseudaureus	N/A	5	Native	P	FACU
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago gigantea	Late Goldenrod	4	Native	P	FACW
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina gracilis	Alkali Cordgrass	6	Native	P	FACW
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliatum	Rayless Aster	0	Native	A	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Thalictrum venulosum	Early Meadow Rue	6	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Thermopsis rhombifolia	Prairie Buck Bean	6	Native	P	UPL
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Triglochin maritima	Arrowgrass	5	Native	P	OBL
Typha angustifolia	Narrow-leaved Cattail	*	Introduced	P	OBL
Typha latifolia	Broad-leaved Cattail	2	Native	P	OBL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Zigadenus elegans	White Camass	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agoseris glauca	False Dandelion	8	Native	P	FAC
Agropyron smithii	Western Wheatgrass	4	Native	P	UPL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Artemisia frigida	Prairie Sagewort	4	Native	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Bolboschoenus fluviatilis	River Bulrush	2	Native	P	OBL
Boltonia asteroides	Violet Boltonia	3	Native	P	FACW
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cicuta maculata	Common Water Hemlock	4	Native	P	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Conyza canadensis	Horseweed	0	Native	A	FACU
Crepis runcinata	Hawk's-beard	8	Native	P	FAC
Distichlis spicata var. stricta	Inland Saltgrass	2	Native	P	FACW
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Equisetum arvense	Field Horsetail	4	Native	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erigeron glabellus	N/A	7	Native	B	FACW
Erysimum cheiranthoides	Wormseed Wallflower	*	Introduced	A	FACU
Euphorbia esula	Leafy Spurge	*	Introduced	P	UPL
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa comata	Needle-and-thread	6	Native	P	UPL
Hippuris vulgaris	Mare's Tail	5	Native	P	OBL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Juncus longistylis	N/A	10	Native	P	FACW
Juncus torreyi	Torrey's Rush	2	Native	P	FACW
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Muhlenbergia asperifolia	Scratchgrass	2	Native	P	FACW
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Polygonum lapathifolium	Pale Smartweed	1	Native	A	OBL
Populus tremuloides	Quaking aspen	4	Native	P	FAC
Potamogeton pectinatus	Sago Pondweed	0	Native	P	OBL
Potentilla anserina	Silverweed	2	Native	P	OBL
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Potentilla paradoxa	Bushy Cinquefoil	2	Native	A	FACW
Potentilla rivalis	Brook Conquefoil	3	Native	A	OBL
Prunus virginiana	Choke Cherry	4	Native	P	FACU-
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ranunculus sceleratus	Cursed Crowfoot	3	Native	A	OBL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL
Scolochloa festucacea	Sprangletop	6	Native	P	OBL
Senecio congestus	Swamp Ragwort	2	Native	A	FACW+
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliolatum	N/A	8	Native	P	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Teucrium canadense	American Germander	3	Native	P	FACW
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Triglochin maritima	Arrowgrass	5	Native	P	OBL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX K. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE NG0111

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agoseris glauca	False Dandelion	8	Native	P	FAC
Agropyron caninum	Slender Wheatgrass	6	Native	P	FAC-
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Androsace occidentalis	Western Rock Jasmine	5	Native	A	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Antennaria microphylla	Pink Pussy-toes	7	Native	P	UPL
Antennaria neglecta	Field Pussy-toes	5	Native	P	UPL
Apocynum cannabinum	Prairie Dogbane	4	Native	P	FAC
Arctium minus	Common Burdock	*	Introduced	B	UPL
Argentina anserina	Silverweed	2	Native	P	OBL
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia frigida	Prairie Sagewort	4	Native	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias ovalifolia	Ovalleaf Milkweed	9	Native	P	UPL
Astragalus flexuosus	Pliant Milk-vetch	4	Native	P	UPL
Bouteloua gracilis	Blue Grama	7	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex aurea	Golden Sedge	8	Native	P	FACW
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex hallii	N/A	10	Native	P	FACW-
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Cerastium arvense	Prairie Chickweed	2	Native	P	FACU
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Comandra umbellata	N/A	8	Native	P	UPL
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Crepis runcinata	Hawk's-beard	8	Native	P	FAC
Dalea purpurea	Purple Prairie Clover	8	Native	P	UPL
Distichlis spicata	Inland Saltgrass	2	Native	P	FACW
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Epilobium leptophyllum	Narrow-leaved Willow-herb	6	Native	P	OBL
Equisetum arvense	Field Horsetail	4	Native	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erigeron philadelphicus	Philadelphia Fleabane	2	Native	B	FACW
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Euphorbia esula	Leafy Spurge	*	Introduced	P	UPL
Euphorbia glyptosperma	Ridge-seeded Spurge	0	Native	A	FACU
Euthamia graminifolia	N/A	6	Native	P	FACW
Festuca ovina	Sheep's Fescue	8	Native	P	FACU
Fragaria virginiana	Wild Strawberry	4	Native	P	FACU
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Gentiana affinis	Northern Gentian	10	Native	P	FACU
Geum aleppicum	Yellow Avens	4	Native	P	FACU
Geum triflorum	Torch Flower, Maidenhair	8	Native	P	FACU
Glaux maritima	Sea Milkwort	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Habenaria viridis	Long-bracted Orchid	10	Native	P	OBL
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Hieracium umbellatum	N/A	6	Native	P	FACW
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus alpinus	N/A	7	Native	P	OBL
Juncus balticus	Baltic Rush	5	Native	P	FACW

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Juncus interior	Inland Rush	5	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lemna trisulca	Star Duckweed	2	Native	P	OBL
Lemna turionifera	N/A	1	Native	P	OBL
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Mentha arvensis	Field Mint	3	Native	P	FACW
Monarda fistulosa	Wild Bergamot	5	Native	P	UPL
Muhlenbergia asperifolia	Scratchgrass	2	Native	P	FACW
Muhlenbergia racemosa	Marsh Muhly	4	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Myriophyllum exalbescens	American Milfoil	3	Native	P	OBL
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU
Onosmodium molle	False Gromwell	7	Native	P	UPL
Orthocarpus luteus	Owl Clover	6	Native	A	FACU
Oxalis stricta	Yellow Wood Sorrel	0	Native	P	FACU
Panicum virgatum	Switchgrass	5	Native	P	FAC
Parnassia palustris	Northern Grass-of-Parnassus	10	Native	P	OBL
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phleum pratense	Timothy	*	Introduced	P	FACU
Plantago major	Common Plantain	*	Introduced	P	FAC
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygala senega	Seneca Snakeroot	10	Native	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum convolvulus	Wild Buckwheat	*	Introduced	A	FAC
Populus tremuloides	Quaking aspen	4	Native	P	FAC
Potamogeton pectinatus	Sago Pondweed	0	Native	P	OBL
Potentilla gracilis	Cinquefoil	5	Native	P	UPL
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Prunus americana	Wild Plum	4	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Prunus virginiana	Choke Cherry	4	Native	P	FACU-
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ranunculus gmelinii	Small Yellow Buttercup	8	Native	P	FACW+
Ranunculus longirostris	White Water Crowfoot	7	Native	P	OBL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Ribes missouriense	Missouri Gooseberry	4	Native	P	FAC
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Salix bebbiana	Beaked Willow	8	Native	P	FACW
Salix exigua	Sandbar Willow	3	Native	P	FACW+
Salix lutea	Yellow Willow	5	Native	P	FACW
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL
Senecio pseudaureus	N/A	5	Native	P	FACU
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliatum	Rayless Aster	0	Native	A	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Symphyotrichum lanceolatum var. hesperium	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Triglochin maritima	Arrowgrass	5	Native	P	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Typha angustifolia	Narrow-leaved Cattail	*	Introduced	P	OBL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW
Viola nuttallii	Nuttall's Violet	8	Native	P	UPL
Zigadenus elegans	White Camass	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agrimonia striata	Striate Agrimony	5	Native	P	FACU
Agropyron repens	Quackgrass	*	Introduced	P	FAC
Agropyron smithii	Western Wheatgrass	4	Native	P	UPL
Agrostis scabra	Ticklegrass	1	Native	P	FAC
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Antennaria neglecta	Field Pussy-toes	5	Native	P	UPL
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Asclepias syriaca	Common Milkweed	0	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Carex sychnocephala	N/A	7	Native	P	FACW
Ceratophyllum demersum	Hornwort, Coontail	4	Native	P	OBL

Scientific Name[1]	**Common Name**	**C-Val[2]**	**Life[3]**	**Origin[4]**	**Ind[5]**
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Conyza canadensis	Horseweed	0	Native	A	FACU
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Cynoglossum officinale	Hound's Tongue	*	Introduced	B	UPL
Dalea purpurea	Purple Prairie Clover	8	Native	P	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Equisetum arvense	Field Horsetail	4	Native	P	FAC
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erigeron philadelphicus	Philadelphia Fleabane	2	Native	B	FACW
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Erysimum cheiranthoides	Wormseed Wallflower	*	Introduced	A	FACU
Euphorbia esula	Leafy Spurge	*	Introduced	P	UPL
Geum triflorum	Torch Flower	8	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Juncus bufonius	Toad Rush	1	Native	A	OBL
Juncus dudleyi	Dudley Rush	4	Native	P	FAC
Juncus interior	Inland Rush	5	Native	P	FACW
Juncus torreyi	Torrey's Rush	2	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Monarda fistulosa	Wild Bergamot	5	Native	P	UPL
Muhlenbergia asperifolia	Scratchgrass	2	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Myriophyllum exalbescens	American Milfoil	3	Native	P	OBL
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Onosmodium molle	False Gromwell	7	Native	P	UPL
Panicum virgatum	Switchgrass	5	Native	P	FAC
Phleum pratense	Timothy	*	Introduced	P	FACU
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum convolvulus	Wild Buckwheat	*	Introduced	A	FAC
Polygonum lapathifolium	Pale Smartweed	1	Native	A	OBL
Populus tremuloides	Quaking aspen	4	Native	P	FAC
Potamogeton crispus	Curly Muckweed	*	Introduced	P	OBL
Potamogeton pusillus	Baby Pondweed	2	Native	P	OBL
Potentilla anserina	Silverweed	2	Native	P	OBL
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Puccinellia nuttalliana	Alkali-grass	4	Native	P	OBL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ranunculus sceleratus	Cursed Crowfoot	3	Native	A	OBL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Rumex stenophyllus	N/A	*	Introduced	P	FACW+
Salix bebbiana	Beaked Willow	8	Native	P	FACW
Salix lutea	Yellow Willow	5	Native	P	FACW
Scirpus acutus	Hard-stem Bulrush	5	Native	P	OBL
Sisyrinchium campestre	White-eyed Grass	10	Native	P	UPL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Solidago ptarmicoides	Sneezewort Aster	8	Native	P	UPL
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliolatum	N/A	8	Native	P	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Teucrium canadense	American Germander	3	Native	P	FACW
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Trifolium repens	White Clover	*	Introduced	P	FACU
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW
Viola pedatifida	Prairie Violet	8	Native	P	FACU

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX L. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE NG0206

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Alisma subcordatum	Common Water Plantain	2	Native	P	OBL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Antennaria microphylla	Pink Pussy-toes	7	Native	P	UPL
Antennaria neglecta	Field Pussy-toes	5	Native	P	UPL
Arabis hirsuta	Rock Cress	7	Native	B	UPL
Arctium minus	Common Burdock	*	Introduced	B	UPL
Argentina anserina	Silverweed	2	Native	P	OBL
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia frigida	Prairie Sagewort	4	Native	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias syriaca	Common Milkweed	0	Native	P	UPL
Astragalus agrestis	Field Milk-vetch	6	Native	P	FACU
Astragalus flexuosus	Pliant Milk-vetch	4	Native	P	UPL
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bouteloua gracilis	Blue Grama	7	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex aurea	Golden Sedge	8	Native	P	FACW
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex hallii	N/A	10	Native	P	FACW-
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW

Scientific Name[1]	**Common Name**	**C-Val[2]**	**Life[3]**	**Origin[4]**	**Ind[5]**
Carex sartwellii	N/A	5	Native	P	FACW
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Comandra umbellata	N/A	8	Native	P	UPL
Crepis runcinata	Hawk's-beard	8	Native	P	FAC
Dalea purpurea	Purple Prairie Clover	8	Native	P	UPL
Distichlis spicata	Inland Saltgrass	2	Native	P	FACW
Echinacea angustifolia	Purple Coneflower	7	Native	P	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis palustris	Spike Rush	4	Native	P	OBL
Elymus repens	Quackgrass	*	Introduced	P	FAC
Elymus trachycaulus	N/A	6	Native	P	FAC-
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erigeron glabellus	N/A	7	Native	B	FACW
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Festuca octoflora	Sixweeks Fescue	0	Native	A	UPL
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Galium verum	Yellow Bedstraw	*	Introduced	P	UPL
Geum aleppicum	Yellow Avens	4	Native	P	FACU
Geum triflorum	Torch Flower	8	Native	P	FACU
Glaux maritima	Sea Milkwort	4	Native	P	OBL
Glyceria striata	Fowl Mannagrass	6	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus pauciflorus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW
Juncus torreyi	Torrey's Rush	2	Native	P	FACW
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Linum perenne	Blue Flax	6	Native	P	UPL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Linum rigidum	Stiffstem Flax	5	Native	A	UPL
Lobelia kalmii	Kalm's Lobelia	10	Native	P	OBL
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia asperifolia	Scratchgrass	2	Native	P	FACW
Muhlenbergia racemosa	Marsh Muhly	4	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Onosmodium molle	False Gromwell	7	Native	P	UPL
Orthocarpus luteus	Owl Clover	6	Native	A	FACU
Panicum virgatum	Switchgrass	5	Native	P	FAC
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phleum pratense	Timothy	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygala alba	White Milkwort	5	Native	P	UPL
Polygala verticillata	Whorled Milkwort	8	Native	A	UPL
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Polygonum coccineum	Swamp Smartweed	0	Native	P	OBL
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potentilla rivalis	Brook Conquefoil	3	Native	A	OBL
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ranunculus gmelinii	Small Yellow Buttercup	8	Native	P	FACW+
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Sagittaria cuneata	Arrowhead	6	Native	P	OBL
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Senecio congestus	Swamp Ragwort	2	Native	A	FACW+
Senecio pseudaureus	N/A	5	Native	P	FACU
Sium suave	Water Parsnip	3	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago gigantea	Late Goldenrod	4	Native	P	FACW
Solidago missouriensis	Prairie Goldenrod	5	Native	P	UPL
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Sparganium eurycarpum	Giant Burreed	4	Native	P	OBL
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Stachys palustris	Hedge-nettle	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliatum	Rayless Aster	0	Native	A	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Trifolium repens	White Clover	*	Introduced	P	FACU
Triglochin maritima	Arrowgrass	5	Native	P	OBL
Typha latifolia	Broad-leaved Cattail	2	Native	P	OBL
Utricularia vulgaris	Common Bladderwort	2	Native	P	OBL
Viola pedatifida	Prairie Violet	8	Native	P	FACU
Zigadenus elegans	White Camass	8	Native	P	FACU
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agropyron smithii	Western Wheatgrass	4	Native	P	UPL
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Alopecurus aequalis	Shortawn Foxtail	2	Native	P	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Ambrosia artemisiifolia	Common Ragweed, Short Ragweed	0	Native	A	FACU
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Antennaria parvifolia	Pussy-toes	6	Native	P	UPL
Artemisia absinthium	Wormwood	*	Introduced	P	UPL
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias syriaca	Common Milkweed	0	Native	P	UPL
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bouteloua gracilis	Blue Grama	7	Native	P	UPL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Carex sartwellii	N/A	5	Native	P	FACW
Carex vulpinoidea	Fox Sedge	2	Native	P	OBL
Chenopodium glaucum	Oak-leaved Goosefoot	*	Introduced	A	FACW
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cirsium arvense	Canada Thistle, Field Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Crataegus rotundifolia	Northern Hawthorn	6	Native	P	FACU
Cynoglossum officinale	Hound's Tongue	*	Introduced	B	UPL
Echinacea angustifolia	Purple Coneflower	7	Native	P	UPL
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glyceria grandis	Tall Mannagrass	4	Native	P	OBL
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Grindelia squarrosa	Curly-top Gumweed	1	Native	B	UPL
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus dudleyi	Dudley Rush	4	Native	P	FAC
Juncus interior	Inland Rush	5	Native	P	FACW
Juncus torreyi	Torrey's Rush	2	Native	P	FACW
Kochia scoparia	Kochia, Fire-weed	*	Introduced	A	FAC
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Mentha arvensis	Field Mint	3	Native	P	FACW
Myriophyllum exalbescens	American Milfoil	3	Native	P	OBL
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Onosmodium molle	False Gromwell	7	Native	P	UPL
Panicum virgatum	Switchgrass	5	Native	P	FAC
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Plantago major	Common Plantain	*	Introduced	P	FAC
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum erectum	Erect Knotweed	0	Native	A	OBL
Polygonum pensylvanicum	Pennsylvania Smartweed	0	Native	A	FACW
Potamogeton pectinatus	Sago Pondweed	0	Native	P	OBL
Potentilla anserina	Silverweed	2	Native	P	OBL
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rudbeckia hirta	Black-eyed Susan	5	Native	B	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Salsola iberica	Russian Thistle, Tumbleweed	*	Introduced	A	UPL
Schizachyrium scoparium	Little Bluestem	6	Native	P	UPL
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle, Marsh Betony	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Thinopyrum ponticum	Tall Wheatgrass	*	Introduced	P	UPL
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Trifolium repens	White Clover, Ladino Clover	*	Introduced	P	FACU
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).

APPENDIX M. PAST AND PRESENT COMPREHENSIVE PLANT SPECIES LIST FOR SITE NSP0433

PAST

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Agoseris glauca	False Dandelion	8	Native	P	FAC
Agropyron caninum	Slender Wheatgrass	6	Native	P	FAC-
Agrostis hyemalis	Ticklegrass	1	Native	P	FACW
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Ambrosia psilostachya	Western Ragweed	2	Native	P	FAC
Andropogon gerardii	Big Bluestem	5	Native	P	FACU
Andropogon scoparius	Little Bluestem	6	Native	P	UPL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Apocynum cannabinum	Indian Hemp Dogbane	4	Native	P	FAC
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Astragalus canadensis	Canada Milk-vetch	5	Native	P	FACU
Bromus latiglumis	Ear-leaved Brome	8	Native	P	FACW
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex aurea	Golden Sedge	8	Native	P	FACW
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex praegracilis	Clustered-field Sedge	5	Native	P	FACW
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cicuta maculata	Common Water Hemlock	4	Native	P	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Crepis runcinata	Hawk's-beard	8	Native	P	FAC
Deschampsia cespitosa	Tufted Hairgrass	9	Native	P	FACW
Desmodium canadense	Canada Tickclover	6	Native	P	FACU
Elaeagnus commutata	Silverberry	5	Native	P	FAC
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Eleocharis parvula	N/A	10	Native	P	OBL
Elymus repens	Quackgrass	*	Introduced	P	FAC
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Equisetum laevigatum	Smooth Scouring Rush	3	Native	P	FAC
Erysimum inconspicuum	Smallflower Wallflower	7	Native	P	UPL
Euphorbia esula	Leafy Spurge	*	Introduced	P	UPL
Euthamia graminifolia	N/A	6	Native	P	FACW
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus balticus	Baltic Rush	5	Native	P	FACW
Juncus interior	Inland Rush	5	Native	P	FACW
Juncus longistylis	N/A	10	Native	P	FACW
Juncus torreyi	Torrey's Rush	2	Native	P	FACW
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lactuca serriola	Prickly Lettuce	*	Introduced	A	FACU
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lobelia spicata	Palespike Lobelia	6	Native	P	FAC
Lycopus americanus	American Bugleweed	4	Native	P	OBL
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Muhlenbergia richardsonis	Mat Muhly	10	Native	P	FAC
Myriophyllum exalbescens	American Milfoil	3	Native	P	OBL
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Orthocarpus luteus	Owl Clover	6	Native	A	FACU
Parnassia palustris	Northern Grass-of-Parnassus	10	Native	P	OBL
Pascopyrum smithii	Western Wheatgrass	4	Native	P	UPL
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Plantago major	Common Plantain	*	Introduced	P	FAC

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Poa compressa	Canada Bluegrass	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibium	Water Smartweed	6	Native	P	FACW
Polygonum amphibium var. emersum	Swamp Smartweed	0	Native	P	OBL
Potamogeton gramineus	Variable Pondweed	6	Native	P	OBL
Potamogeton pectinatus	Sago Pondweed	0	Native	P	OBL
Potentilla anserina	Silverweed	2	Native	P	OBL
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus cymbalaria	Shore Buttercup	3	Native	P	OBL
Ratibida columnifera	Prairie Coneflower	3	Native	P	UPL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Salix amygdaloides	Peachleaf Willow	3	Native	P	FACW
Salix exigua	Sandbar Willow	3	Native	P	FACW+
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL
Senecio congestus	Swamp Ragwort	2	Native	A	FACW+
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago gigantea	Late Goldenrod	4	Native	P	FACW
Solidago mollis	Soft Goldenrod	6	Native	P	UPL
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina gracilis	Alkali Cordgrass	6	Native	P	FACW
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Sporobolus heterolepis	Prairie Dropseed	10	Native	P	UPL
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliatum	Rayless Aster	0	Native	A	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Symphyotrichum falcatum	N/A	4	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Symphyotrichum lanceolatum	Panicled Aster	3	Native	P	FACW
Taraxacum officinale	Common Dandelion	*	Introduced	P	FACU
Teucrium canadense	American Germander	3	Native	P	FACW
Thalictrum dasycarpum	Purple Meadow Rue	7	Native	P	FAC
Triglochin maritima	Arrowgrass	5	Native	P	OBL
Triglochin palustris	N/A	8	Native	P	OBL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Viola nephrophylla	Northern Bog Violet	8	Native	P	FACW
Viola pedatifida	Prairie Violet	8	Native	P	FACU

PRESENT

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Achillea millefolium	Yarrow	3	Native	P	UPL
Alisma gramineum	N/A	2	Native	P	OBL
Alisma subcordatum	Common Water Plantain	2	Native	P	OBL
Allium stellatum	Pink Wild Onion	7	Native	P	UPL
Alopecurus aequalis	Shortawn Foxtail	2	Native	P	OBL
Anemone canadensis	Meadow Anemone	4	Native	P	FACW
Anemone cylindrica	Candle Anemone	7	Native	P	UPL
Arabis hirsuta	Rock Cress	7	Native	B	UPL
Artemisia biennis	Biennial Wormwood	*	Introduced	B	FAC
Artemisia ludoviciana	White Sage	3	Native	P	UPL
Asclepias speciosa	Showy Milkweed	4	Native	P	FAC
Beckmannia syzigachne	American Sloughgrass	1	Native	A	OBL
Bidens frondosa	Beggar-ticks	1	Native	A	FACW
Bolboschoenus fluviatilis	River Bulrush	2	Native	P	OBL
Bromus inermis	Smooth Brome	*	Introduced	P	UPL
Calamagrostis stricta	N/A	5	Native	P	FACW+
Campanula rotundifolia	Harebell	7	Native	P	FAC

Scientific Name[1]	**Common Name**	**C-Val[2]**	**Life[3]**	**Origin[4]**	**Ind[5]**
Carex atherodes	Slough Sedge	4	Native	P	OBL
Carex brevior	Fescue Sedge	4	Native	P	FACU
Carex laeviconica	Smoothcone Sedge	6	Native	P	OBL
Carex lanuginosa	Woolly Sedge	4	Native	P	OBL
Carex sartwellii	N/A	5	Native	P	FACW
Ceratophyllum demersum	Hornwort	4	Native	P	OBL
Chenopodium rubrum	Alkali Blite	2	Native	A	OBL
Cirsium arvense	Canada Thistle	*	Introduced	P	FACU
Cirsium flodmanii	Flodman's Thistle	5	Native	P	FAC
Cirsium vulgare	Bull Thistle	*	Introduced	B	UPL
Conyza canadensis	Horseweed	0	Native	A	FACU
Dalea purpurea	Purple Prairie Clover	8	Native	P	UPL
Echinacea angustifolia	Purple Coneflower	7	Native	P	UPL
Eleocharis acicularis	Needle Spikesedge	3	Native	P	OBL
Eleocharis compressa	Flatstem Spikesedge	8	Native	P	FACW
Eleocharis macrostachya	Spike Rush	4	Native	P	OBL
Elymus canadensis	Canada Wild Rye	3	Native	P	FACU
Elymus repens	Quackgrass	*	Introduced	P	FAC
Epilobium ciliatum	Willow-herb	3	Native	P	OBL
Erigeron glabellus	N/A	7	Native	B	FACW
Erigeron strigosus	Daisy Fleabane	3	Native	A	FACU
Galium boreale	Northern Bedstraw	4	Native	P	FACU
Glycyrrhiza lepidota	Wild Licorice	2	Native	P	FACU
Helianthus maximilianii	Maximilian Sunflower	5	Native	P	FACU
Helianthus nuttallii	Nuttall's Sunflower	8	Native	P	FAC
Helianthus rigidus	Stiff Sunflower	8	Native	P	UPL
Hesperostipa spartea	Porcupine-grass	8	Native	P	UPL
Hordeum jubatum	Foxtail Barley	0	Native	P	FACW
Juncus articulatus	N/A	7	Native	P	OBL
Lactuca oblongifolia	Blue Lettuce	1	Native	P	FACU
Lemna minor	Duckweed	9	Native	P	OBL
Lemna trisulca	Star Duckweed	2	Native	P	OBL
Liatris ligulistylis	Gay-feather	10	Native	P	FAC
Lotus purshianus	Prairie Trefoil	3	Native	A	UPL
Lycopus americanus	American Bugleweed	4	Native	P	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Lycopus asper	Rough Bugleweed	4	Native	P	OBL
Medicago lupulina	Black Medick	*	Introduced	P	FACU
Melilotus alba	White Sweet Clover	*	Introduced	A	UPL
Melilotus officinalis	Yellow Sweet Clover	*	Introduced	A	FACU-
Mentha arvensis	Field Mint	3	Native	P	FACW
Myriophyllum exalbescens	American Milfoil	3	Native	P	OBL
Nassella viridula	Green Needlegrass	5	Native	P	UPL
Oenothera biennis	Common Evening Primrose	0	Native	B	FACU
Phalaris arundinacea	Reed Canarygrass	0	Native	P	FACW+
Phleum pratense	Timothy	*	Introduced	P	FACU
Poa palustris	Fowl Bluegrass	4	Native	P	FACW
Poa pratensis	Kentucky Bluegrass	*	Introduced	P	FACU
Polygonum amphibian	Water Smartweed	6	Native	P	FACW
Populus tremuloides	Quaking aspen	4	Native	P	FAC
Potamogeton crispus	Curly Muckweed	*	Introduced	P	OBL
Potamogeton pectinatus	Sago Pondweed	0	Native	P	OBL
Potamogeton pusillus	Baby Pondweed	2	Native	P	OBL
Potentilla anserina	Silverweed	2	Native	P	OBL
Potentilla arguta	Tall Cinquefoil	8	Native	P	FACU
Potentilla norvegica	Norwegian Cinquefoil	0	Native	A	FAC
Potentilla paradoxa	Bushy Cinquefoil	2	Native	A	FACW
Potentilla rivalis	Brook Conquefoil	3	Native	A	OBL
Psoralea argophylla	Silver-leaf Scurf-pea	4	Native	P	UPL
Ranunculus longirostris	White Water Crowfoot	7	Native	P	OBL
Ranunculus pensylvanicus	Bristly Crowfoot	4	Native	A	FACW+
Ranunculus sceleratus	Cursed Crowfoot	3	Native	A	OBL
Rorippa palustris	Bog Yellow Cress	2	Native	A	OBL
Rosa arkansana	Prairie Wild Rose	3	Native	P	FACU
Rosa woodsii	Western Wild Rose	5	Native	P	FACU
Rumex crispus	Curly Dock	*	Introduced	P	FACW
Rumex maritimus	Golden Dock	1	Native	A	FACW
Rumex stenophyllus	N/A	*	Introduced	P	FACW+
Sagittaria cuneata	Arrowhead	6	Native	P	OBL

Scientific Name[1]	Common Name	C-Val[2]	Life[3]	Origin[4]	Ind[5]
Salix petiolaris	Meadow Willow	8	Native	P	OBL
Schoenoplectus acutus	Hard-stem Bulrush	5	Native	P	OBL
Schoenoplectus pungens	N/A	4	Native	P	OBL
Sium suave	Water Parsnip	3	Native	P	OBL
Solidago canadensis	Canada Goldenrod	1	Native	P	FACU
Solidago rigida	Rigid Goldenrod	4	Native	P	FACU-
Sonchus arvensis	Field Sow Thistle	*	Introduced	P	FAC
Spartina pectinata	Prairie Cordgrass	5	Native	P	FACW
Stachys palustris	Hedge-nettle, Marsh Betony	3	Native	P	FACW
Symphoricarpos occidentalis	Western Snowberry	3	Native	P	UPL
Symphyotrichum ciliolatum	N/A	8	Native	P	FACW
Symphyotrichum ericoides	White Aster	2	Native	P	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	Native	P	UPL
Symphyotrichum lanceolatum	Panicled Aster	4	Native	P	OBL
Tragopogon dubius	Goat's Beard	*	Introduced	B	UPL
Typha x glauca	Hybrid Cattail	*	Introduced	P	OBL
Urtica dioica	Stinging Nettle	0	Native	P	FACW
Zizia aptera	Meadow Parsnip	8	Native	P	UPL

Species scientific names follow the nomenclature of the USDA Plants Database (USDA, NRCS 2008). Authorities of plant species can be found in the USDA Plants Database. All plant species identification was accomplished with the use of Flora of the Great Plains (Great Plains Flora Association 1986) and Aquatic and Wetland Vascular Plants of the Northern Great Plains (Larson 1993).

[2] C-Values were assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

[3] Life-form – P = perennial, A = annual, B = biennial.

[4] Origin.

[5] Indicator categories follow those in National List of Plant Species that Occur in Wetlands: Northern Plains (Region 4) (Reed 1988).