5-1-2022

EFFECTS OF FIRE ON VEGETATION OF THE BLACK OAK SAND SAVANNAS OF KANKAKEE SANDS FROM 2002-2020

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by

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B.S., Southern Illinois University, 2018

A Thesis
Submitted in Partial Fulfillment of the Requirements for the
Master of Science Degree

Department of Forestry
in the Graduate School
Southern Illinois University Carbondale
May 2022

THESIS APPROVAL

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Approved by:

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March 1, 2022

AN ABSTRACT OF THE THESIS OF

Megan Alkazoff, for the Master of Science degree in Forestry, presented on March 1, 2022, at Southern Illinois University Carbondale.

TITLE: EFFECTS OF FIRE ON VEGETATION OF THE BLACK OAK SAND SAVANNAS OF KANKAKEE SANDS FROM 2002-2020

MAJOR PROFESSOR: Dr. Charles Ruffner

Many plant and animal species rely on tallgrass prairie and sand savanna ecosystems that once covered much of northern to central Illinois but are now fragmented landscapes across the Midwest. In northeastern Illinois, The Nature Conservancy manages five sites containing fragments of remaining tallgrass prairie and sand savanna within the Kankakee Sands section of Illinois using techniques such as prescribed burning and invasive species removal. The objective of this study was to conduct an eighteen-year resampling of the ground flora to assess management impacts on species composition and conservation status. Permanent transect lines were resampled using a 1m² quadrat to determine the Cover Class (%) of each species <50 cm in height that were rooted inside the quadrat. Species composition was characterized by three values: Shannon-Wiener Diversity Index (H'), the Floristic Quality Index (FQI), and the mean Coefficient of Conservatism ($\bar{C}$). Linear regression was used to illustrate the relationship between fire occurrence and species composition on the landscape over 18 years of management. To test whether frequency of management had a significant effect on a site's FQI, H', $\bar{C}$, a Kruskal-Wallis one-way nonparametric analysis of variance test was used. ANOVA was used to test for physiognomic changes in vegetation.

Results concluded that while there were non-significant changes in the species composition of the sites, there were significant physiognomic changes in the Kankakee Sands sites between 2002-2020. These results suggest current management regimes are working to

maintain the quality natural areas that make up the Kankakee Sands sites, however, increased coverage of *Rhus* species threatens to displace valued prairie and savanna species threatening the quality of these natural areas. Land managers of the Kankakee Sands and other such habitats should consider targeted management of *Rhus copallinum* and *Rhus glabra* with herbicides, as well as practice flexibility regarding the seasons in which they burn such sites.

ACKNOWLEDGMENTS

First, I would like to thank The Nature Conservancy and McIntire Stennis Cooperative Research Program for making this research opportunity possible. Dr. Charles Ruffner, Dr. John Groninger, and Dr. Eric Holzmueller have been greatly appreciated for their guidance, patience, and assurance throughout the process of gathering my data as well as writing this thesis. I would like to extend my gratitude to Rob Litiken, Fran Harty, and Kim Roman for sharing their knowledge of the land where this research took place. Many thanks to Leah Harper who helped me navigate the waters of graduate school. I would like to acknowledge Patti Cludray and all other forestry faculty for their help with the countless miscellaneous tasks that are required to complete research and ultimately a smooth educational experience. Lastly, thank you to my parents and family who support my educational journey and interests whether they understand them or not!

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CHAPTER 1

INTRODUCTION

Management practices such as prescribed fire and brush removal are crucial to preserving prairies and savannas, which without management would quickly grow into woodlands or even forests (Anderson et al. 1999). Aside from vegetation density, diversity is another important component to maintaining prairies and savannas. Land managers in the Midwest typically perform prescribed burns during the spring and fall seasons, selecting for warm-season grasses (O'Connor 2006). Brush removal usually covers only nonnative invasive species, and tree species such as sassafras that grow in abundance and potentially threaten the structure of these ecosystems. Because these systems are constantly threatened by invasive species and the potential of succeeding into a woodland or forest, the management techniques listed above and their effects need to be consistently adjusted and monitored in efforts to properly maintain these ecosystems.

Much of the remaining sand prairie and black oak sand savanna of the Midwest are currently being managed by The Nature Conservancy (TNC) in an area known as the Kankakee Sands. The Nature Conservancy has been acquiring land in the Kankakee Sands section since 2002, they currently own 728 hectares that make up the Kankakee Sands savannas and manage these sites using prescribed fire and spot treatment of invasive species. Five of these Kankakee Sands savannas were sampled upon ownership in 2002 to gather data on ground flora and canopy composition. Four of the sites were resampled in 2007 for canopy data. In 2020, ground flora data was gathered for this study in efforts to observe any changes in composition and to assess the effects of management techniques on vegetation.

The goal of this 2020 study was to assess the effects of 18 years of fire management on the prairie vegetation of black oak savannas of the Kankakee Sands. Assessing results of the management practices thus far will help land managers with future management decisions. This study will analyze the effect of fire on species composition (characterized by Shannon-Wiener Index H' (H'), Floristic Quality Index (FQI), and a site's mean C value ($\bar{C}$)) and site quality between the Kankakee Sands savannas and over the 18 years. It was hypothesized that: 1) Frequency of fire shows a significant effect on a site's H', FQI, and $\bar{C}$, and significant changes would be seen in those values from 2002 to 2020, 2) Burning more frequently would result in higher coverage of species higher on the coefficient of conservatism scale, and 3) Sites burned every 2 years will have decreased densities of shrubs and more forbs, sedges, and grasses in 2020 compared to 2002 than those burned every 3-4 years.

CHAPTER 2

LITERATURE REVIEW

Prairies and Savannas of the Midwest

Prior to European settlement, 3.6 million square kilometers of continuous prairie covered the Midwest in roughly the shape of triangle (Roberston et al. 1997). The creation of these prairies is associated with increased aridity attributed to the uplift of the Rocky Mountains and the spread of the Antarctic ice sheet, events which limited atmospheric moisture to the interior portion of the continent (Anderson 1991). As woody plants are less adapted to drought, grasslands spread throughout the Midwest, displacing woodlands and forests and increasing the numbers of grazing animals. Grazing further influenced the creation of these prairies, whose grass coverage declines when excess plant litter is not removed by grazers or fire (Robertson et al. 1997). Lastly, fire also influenced prairie establishment for the same reasons grazers had. These disturbances increased species richness and spatial heterogeneity throughout the established tallgrass prairies that formed the prairie triangle (Robertson et al. 1997). At the apex of this triangle of central grasslands, known as the Prairie Peninsula, are Illinois, Iowa, Indiana, Minnesota, Missouri, and Wisconsin prairies (Transeau 1935). Like the rest of the central grasslands, these prairies were created as a result of drought, grazing, and periodic fire (Robertson et al. 1997).

The tallgrass prairies that once stretched across northern and central Illinois covered about 8 million hectares of the state (Anderson et al. 1999, Sampson and Knopf 1994). Although there is no estimate of the presettlement extent of savannas for Illinois, thirty-five high to mid-quality oak savannas were located in Illinois in 1985 (Nuzzo 1986). Many plants and animals evolved to depend on these types of ecosystems, including large herbivores like bison and elk

that historically grazed the tallgrass prairies of Illinois. Not only do prairies and savannas provide great habitat for much of the native flora and fauna, but they also store large amounts of carbon, acting as exceptional carbon sinks even compared to forests (Seastedt and Knapp 1993). By the 1900's, European settlement and the conversion of land for agriculture left the state with less than .01% of the original high quality prairie acreage in Illinois, and less than .02% of the original oak savannas in the Midwest (Nuzzo 1986, Sampson and Knopf 1994, McClain et al. 2021). Due to the amount of plant and animal species that rely on these types of ecosystems, it is crucial that the remaining tallgrass prairies and oak savannas be conserved, managed, and monitored for future generations and as public repositories for biodiversity resilience in the face of climate change (Lovett et al. 2007).

Prairies and savannas typically comingle on the landscape, gradually merging with one another but distinguished by the percentage of land covered by trees. According to The Nature Conservancy, prairies experience tree coverage of 0-10%, whereas savannas experience tree coverage from 10-25% (Anderson et al. 1999). The Kankakee Sands savannas currently exhibit the gradual merging of these landcover types, many of the sites having a mixture of prairie and savanna tree coverage percentages and plant species. Both prairies and savannas are ecosystems dependent on disturbance for their conservation. Management techniques, such as grazing and prescribed fire, have been used to keep these landscapes from succeeding into the stem exclusion stage of forest development (Manning et al. 2017). Aside from preventing succession, management techniques are also used and needed to maintain the floristic integrity of these sites (Maginel et al. 2016). Although it is understood that fire and invasive species removal is a crucial part of maintaining these ecosystems, more research is needed to establish the ideal fire

frequency and seasonality of prescribed burns, especially in relation to species response (Barnes et al. 1989, Anderson et al. 1999).

Kankakee Sands

The Greater Kankakee Sands Ecosystem in Illinois is an undeniably unique landscape. This ecosystem consists of the Kankakee Sands section, which gets its name from the sandy soils of the region that were deposited by the "Kankakee Torrent," a series of glacial flooding events that deposited massive amounts of sand and gravel into the Kankakee and Illinois River valleys 14,000 years ago (Harty 2007). These natural events set the stage for the formation of the ancient landscape that still persists.

Owned and managed by The Nature Conservancy since 2000, 728 hectares of the Kankakee Sands harbor globally significant prairies, sedge meadows, and oak savannas and barrens (Illinois 2005). The tallgrass prairies still extant there represent about .01% of the original 8,900,000 hectares of tallgrass prairies historically covering much of Illinois (Sampson and Knopf 1994, Considine et al. 2013). The black oak savannas found in the Kankakee Sands section represent some of the greatest concentrations remaining in the US (Sampson and Knopf 1994, Considine et al. 2013). It has been generally understood that sandy soils are important for these types of ecosystems to exist, as is periodic fire needed for them to proliferate and be maintained through time. Prairies, barrens, and savannas are all communities dependent on fire for both their formation and their maintenance (Barnes et al. 1998). Without fire these communities quickly succeed into a stem exclusion stage that closes the canopy and reduces opportunity for new in-growth, especially of sun loving prairie vegetation (Anderson et al. 1999).

The importance of these prairies and savannas found in Kankakee county make the need for continued research and monitoring there apparent. The effects of the management tools being

used there such as fire and invasive species removal need to be assessed to ensure that these landscapes are being maintained. Other techniques include the introduction of grazers along with the management tools discussed previously and should also be considered when managing these sites. Overall, an adaptive management approach where techniques are continually assessed and altered depending on the results seen at both Kankakee Sands savannas and other prairies and savannas should be taken.

Floristic Quality Assessment and Shannon-Wiener Diversity Index

The health of a prairie/grassland and black oak savanna ecosystem is not only determined by the canopy cover on the site but can also be gauged by evaluating the species present in the ground layer. Floristic Quality Assessment (FQA) is a tool that can be used to assess an area's ecological integrity based on its plant species composition. In an FQA, floristic inventory data are used to calculate several parameters of vegetation including species richness, floristic quality index, mean coefficient of conservatism, and many others (Taft et al. 1997). The Universal FQA Calculator is a plant community monitoring website that uses the Coefficient of Conservatism (CC) of individual plant species as well as their frequency in an area to determine the species richness, Adjusted Floristic Quality Index and $\bar{C}$ of a natural area (Freyman et al. 2015). The Shannon-Wiener Index is another important variable that gauges the diversity of ground flora in an area. These values are often used for ecological research, habitat monitoring, assessing restoration success, and guiding ecological and management practices and techniques (Spyreas 2019).

The Shannon-Wiener Index, proposed by Claude Shannon in 1948, is the most common measure of biological diversity in a community (Spellerberg and Fedor 2003). The minimum value for H' is 0, and the maximum value is 5. An H' value of 0 would indicate that there is only

one species present in a community, while an H' value of 5 indicates broadest heterogeneity in a community (Thurkal 2017). This factor alone should not be considered a sensitive indicator of the quality of a natural area due to a degraded site's ability to host many species, but H' can be used along with the FQI and $\bar{C}$ of a site to help determine habitat quality based on the presence or absence of native species of high conservatism (Taft et al. 1997). The Adjusted Floristic Quality Index is a weighted index of species richness and is the product of the average coefficient of conservatism and the square-root of species richness of an inventory unit (Taft et al. 1997). An FQI score of 1-19 indicates low vegetative quality, while a score of 20-35 indicates high vegetative quality, and a score above 35 indicates natural area quality (Wilhelm and Rerich 2017).

Each taxon native to Illinois has been given an integer between 0-10 that is called its coefficient of conservatism, or C value. This value represents patterns of occurrence for that species within the state. Those species with a C value of 0-1 are associated with areas of severe disturbance, while species assigned a C value of 2-3 are associated with degraded but stable environments (Taft et al. 1997). Species assigned a coefficient of 4-6 occur regularly in given community types, whereas species given C values of 7-8 are those that are associated closely with natural areas but can also be found in degraded areas. Finally, species with C values of 9-10 are those that are restricted to high-quality natural areas. Non-native species are given an asterisk (*) for their C value designation and are counted as a C value of 0 in the calculations to find site indices such as FQI and $\bar{C}$ (Taft et al. 1997).

The Shannon-Wiener Index, adjusted floristic quality index, and mean C value of a site are values that help assess the floristic integrity of that site. These parameters of plant communities are helpful when it comes to monitoring sites and gauging the effects of

management applications, and they help land managers assess the quality of natural areas as well as influence their management decisions. For example, in 1994 Taft performed a floristic quality assessment of the proposed US Route 34/IL Route 31 project area where the FQI and $\bar{C}$ were calculated and used to determine whether the sites that made up the area were regionally significant natural areas (Taft 1994).

CHAPTER 3

METHODOLOGY

Study Area

This study was conducted within five sites in the Kankakee Sands section referred to as the Kankakee Savannas (Figure 1). All sites are in Kankakee County and are owned and managed by TNC in Illinois, except for Sweet Fern which is privately owned and managed by the landowner with conservation partners such as the Illinois Nature Preserves Commission (INPC) and TNC. Four of these sites- Pembroke Savanna, Sweet Fern Savanna, Hopkins Park Savanna, and Carl N. Becker Savanna- were recognized by the Illinois Natural Areas Inventory as high-quality natural communities and specific suitable habitat for state-listed species (White 1978). These sites are composed of a mixture of dry-sand savannas, dry-mesic savannas, dry-sand prairies, wet sand prairies, sand flatwoods, shrub prairies, and other early successional communities all driven by the glacial geology of this area (Phillippe et al. 2003).

Pembroke Savanna is a 49 hectare parcel located about 3 kilometers Northwest of the village of Hopkins Park. It has been owned and managed by TNC since 2002. Data gathered then revealed that the top five species in frequency and coverage were *Schizachyrium scoparium* (little bluestem), *Carex pensyylvanica* (Pennsylvania sedge), *Dichanthelium villosissimum* (white-haired panic grass), *Euphorbia corollata* (flowering spurge), and *Viola pedata* (bird's foot violet). At that time, this site had an adjusted FQI score of 49.3, a $\bar{C}$ of 4.7, and an H' of 3.45. Tree species with diameters ≥10cm were dominated by *Quercus velutina* (black oak) and totaled 43 stems/ha (Phillippe et al. 2003). Data gathered in 2007 did not include ground flora but revealed tree species with diameters ≥10cm were dominated by *Q. velutina* followed by other

fire tolerant *Quercus* species *Q. alba* (white oak), and *Q. palustris* (pin oak), totaling about 43 stems/ha (Considine et al. 2013).

Carl N. Becker Savanna, owned and managed by TNC since 2005, is a site in the Southwestern most corner of Kankakee County spanning 47 hectares. Data gathered in 2002 revealed that *Carex pensyylvanica*, *Schizachyrium scoparium*, *Chamaecrista nictitans* (Sensitive partridge pea), *Quercus velutina* (Black oak), and *Rhus copallinum* (Winged sumac) were the top five species in frequency and coverage on this site. Carl Becker then had an adjusted FQI score of 56, a $\bar{C}$ of 5.4, and an H' of 3.66. Tree species with diameters ≥10cm were dominated by *Q. velutina*, *Q. alba*, and *Q. palustris*, totaling 74.1 stems/ha (Phillippe et al. 2003). Data gathered in 2007 revealed tree species with diameters ≥10cm were dominated by *Q. velutina* and fire tolerant *Quercus* species totaling about 108 stems/ha (Considine et al. 2013).

Mskoda LWR is a 260 hectare parcel located 5.6 kilometers Northwest of the village of Hopkins Park. It has been owned and managed by TNC since 2000. Data gathered in 2002 revealed the top five species in frequency and coverage to be *Carex pensylvanica, Schizachyrium scoparium, Euphorbia corollata, Q. velutina,* and *Rhus copallinum*. At the time, this site had an adjusted FQI score of 44.2, a $\bar{C}$ of 4.2, and an H' of 3.47. Tree species with diameters ≥10cm were dominated by *Q. velutina*, and *Q. alba*, totaling 169.2 stems/ha (Phillippe et al. 2003). Data gathered in 2007 revealed tree species with diameters ≥10cm to be dominated by *Q. velutina* and fire tolerant *Quercus* species totaling about 145 stems/ha (Considine et al. 2013).

Hopkins Park Savanna (30 hectares) is located 8 kilometers Northeast of Hopkins Park village. It has been owned and managed by TNC since 2002, and data gathered then revealed that this site was characterized by *Helianthus divaricatus* (Woodland sunflower), *Rosa Carolina* (Pasture rose), *Schizachyrium scoparium, Carex pensylvanica,* and *Rhus copallinum*. Hopkins

Park then had an adjusted FQI score of 50.1, a $\bar{C}$ of 4.8, and an H' of 3.80. Tree species with diameters ≥10cm were dominated by *Q. velutina,* and *Q. alba*, totaling 287.6 stems/ha (Phillippe et al. 2003). Data gathered in 2007 revealed tree species with diameters ≥10cm to be dominated by *Q. velutina* followed by other fire tolerant *Quercus* species, totaling about 245 stems/ha (Considine et al. 2013).

Sweet Fern Savanna is a 60 hectare parcel in the Northeast section of the village of Hopkins Park. The private landowner has been acquiring land for conservation since 2002. Data gathered in 2002 revealed that this site was dominated by *Schizachyrium scoparium, Carex pensylvanica, Euphorbia corollata, Rosa Carolina,* and *Rubus allegheniensis* (Allegheny blackberry). Sweet Fern had an adjusted FQI score of 52.7, a $\bar{C}$ of 5.1, and an H' of 3.74. Tree species with diameters ≥10cm were dominated by *Q. velutina*, and *Q. alba*, totaling 104.1 stems/ha (Phillippe et al. 2003). No data was gathered for this site in 2007 because permission was not granted to collect tree-cross sections (Considine 2009).

All sites owned and managed by The Nature Conservancy (Pembroke, Becker, Mskoda, and Hopkins) have been managed through prescribed fire as well as spot treatment of invasive plants. *Phragmites australis* (Phragmites), *Phalaris arundinacea* (reed canary grass), *Cirsium arvense* (Canada thistle), *Alliaria petiolata* (garlic mustard) are sprayed with Rodeo herbicide as they are found on the sites. Woody invasive plants such as *Robinia pseudoacacia* (black locust), *Elaeagnus umbellata* (autumn olive), *Lonicera maackii* (bush honeysuckle), *Populus deltoides* (cottonwood), *Populus tremuloides* (quacking aspen), *Populus grandidentata* (big-tooth aspen), *Prunus serotina* (black cherry), and *Sassafras albidum* (sassafras) are foliar sprayed or basal bark treated with triclopyr. These woody species are also treated only as they are encountered on the sites. At some sites, *Q. velutina* is treated along with other woody invasives due to its excessive

coverage. Sweet Fern Savanna has been managed through fire as well as the use of herbicide to control *Elaeagnus umbellata* and *Lonicera maackii* as it is encountered.

Topography, Soils, and Climate

The Kankakee Savannas are in the Grand Prairie natural division of Illinois (Schwegman 2016). Elevations at these sites range from 660 feet (Mskoda LWR) to 684 feet (Hopkins Park Savanna) above sea level. The soils of these sites consist mainly of the Oakville soil series with some transects falling on Morocco and Watseka soils. Oakville soil series are those that are very deep and excessively drained, and they are formed in sandy aeolian deposits on dunes (Natural Resource Conservation Service 2012). Morocco soils and Watseka soils are also very deep, but they are somewhat poorly drained soils. These soils formed in sandy outwash, aeolian deposits, or from sediments that have been deposited into lakes that were formed by glacial activity (Natural Resource Conservation Service 2012), such as the Kankakee Torrent, famous for its blustering deposition of this ancient riparian landscape.

The mean annual temperature for Kankakee was 16.2°C for years 2002-2020, averaging highs of 18.6°C and lows of 12.8°C. The average annual precipitation during this time (2002-2020) was 2.8mm (National Oceanic and Atmospheric Administration 2021), with 2.8mm and 0.0mm comprised of rain and snow, respectively.

Fire History

Although broad fire suppression in the United States was entrenched by the late 1940s up to the 1970s, the Kankakee Savannas never experienced total suppression of fire on the landscape (Harty 2007). Accidental escape of anthropogenic fires has resulted in wildfires in this part of Kankakee County. Some of these wildfires were reportedly devastating to the surrounding

structures, but without these wildfires the Kankakee Savannas would not have persisted as the prairies and savannas that represent just a fraction of Illinois' historical land cover.

The Nature Conservancy's records of fires on the Kankakee Sands sites only begins in 2002 (Table 1). Pembroke Savanna has burned on average once every two years, and fire returns here range from 2-4 years. Carl Becker has burned most frequently, averaging once every two years with fire returning between 1-3 years. Mskoda Land and Water Reserve has burned on average once every three years, and fire returns here range from 2-5 years. Hopkins Park has burned on average once every three years, and fire returns here range from 2-4 years. Sweet Fern Savanna has burned on average once every four years, and fire returns here range from 4-6 years.

Data Collection

During the summer of 2020, all sites were sampled along permanent transect lines that had been established by the Illinois Natural History Survey (INHS) for the 2002 study of the Kankakee Savanna's vascular flora reported in Phillippe et al. 2003. Most sites had 2 transects that were 350 meters long, excluding those on Carl N. Becker Savanna where there were 3 transects each 225 meters long. The southernmost transect of Carl N. Becker Savanna was not sampled for this study due to property boundary issues. Transects ran east to west (Carl N. Becker Savanna and Sweet Fern Savanna), north to south (Hopkins Park Savanna and Mskoda LWR) or west to east (Pembroke Savanna) and were marked with a flag every 25 meters. Before sampling took place, about twenty hours was spent finding the pins along the previously established transects and marking them with flagging as well as marking their location in a Garmin GPS.

Sampling began June 30th 2020 starting with Mskoda LWR and ended the week of September 1st 2020 with Sweet Fern Savanna. At each site, the permanent transect line was

sampled using a 1m x 1m quadrat. Consistent with the Phillippe et al. (2002) study, upon navigating to each pin, a 5m long segment was laid out using a measuring tape either to the right of the pin (odd numbered meters) or the left of the pin (even numbered meters). Along the 5m long segment the quadrat was dropped to the right of the measuring tape, alternating left and then back right down the segment until all 5 meters of the segment had been sampled (Figure 2). Each time the quadrat was placed along the segment the cover of every species ≤50cm rooted in the quadrat was recorded using the % Cover method (0-100) where the individual collecting the data notes the percentage of that quadrat that is being filled by the species. After completing the sampling for a whole transect, 75 quadrats were sampled with their species composition recorded. This totals 150 quadrats per site, excluding Carl N. Becker (where there are shorter transects) which resulted in 100 quadrats sampled.

Data Analysis

After collecting the vegetative data for all five sites ending in September 2020, data were entered into the Universal Floristic Quality Assessment (FQA) Calculator. The Adjusted Floristic Quality Index (FQI), and $\bar{C}$ are the standard outputs of the calculator that were of interest in this study. H' was calculated using the formula below.

$$Shannon - Wiener\ Index\ (H') = -\sum [pi \ln(pi)]$$

In this index, the proportion of species (i) relative to the total number of species (p_i) is calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The product is then summed across species and multiplied by -1.

RStudio was used to run all statistical analyses. A Kruskal-Wallis test was used to test whether frequency of management has a significant effect on a site's H', FQI, and $\bar{C}$ value. A non-parametric ANOVA test was used to test for physiognomic changes in vegetation. A p-value

≥ 0.05 was used to accept or reject the null hypothesis. All graphs and charts were created using RStudio.

CHAPTER 4

RESULTS

H', FQI, and $\bar{C}$

Fire frequency at the site level did not significantly effect the FQI, $\bar{C}$, and H' for all sites ($F_{1,8}$=0.218, p=0.653, Figures 3). Additionally, there were no significant changes in FQI from 2002 to 2020 (chi-squared=0.098, df=1, p=0.754). Fire frequency did not have a significant effect on $\bar{C}$ ($F_{1,8}$=0.318, p=0.588, Figure 4), and there were no significant changes in $\bar{C}$ values from 2002 to 2020 (chi-squared=0.044, df=1, p=0.833). Similar to FQI and $\bar{C}$, fire frequency did not have a significant effect on H' ($F_{1,8}$=2.09, p=0.187, Figure 5), and that there were no significant changes in H' values from 2002 to 2020 (chi-squared=0.884, df=1, p=0.347).

Species Response

There was a highly significant difference ($F_{2,7}$=13.988, p=0.004) in the distribution of the C values as a result of fire frequency between 2002 and 2020, however there is a non-significant effect of fire frequency on high C values ($F_{1,8}$=1.09, p=0.325). Figure 6 represents the significant differences experienced in the distribution of C values among the Kankakee Savanna sites between 2002 and 2020 as a result of fire frequency. Figure 7 helps break down the distribution of C values for each site in 2002. Figure 8 represents the distribution of C values for each site in 2020. An ANOVA test indicated that there was a non-significant effect of fire frequency on high C values (F1,8=1.09, p=0.325). Linear regression (figure 9) reveals the same changes in high C values (4-10) as the bar graphs in figure 7 and 8.

Many of the five dominant species in the understory are the same for 2002 and 2020 censuses, however, some species changed their place in the top five while others were replaced entirely. Pembroke no longer has *Dichanthelium villosissimum*, and *Viola pedata* in the top five

frequency and coverage as they were replaced with *Asclepias verticillata* and *Rhus glabra*. Becker lost *Q. velutina* but gained *Euphorbia corollata* and experienced an increase in *Rhus copallinum* frequency and coverage. Mskoda gained *Tephrosia virginiana* but lost *Euphorbia corollata* in its top five species frequency and coverage. Here, there was an increase in *Rhus copallinum* and decrease in *Schizachyrium scoparium*. Hopkins gained *Q. velutina* and lost *Rhus copallinum*, while decreasing frequency and coverage of *Helianthus divaricatus* and *Rosa carolina* and increasing frequency and coverage of *Schizachyrium scoparium*. Lastly, Sweet Fern experienced the most change in its top five species frequency and coverage. The site gained *Rhus copallinum*, *Asclepias verticillata*, and *Tephrosia virginiana*, replacing the previously abundant *Euphorbia corollata*, *Rosa carolina*, and *Rubus allegheniensis*.

Physiognomic Changes

An ANOVA test revealed highly significant differences in shrub, forb, and sedge coverage between 2002 and 2020 data, however the difference was not in relation to fire frequency ($p>0.05$). No significant difference was found among the coverage of grasses ($F_{1,8}=0.116$, $p=0.742$), rushes ($F_{1,8}=1$, $p=0.347$), ferns ($F_{1,8}=0.017$, $p=0.901$), vines ($F_{1,8}=0.940$, $p=0.361$), and trees ($F_{1,8}=0.331$, $p=0.581$) between 2002 and 2020.

There was a highly significant increase in shrub coverage ($F_{1,8}=18.261$, $p=0.003$) between 2002 and 2020 on all sites (Figure 10). Contrary to predictions, the ANOVA test indicated that all sites gained shrub coverage within the last 18 years, but that this was not an effect of fire frequency ($p>0.05$). There was a highly significant decrease in forb coverage ($F_{1,8}=22.61$, $p=0.001$) between 2002 and 2020 on all sites (Figure 11). All sites lost forb coverage rather than gained it within the last 18 years but that this was not an effect of fire frequency ($p>0.05$). There was a highly significant increase in sedge coverage ($F_{1,8}=43.77$,

p=0.000) on all sites between 2002 and 2020 (Figure 12). All sites gained sedge coverage but that this was not an effect of fire frequency ($p>0.05$).

CHAPTER 5

DISCUSSION

H', FQI, and $\bar{C}$

Previous studies testing the effects of fire frequency on vegetative composition provide results like those seen from testing hypothesis 1 in this study which concluded that fire frequency had no significant effect on the H', FQI, and $\bar{C}$ for all sites and that those values did not change significantly from 2002 to 2020. Manning et al. (2017) revealed that plant species composition did not differ among fire frequency treatments but did differ when analyzing composition between grazed and ungrazed prairies. Likewise, the Copeland et al. (2002) study repeated that there was no species richness increase in spring burn plots but that there was an increase in species richness for summer burn plots. Although this study did not look only at species richness and composition, the values analyzed (FQI, H', and $\bar{C}$) all relate to species richness and composition which are factored into the calculation of these variables. The studies previously mentioned attribute the lack of significance to the seasons in which the burns are taking place (Copeland et al. 2002) and to the topography where the sampling occurred (Manning et al. 2017).

Fire as a management tool for prairies and savannas has almost always taken place in early or late spring (Copeland et al. 2002), but studies show that burning during different seasons will result in a variety of species composition and density impacts (Biondini et al. 1989, Copeland et al. 2002). Biondini et al. (1989) found that H' diversity was highest on unburned and summer burn treatments. In their study, Copeland et al. (2002) confirmed that summer burn plots exhibited increased species richness following late-summer burns. Manning et al. (2017) found that grazing had a positive effect on FQI, whereas fire frequency did not. Topography proved to be a strong influence on the plant community structure at Konza prairie, where the

lowland soils were deeper, moister, and more productive compared to the drier and more shallow soils of the upland parts of the prairie (Manning et al. 2017).

Considering the results of the previous studies, it is plausible that the lack of effect of fire frequency on a site's FQI, H', and $\bar{C}$ value could be caused by the limited seasons in which these sites are being burned and the limited number of disturbances they are experiencing, explaining the lack of significant change in these values from 2002 to 2020. The unique sandy soils of this region are also highly likely to be influencing the composition and structure of the vegetation found on these sites, ultimately effecting their FQI, H', and $\bar{C}$. Despite the lack of significant plant diversity response to recent management regimes, these suggest that these are arresting forest stand development at the Kankakee Sands from progressing into the stem exclusion stage of forest development (Oliver 1981).

Species Response

C value distribution varied significantly from site to site between the Kankakee Savannas, however, there was no statistically significant effect of fire frequency on low C values. It appears that there has been a mix of decreasing and increasing distribution of species with C values of 0-3, likely attributable to the amount of shrub and tree species in the top five of frequency and coverage. These shrub and trees species limit the number of resources, especially sunlight, available for valuable prairie plants. The overall increase of vegetation with C values of 4-10 is commendable and has been seen in other studies where fire is considered. Manning et al. (2017) found similar results, where burning more frequently promoted species with higher conservation values. This a positive change for these sites to experience, as it suggests that management of these sites for conservative prairie and savanna species has been largely successful. Although this change was not a direct effect of fire frequency ($p>0.05$), the increased

conservative vegetation is likely due to the use of other management practices along with fire rather than fire by itself. Removal and treatment of invasive shrub and tree species has occurred on these sites since The Nature Conservancy began managing the Kankakee Savannas (R. Littiken, personal communication, February 5, 2021).

Pembroke Savanna lost *Dichanthelium villosissimum* and *Viola pedata* from its top five but gained *Asclepias verticillata* and *Rhus glabra* in their place. This change in species is negative because *Dichanthelium villosissimum* and *Viola pedata* are species higher on the conservative scale than the species they were replaced with, having a C value of 8 and 9 vs. 1 and 1 respectively. Not only are these species lower on the conservatism scale, but *Rhus glabra*, although native, is known to be an aggressive invader that can easily shade out and replace desired prairie plants (Hutchinson 2017).

Becker experienced a similar change as Pembroke where *Q. velutina* (C value of 5) was lowered from the top five dominant species and replaced with *Euphorbia corollata* (C value of 4). *Rhus copallinum* made its way further up the top five list for Becker. The decreasing frequency and coverage of *Q. velutina* is a positive change in this case. Although the C value of *Euphorbia corollata* is lower than that of black oak, it is better to see the increase of a forb characteristic of prairies and savannas rather than to see increased coverage of trees. A less desired change for savanna managers for the site is the increased presence of *Rhus copallinum*, which has the same reputation as *Rhus glabra* in the way that the species can easily shade out sun-loving prairie species and grow via rhizomes (Tunnell et al. 2006).

As seen with other Kankakee sites, Mskoda experienced an increase in *Rhus copallinum*. Here, the sumac seems to be outcompeting characteristic species such as *Schizachyrium scoparium* and *Euphorbia corollate* despite the frequent application of prescribed fire. However,

a very positive change seen in Mskoda between 2002 and 2020 is an increase in frequency and coverage of *Tephrosia virginiana,* a forb indicative of healthier sand prairies. This conservative species has a C value of 8.

Hopkins experienced an overall positive change in its top five species, where we saw the replacement of aggressive *Rhus copallinum* with *Q. velutina* and an increase in *Schizachyrium scoparium*. Both species are desired in prairie and savanna landscapes, and the increased frequency and coverage of them indicate that there is plenty of light reaching the ground on this site. However, managers must be aware of the increased presence of black oak at this site. Although it is an indicator for sand savannas, if left unchecked, black oak could easily regenerate to the point where it limits sun and space for other species, converting the prairie/sand savanna into a forest.

Lastly, Sweet Fern experienced a big shift in its five most abundant species. *Euphorbia corollata*, *Rosa carolina*, and *Rubus allegheniensis* were replaced with *Rhus copallinum*, *Asclepias verticillata*, and *Tephrosia virginiana*. The main changes to note here are the increased occurrence of sumac and *Tephrosia virginiana*. As discussed earlier an increase of sumac species would result in the displacement of prairie plants. On the other hand, the increased abundance of *Tephrosia virginiana* is an indicator of high quality sand prairie and savannas.

The changes seen on these sites that are of concern are the increased occurrences of shrub species such as *Rhus copallinum* and *Rhus glabra* (Tunnell et al. 2006, Hutchinson 2017). The increase of shrubs after fire treatments has been seen in other studies of similar ecosystems, such as Anderson and Schwegman's study on a southern Illinois barren where shrubs were reported to have a positive response to fire (Anderson and Schwegman 1991). Taft's 2003 study concluded rapid recovery of shrubs during post-fire periods in dry sandstone barrens (Taft 2003), and his

2005 study reported significant increase in shrub and sapling densities following three prescribed burns in a south-central Illinois flatwood remnant (Taft 2005). Sumac species in particular have been found to increase in density following burning due to top killing and then resprouting of the shrub (Tunnell et al. 2006). This seems to be the case on these Kankakee Sands savannas, where an increase in sumac coverage and frequency is seen on nearly every site. However, although there are increased shrub and/or sapling densities on all sites, it is important to acknowledge that the five most abundant species on each site in both 2002 and 2020 are all species characteristic of sand prairies and savannas, as they are species strongly correlated to the 10-50% canopy cover definition of a savanna (Anderson et al. 1999).

Physiognomic Changes

Tracking physiognomic changes is an important component of Floristic Quality Analysis, as changes in communities can occur without changes in FQI or $\bar{C}$ (Taft et al. 1997). Contrary to predictions, all Kankakee sites experienced an increase in shrub coverage, and a decrease in forb coverage. As mentioned in the results section, these changes in physiognomic coverage were not a direct effect of fire frequency. However, the change is due to increased stem density as a result of top killing the sumac shrubs found on these sites. The coverage of shrub species that grow tall and reach more light highly influences the ground flora that can grow beneath them, oftentimes limiting the growth of forbs that require light levels indicative of prairies and savannas. When managing for prairies and/or oak savannas, it is important to keep shrub coverage low, as these landscapes can quickly grow into closed forests with little to no forb coverage (Anderson et al. 1999). All sites experienced an increase in sedge coverage; however, it is important to note that the Kankakee Savannas did not experience an introduction of any new sedges between 2002 and 2020. Sedges are a crucial part of prairies and savannas, typically forming most of the biomass in

these systems (O'Connor 2006). For this reason, an increase in sedge coverage on these sites is indicative of prairie and savanna maintenance, even if it may not be a direct result of prescribed fire. Many sedge species are clonal, spreading through rhizomes and rapidly expanding into other plant communities. Sedges are often top killed by fire along with adjacent vegetation and quickly occupy fire-generated gaps, spreading aggressively through clonal propagation (Zouhar 2015). Only when an exceedingly hot fire burns the rhizomes and roots of the plant does prescribed burning discourage the growth of sedges.

The fact that all sites experienced an increase in sedge coverage indicates that the prairie and savanna landscape are being maintained. However, forb decline is alarming for prairie and savanna managers. This decrease in forbs is likely due to the seasons in which these sites are being burned. As shown in table 1, the Kankakee Savannas are typically burned in the spring and fall with an occasional burn in early or late winter. Copeland et al. (2002) suggested that mid to late summer fires could reduce tallgrass vigor and in turn decrease competition for forbs, increasing their densities and vigor. O'Connor's Natural Features Inventory (2006) summarizes well the studies of Howe 1994, 1995; Coppedge et al. 1998; Sparks et al. 1998 and Copeland et al. 2002 that all reported an increase of forb coverage as a result of mid-summer, late summer, and fall burns. Summer burns tend to reduce warm season grasses that dominate and even out-compete other native species, allowing an increase in early and mid-flowering forbs, sedges, and cool-season grasses (O'Connor 2006). To summarize, the decrease in forbs on the Kankakee Savanna sites is likely due to the lack of fire being implemented during the summer season. These sites have been burned predominately during the spring and fall which increases warm season grasses that are outcompeting the forbs and managers should consider altering their future burn seasons.

Limitations

The initial data gathered by Phillippe et al. was gathered in 2002 in only one week, the final week in August which allowed for them to get the most accurate representation of the herbaceous cover of the sites. In contrast, for the 2020 study, data were gathered primarily in the month of July, exceptions being the first transect that was sampled on June 30th and the last transects sampled on September 4th and 5th. This spread of sampling dates could have strongly influenced the species seen at the Kankakee Savannas during 2020. Inconsistences in sampling were due to the Coronavirus pandemic which influenced quarantining and impacted travelling ability for the researchers. Vegetative sampling in midwestern US during a single visit in early June to late August gives the best representation of the site and can result in an 80% complete inventory due to the seasonality of prairie plants (Taft et al. 1997). A study done in a Northern Great Plains mixed prairie concluded that early summer season vegetation samples showed low biomass values with values increasing around midsummer and finally dropping off to early spring values after the middle of August (Ode et al. 1980). This provides a small window of time where it is ideal to gather vegetative data on prairie sites.

Another limitation of this study would be the lack of vegetative data from 2007 and the lack of canopy data from 2020. If research and monitoring occurs on these sites in the future, it is advised that both vegetative and canopy data be gathered to more clearly evaluate the interaction of fire and other management treatments on species composition and structure.

CHAPTER 6

CONCLUSION

Pembroke Savanna experienced a non-significant change in FQI and $\bar{C}$, while decreasing slightly in its diversity (H'). Carl N. Becker Savanna experienced a slight decrease in all factors (FQI, $\bar{C}$, H'). Mskoda Land and Water Reserve experienced a non-significant decrease in FQI and a non-significant increase in $\bar{C}$ and H'. Hopkins Park Savanna experienced a non-significant decrease in FQI, and H', while experiencing no change in $\bar{C}$. Sweet Fern Savanna experienced a non-significant decrease in FQI and H', and an increase in $\bar{C}$. All changes in those three factors were found to be statistically insignificant and were not an effect of prescribed fire. The overall increase in shrub and sedge coverage and decrease of forb coverage, although not a direct result of fire frequency, were both significant. Increased shrub coverage is most likely due to implementing prescribed burns predominantly in the spring, resulting in the top killing and resprouting of sumac species including *Rhus copallinum* and *Rhus glabra*. Decreased forb coverage is due to the increase of shrub coverage and competition between forbs and warm season grasses. Increased sedge coverage is due to the ability of the *Carex* species to be able to propagate through rhizomes that are typically untouched by fire.

Management Implications

Fire alone does not seem to be enough of a disturbance to change species composition (Biondini et al. 1989), but when carefully selecting the timing of prescribed fires and using other management tools along with applied fire, prairie and savanna managers should be able to more closely influence the species seen on the landscape. Research suggests that The Nature Conservancy should have as much flexibility with the timing of their prescribed burns, and that

they will likely need to investigate management activities against further invasion of native sumac species.

Land managers of the Kankakee Savannas should consider expanding their prescribed burn windows to include mid to late summer burns in efforts to maintain and potentially increase coverage of desired forb species (Copeland et al. 2002). Spring burns typically increase warm season grasses and sedges and late-flowering forbs, while mid to late summer burns will likely increase cool season grasses and early to mid-flowering forbs (O'Connor 2006). Increased fire seasonality will select for a variety of groups of grasses and forbs rather than selecting for specific groups, increasing diversity and quality of the prairie and savanna landscapes. To avoid negative impact on wildlife when burning during the summer, land managers should consider burn completeness, ignition pattern and timing, and the type of burn used (O'Connor 2006). For example, breaking up a site into different units and alternating the units that are being burned rather than burning them all at once would leave refugia for wildlife that are known to be impacted by fire such as turtles, snakes, and insects.

Management of the native, but aggressive sumac species needs to begin on these sites of the Kankakee Savannas. Tunnell et al. (2006) found that fire alone, even at moderate frequencies, is not enough to mitigate sumac invasion. In fact, fire has been found to increase the density of sumac species on a site due to resprouting that is influenced by top killing the shrubs (Tunnell et al. 2006). While it should not be removed entirely, sumac must be managed through herbicide treatments such as basal bark, cut-stump, or foliar applications where it is outcompeting more desired vegetation. An oil based triclopyr herbicide can be used for basal bark treatment, where Garlon 4 should be mixed with vegetable or mineral oil to form a 10% active ingredient solution (Hutchinson 1992). This solution should be sprayed on the lowest 12-

15 inches of the stem for basal bark treatments. A 25% active ingredient solution of glyphosate has proved to be effective in cut-stump treatment of sumac species. Triclopyr formulated as a triethylamine salt as a 0.4% active ingredient has proven to be effective for broadleaf specific foliar applications (Hutchinson 1992). Follow up treatment in all cases may be necessary, as many shrubs survive initial treatment. If these herbicidal treatments threaten desired species that are growing closely with sumac, it may be treated by being cut twice, once in July and once in August (Hutchinson 1992). This method, however, may need to be repeated for several years before results are seen. With further management of this layer, many sites of the Kankakee Savannas will not be at risk of succeeding past a sand savanna and into a forested landscape.

EXHIBITS

Table 1. Fire History of the Kankakee Savannas.

Site	**Season/Year**	**Type**
Pembroke Savanna	Spring 2006	Wildfire (Wild)
	Spring 2009	Prescribed Fire (R_x)
	Fall 2013	R_x
	Winter 2016	R_x
	Spring 2018	Wild
Carl N. Becker Savanna	Fall 2007	R_x
	Spring 2009	Wild
	Winter 2010	Wild
	Fall 2012	Wild
	Fall 2015	R_x
	Spring 2018	Wild
Mskoda Land and Water Reserve	Spring 2002	R_x
	Spring 2004	R_x
	Fall 2007	R_x
	Spring 2011	R_x
	Spring 2014	Wild
	Spring 2019	R_x
Hopkins Park Savanna	Fall 2006	R_x
	Spring 2009	R_x
	Spring 2013	R_x
	Spring 2015	Wild
	Spring 2019	Wild
Sweet Fern Savanna	Spring 2009	Wild
	Spring 2015	R_x
	Spring 2019	R_x

Table 2. Universal Floristic Quality Assessment values for the Kankakee Savannas in 2002.

Site	**Adjusted FQI**	**Mean C**	**H'**
Pembroke	49.3	4.7	3.45
Becker	56	5.4	3.66
Mskoda	44.2	4.2	3.47
Hopkins	50.1	4.8	3.80
Sweet Fern	52.7	5.1	3.74

Table 3. Universal Floristic Quality Assessment values for the Kankakee Savannas in 2020.

Site	**Adjusted FQI 2020**	**Mean C 2020**	**H' 2020**
Pembroke	51.8	5.1	3.28
Becker	44.6	4.2	3.56
Mskoda	45.9	4.4	3.50
Hopkins	49.4	4.8	3.60
Sweet Fern	54	5.3	3.57

Table 4. Results of all statistical tests. Sig= Result of the significance test, NS= non-significant, *= significant, p=p-value, Δ=change from 2002 to 2020.

Site Metrics	**Factors**	**p**	**Sig**
FQA	Δ FQI	0.754	NS
	Δ $\bar{C}$	0.833	NS
	Δ H’	0.347	NS
	Fire Frequency x FQI	0.653	NS
	Fire Frequency x $\bar{C}$	0.588	NS
	Fire Frequency x H’	0.187	NS
C values	Fire frequency x Distribution	0.004	*
	Fire frequency x Low C (0-1)	0.250	NS
Physiognomy (Δ in coverage of physiognomic groups)	Shrub	0.003	*
	Forb	0.001	*
	Sedge	0.000	*
	Grass	0.742	NS
	Rush	0.346	NS
	Fern	0.901	NS
	Vine	0.361	NS
	Tree	0.581	NS

Figure 1. Study Areas within Kankakee County, Illinois.

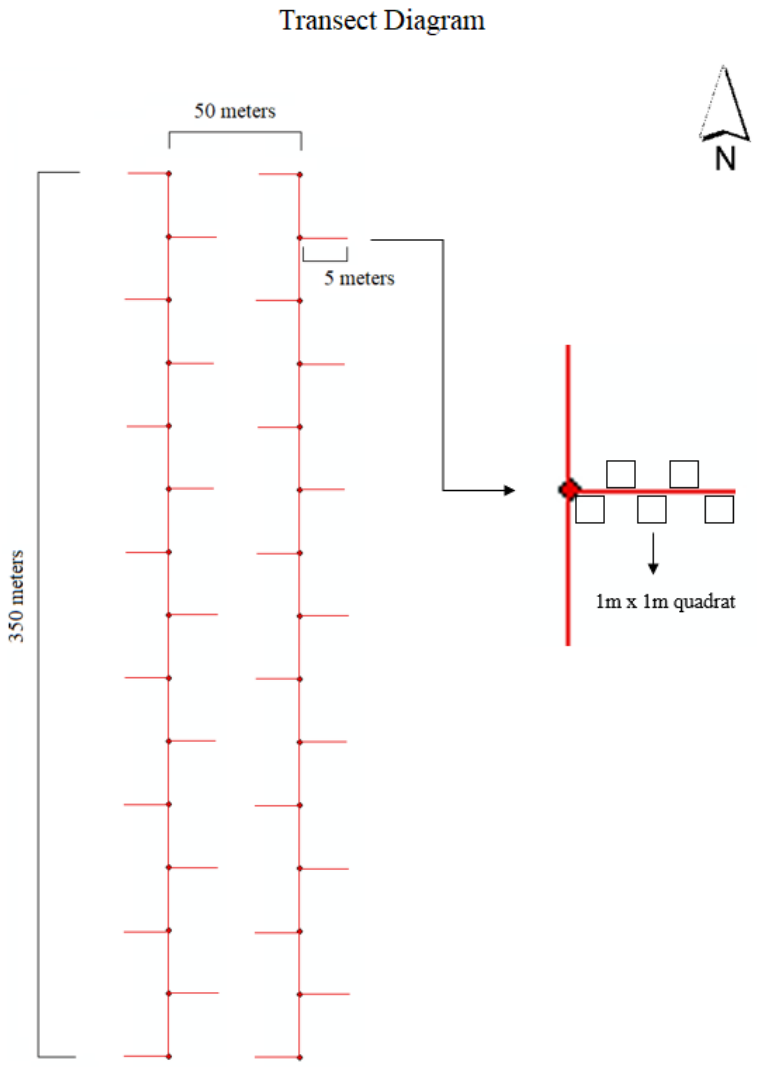

Figure 2. Transect sampling diagram. This example shows the transects as they were sampled at sites whose transects run north to south (Hopkins Park and Mskoda LWR). Starting in the north and travelling south, the first pin (odd-numbered) had a 5-meter-long segment measured and sampled to the right (west) of the pin. The first quadrat on a segment was always placed on the right side of the measuring tape, alternating left then back right and on until the whole 5 meters was sampled. At the second pin (even numbered), the 5-meter-long segment was laid out to the left (east) of the pin.

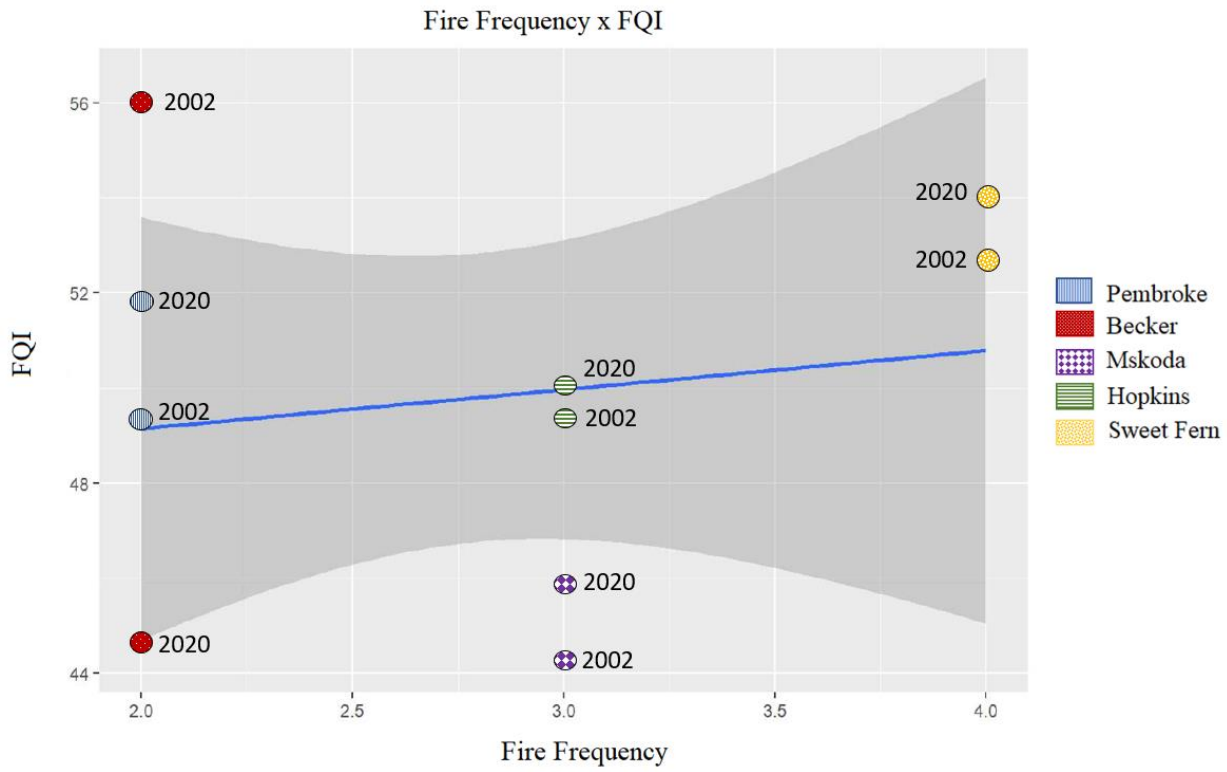

Figure 3. Linear regression of fire frequency and Floristic Quality Index of the Kankakee Savannas managed by TNC.

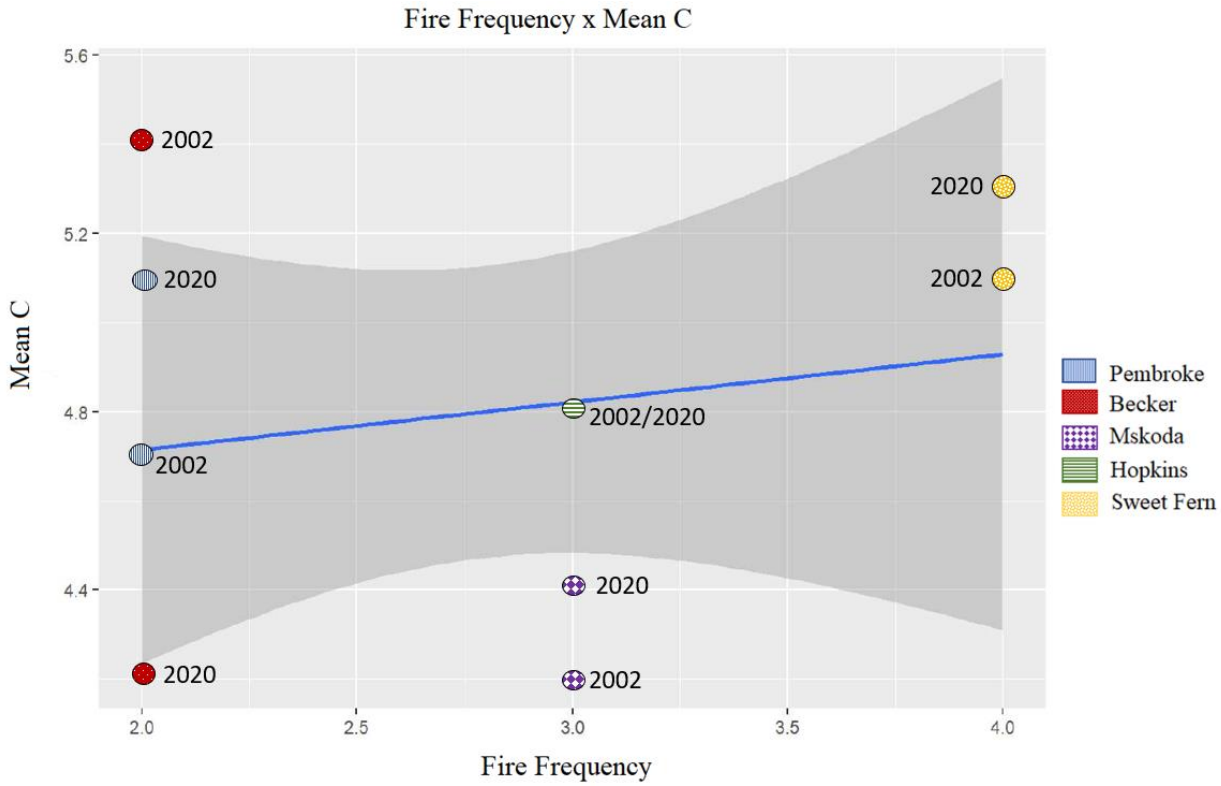

Figure 4. Linear regression of fire frequency and mean conservatism coefficient (average value of conservatism for all native and non-native species) of the Kankakee Savannas.

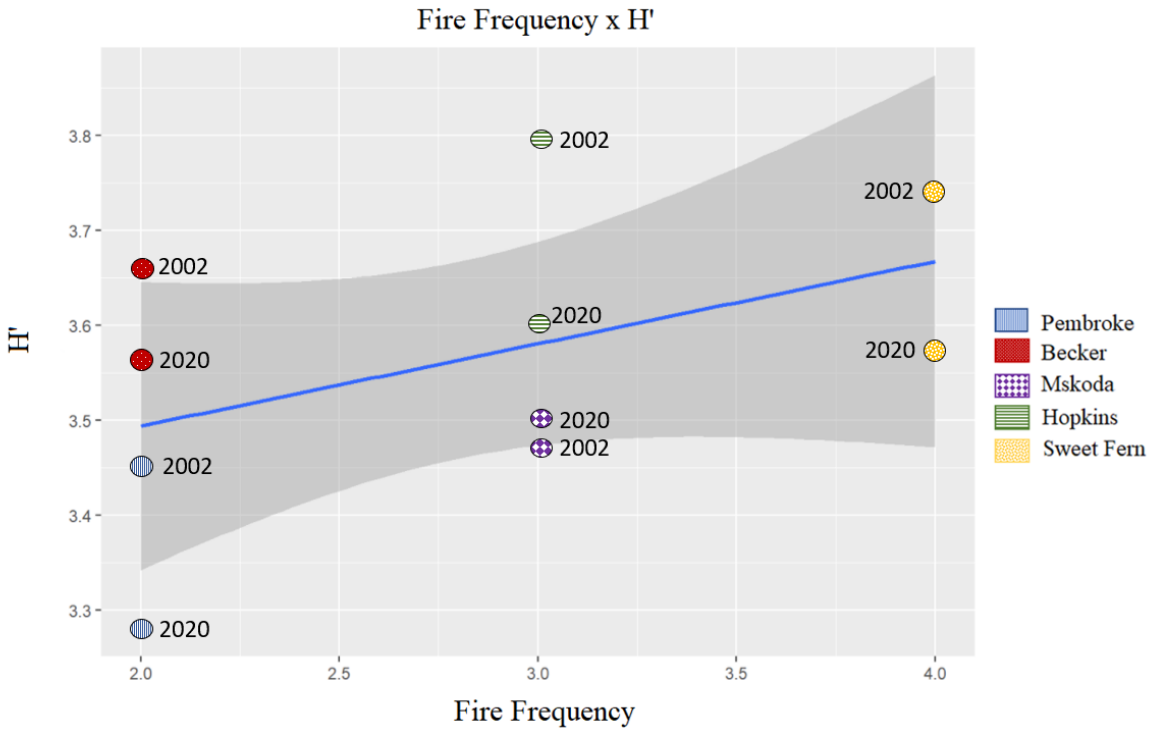

Figure 5. Linear regression of fire frequency and Shannon-Wiener Diversity Index (H') of the Kankakee Savannas.

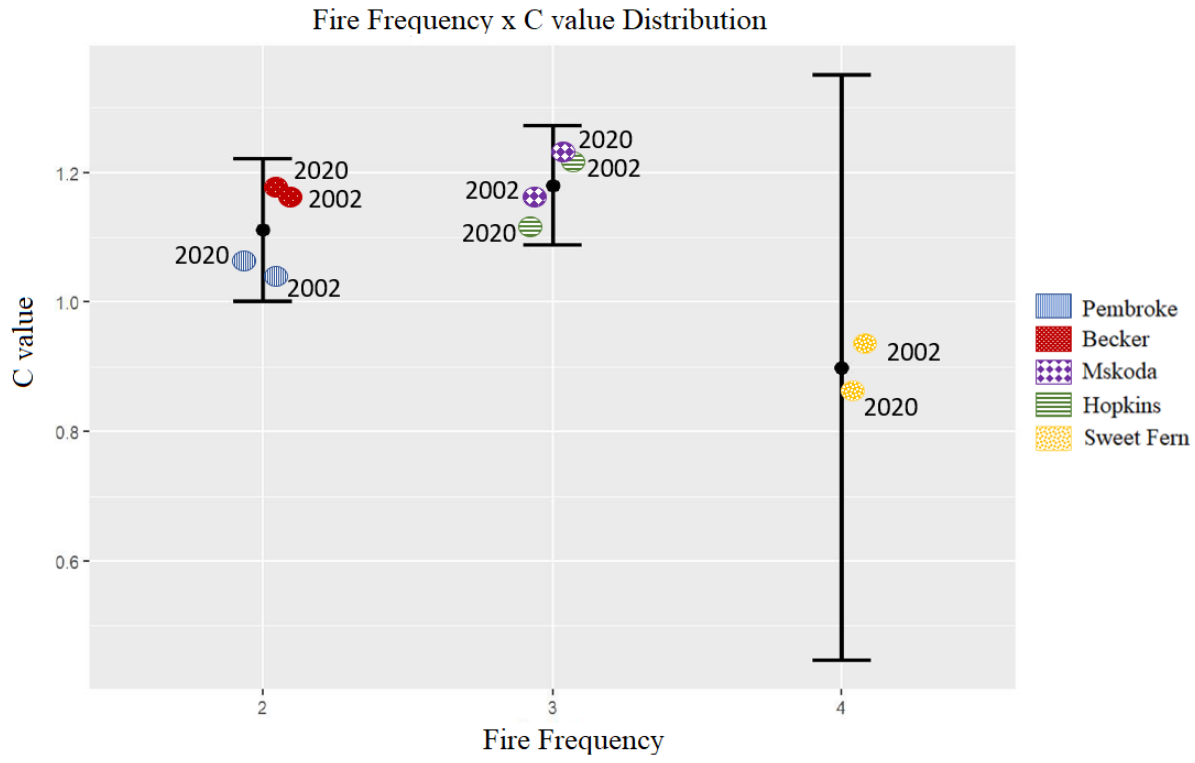

Figure 6. Fire frequency and the differences in C value distribution of the Kankakee Savannas 2002 vs 2020. The error bars represent the spread of data around the mean value, for example those sites with a fire frequency of 3 years experience C value distributions close to the $\bar{C}$, whereas Sweet Fern's C value distribution ranges much higher and lower than the $\bar{C}$.

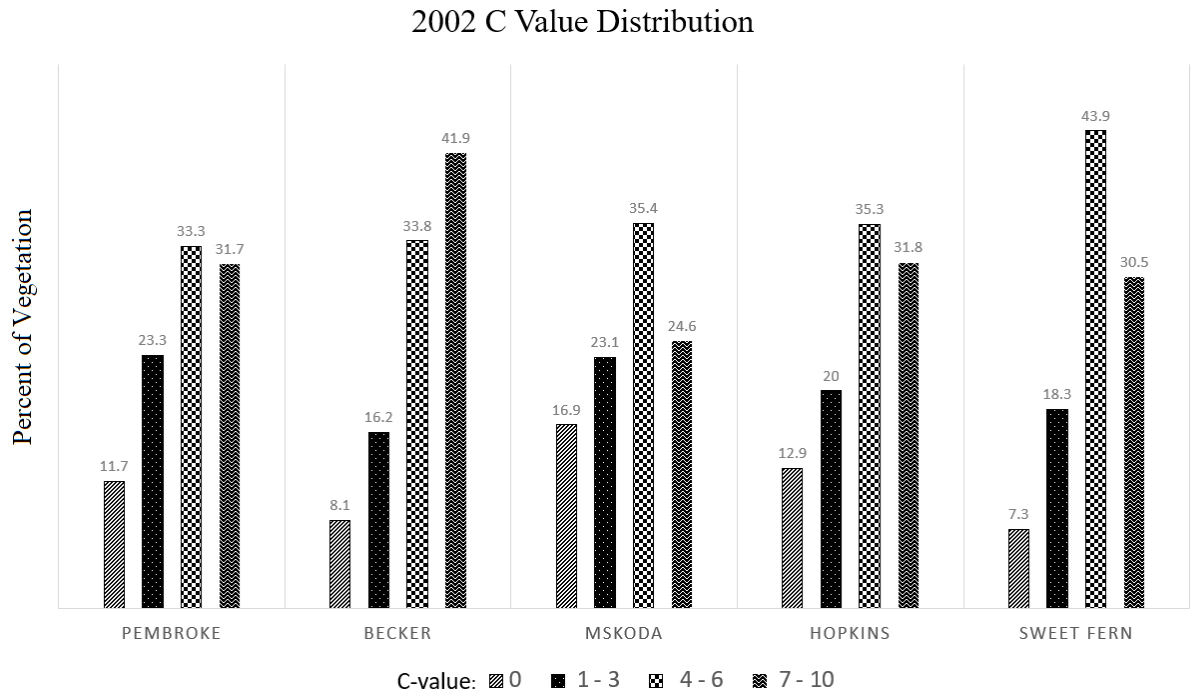

Figure 7. C value distribution in 2002 for Kankakee Savanna sites.

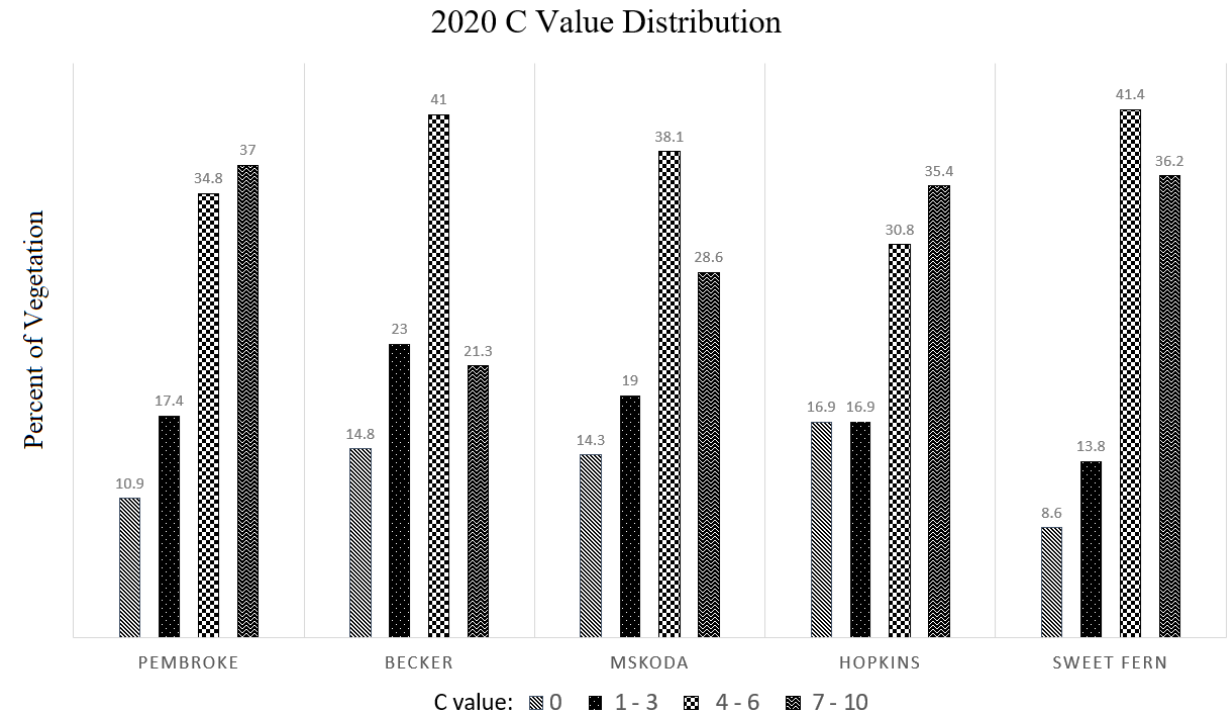

Figure 8. C value distribution in 2020 for Kankakee Savanna sites.

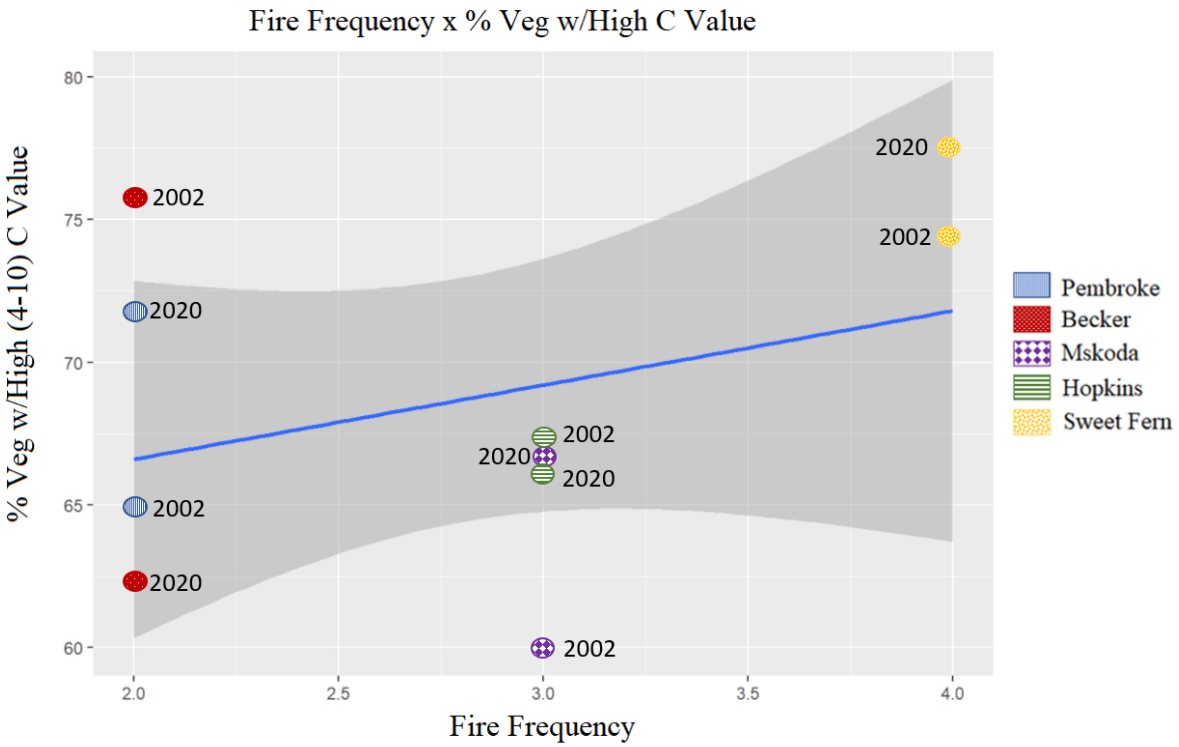

Figure 9. Linear regression showing the non-significant effect of fire frequency on coverage of vegetation with high (4-10) C values.

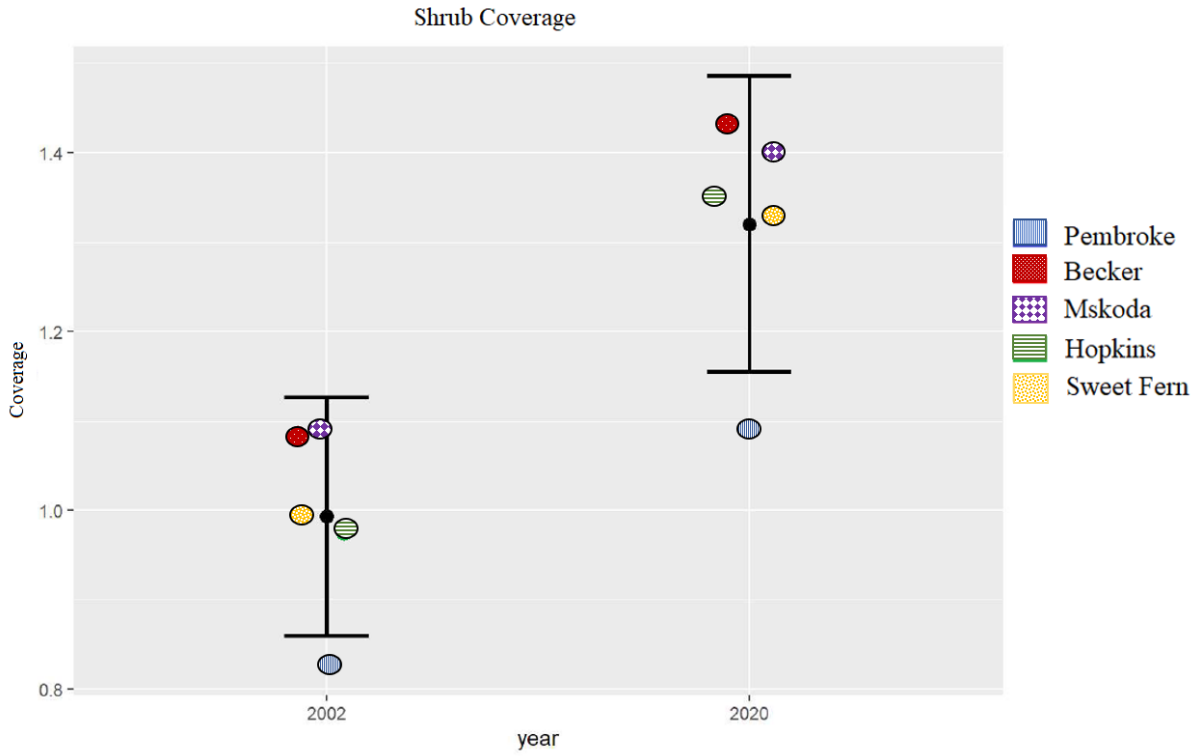

Figure 10. Significant differences in shrub coverage for the Kankakee Savannas in 2002 and 2020. Significance was tested with a log10 transformation. Error bars represent the spread of data around the mean value.

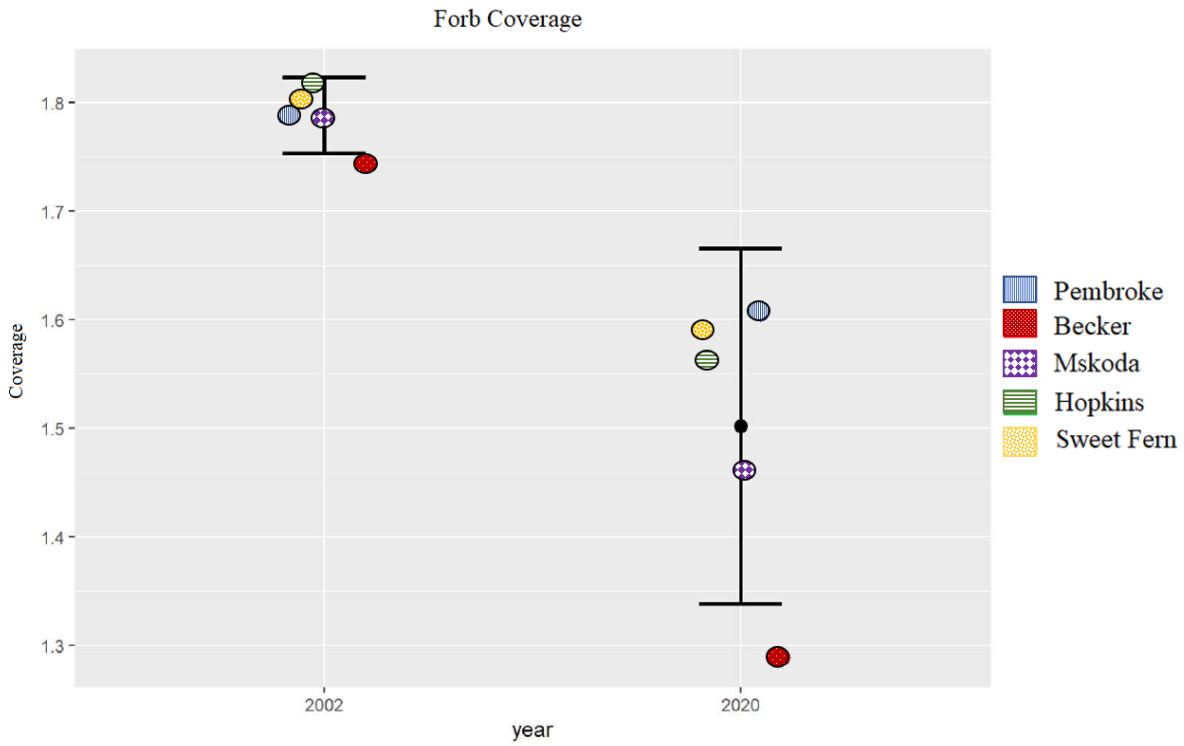

Figure 11. Significant differences in forb coverage for the Kankakee Savannas in 2002 and 2020. Significance was tested with a log10 transformation. Error bars represent the spread of data around the mean value.

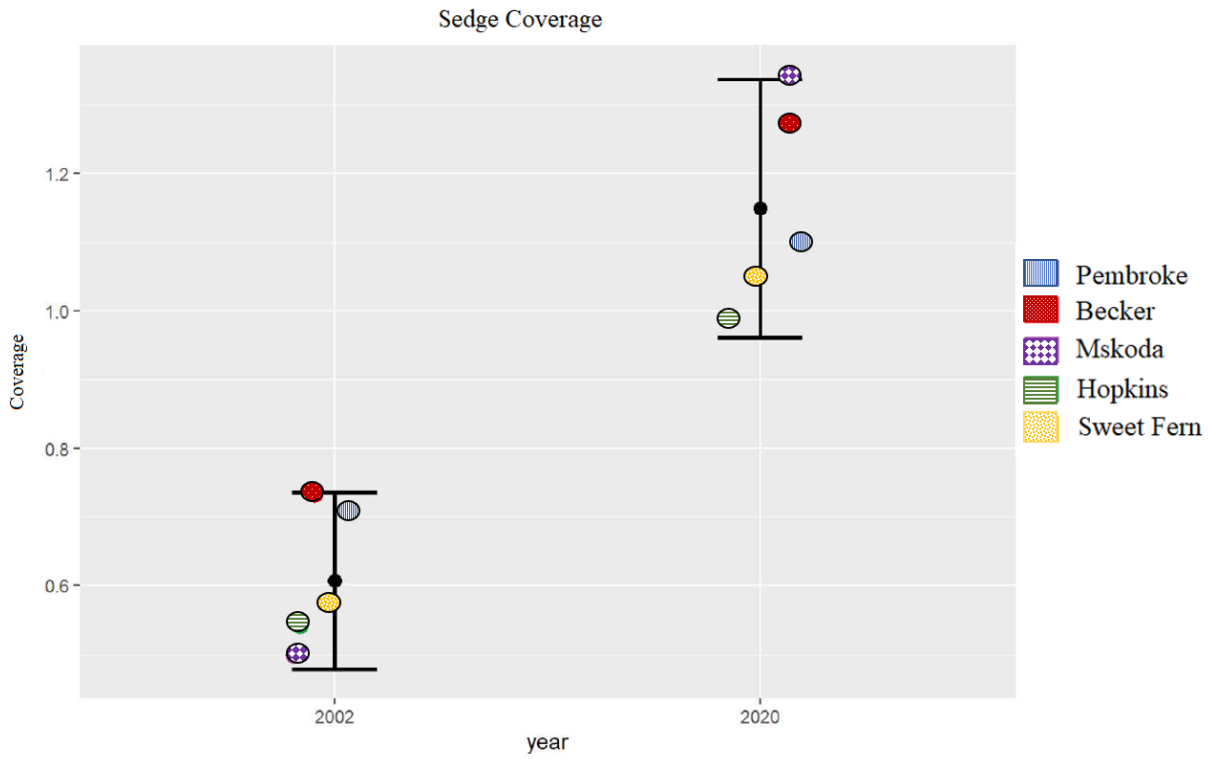

Figure 12. Significant differences in sedge coverage for the Kankakee Savannas in 2002 and 2020. Significance was tested with a log10 transformation. Error bars represent the spread of data around the mean value.

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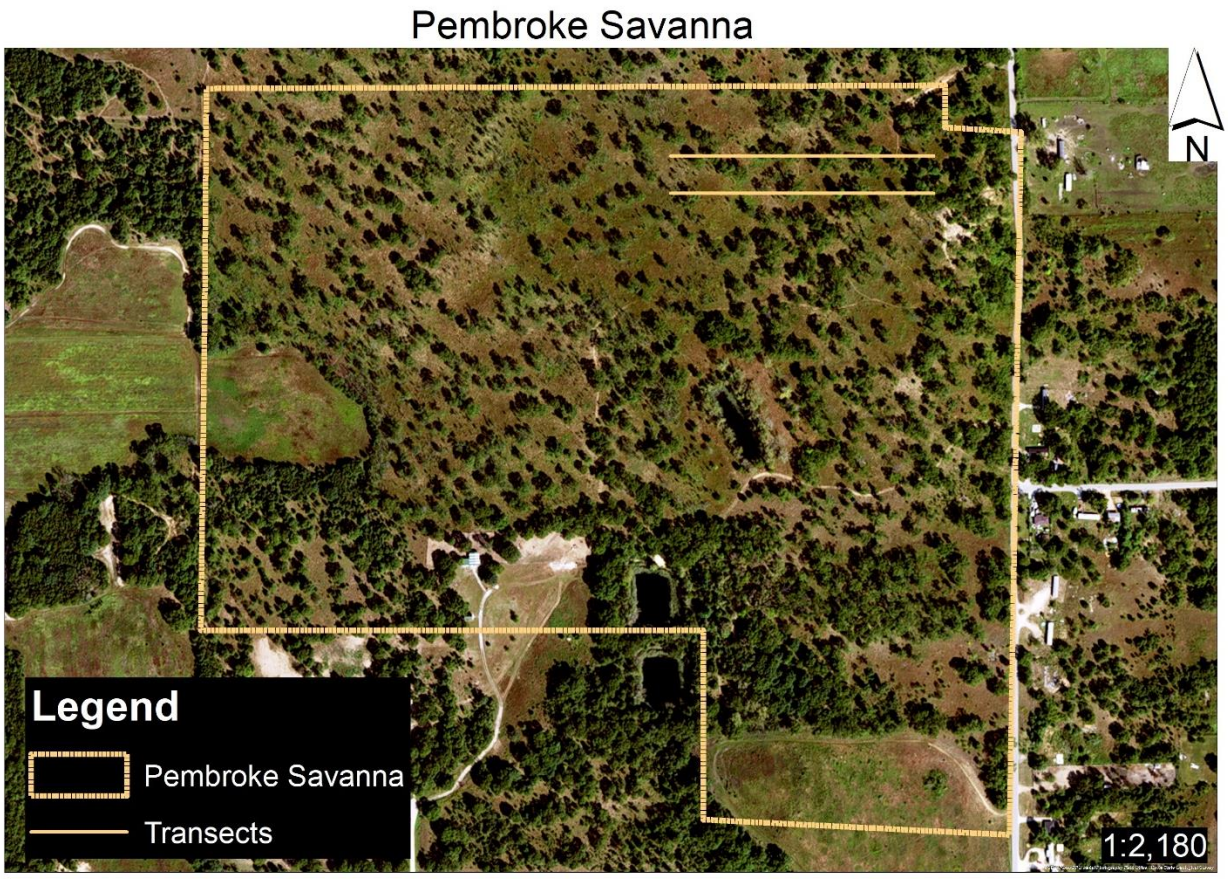
APPENDIX A

LOCATION DATA FOR PERMANENT PLOTS

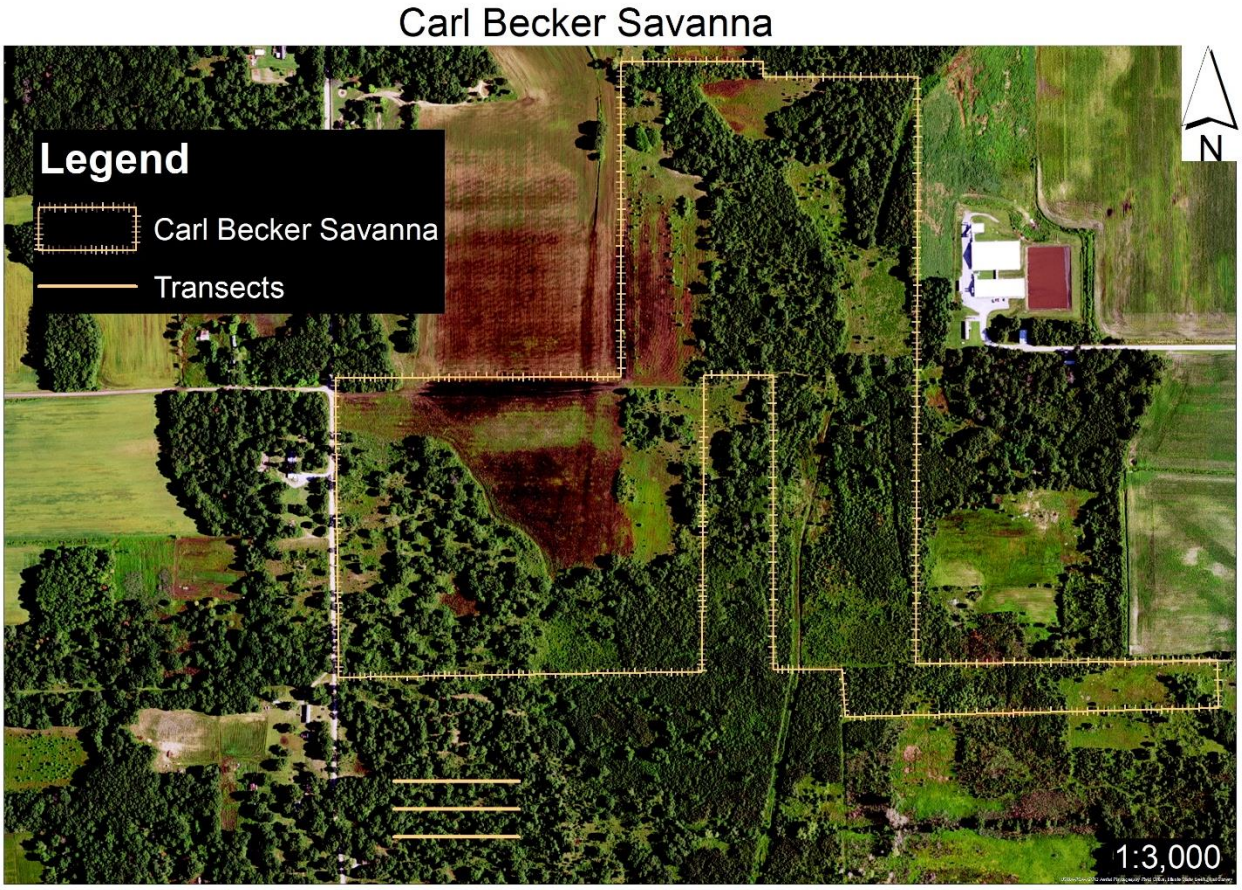
Pembroke Savanna

Transect Point	Coordinates	Notes
North-west	41.075146, -87.644661	- 2 transects running West-East. - Transects= 350 meters long. - 15 pins along the transect.
North-east	41.075150, -87.640505	
South-west	41.074510, -87.644737	
South-east	41.074411, -87.640547	



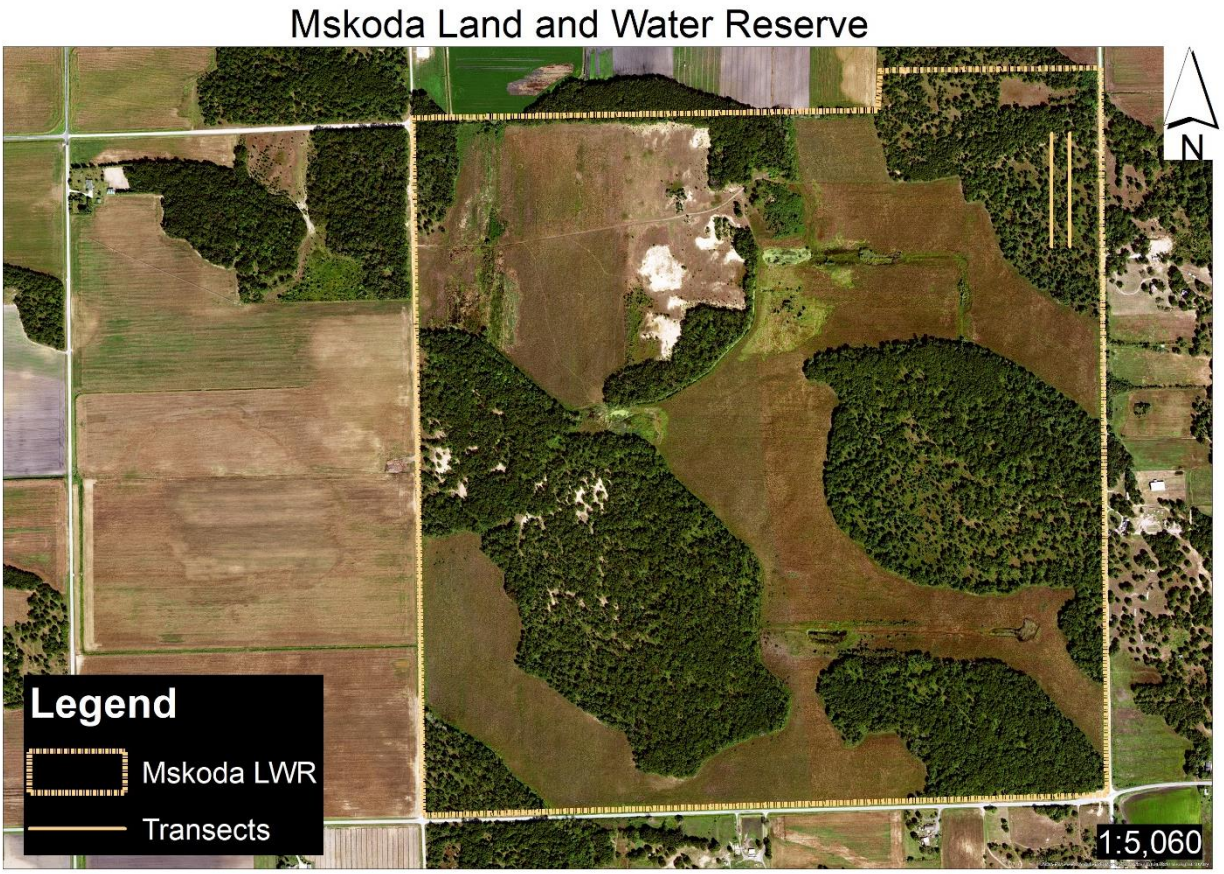
Carl N. Becker Savanna

Transect Point	Coordinates	Notes
North-west	41.012530, -87.541270	- 2 transects running West-East. - Transects= 225 meters long. - 10 pins along the transect. *South transect excluded due to property boundary issues.
North-east	41.012780, -87.538630	
Central-west	41.012230, -87.541180	
Central-east	41.012330, -87.538540	
South-west	41.011810, -87.541150	
South-east	41.011840, -87.538350	



Mskoda Land and Water Reserve

Transect Point	Coordinates	Notes
North-west	41.079680, -87.658647	- 2 transects running North-South. - Transects= 350 meters long. - 15 pins along the transect.
South-west	41.076662, -87.658359	
North-east	41.079806, -87.657371	
South-east	41.076712, -87.657246	

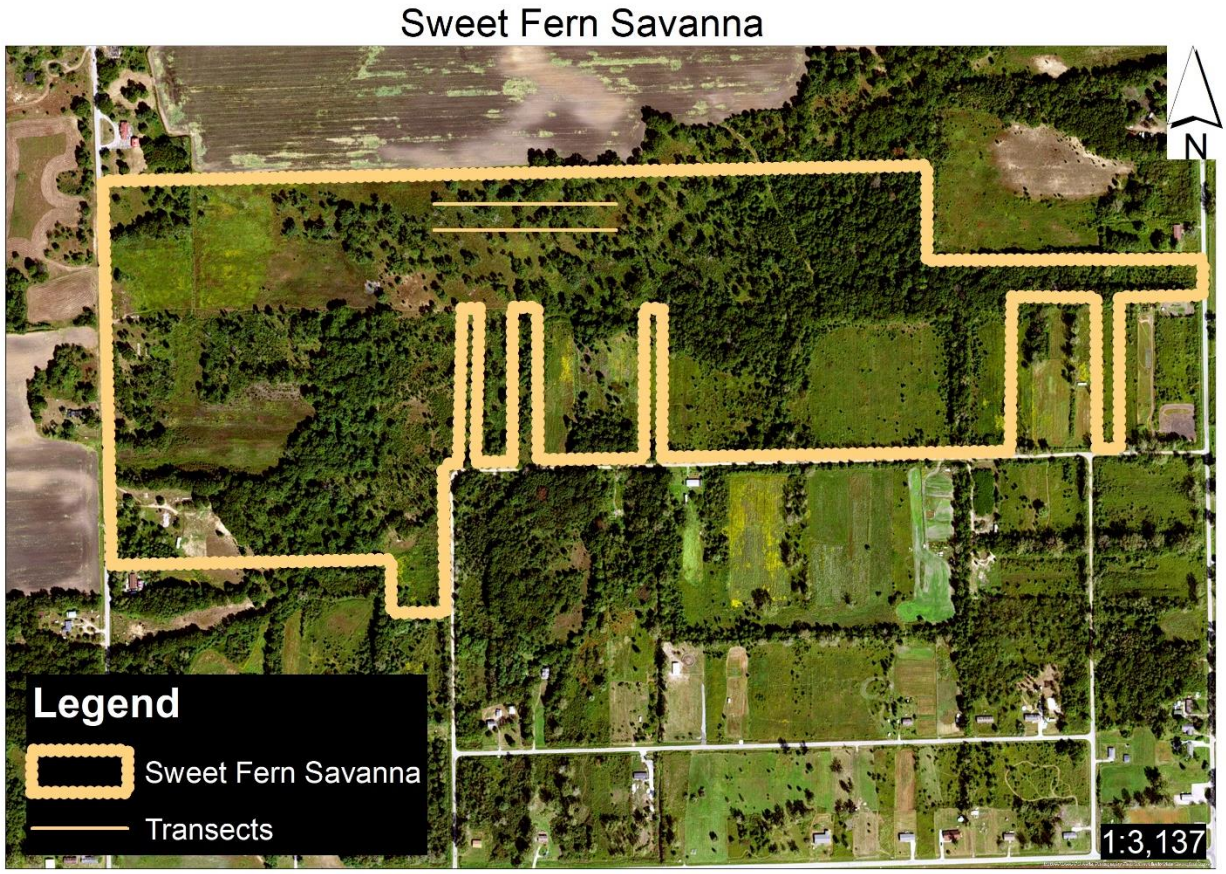


Hopkins Park Savanna

Transect Point	Coordinates	Notes
North-west	41.089920, -87.564547	- 2 transects running North-South. - Transects= 350 meters long. - 15 pins along the transect.
South-west	41.086763, -87.564278	
North-east	41.089945, -87.563987	
South-east	41.086788, -87.563690	

Sweet Fern Savanna

Transect Point	Coordinates	Notes
North-west	41.075732, -87.596156	- 2 transects running West-East. - Transects= 350 meters long. - 15 pins along the transect.
North-east	41.075999, -87.592044	
South-west	41.075460, -87.596176	
South-east	41.075650, -87.592082	



APPENDIX B

PHILLIPEE ET AL. 2002 DATA*

Mt. Fraker (Pembroke Savanna)

Table 9. Frequency (%), average cover, relative frequency, relative cover, and importance values (IV) of the ground layer species encountered at Mt. Fraker (Site # 4) at the Pembroke Savanas, Kankakee County, Illinois. (* = exotic species)

Species	Frequency %	Average Cover	Relative Frequency	Relative Cover	I.V.
Schizachyrium scoparium	83	14.34	8.0	26.1	34.1
Carex pensylvanica	99	7.83	9.6	14.2	23.8
Panicum villosissimum	63	4.24	6.1	7.7	13.8
Euphorbia corollata	70	3.42	6.8	6.2	13.0
Viola pedata	44	2.87	4.2	5.2	9.4
Koeleria pyramidata	65	1.65	6.3	3.0	9.3
Cassia fasciculata	45	2.27	4.4	4.1	8.5
Aster linariifolius	16	2.97	1.6	5.4	7.0
Cyperus filiculmis	51	0.46	4.9	0.8	5.7
Asclepias verticillata	45	0.64	4.4	1.2	5.6
Solidago nemoralis	35	1.08	3.4	2.0	5.4
Liatris aspera	31	0.75	3.0	1.4	4.4
Quercus velutina	19	1.20	1.8	2.2	4.0
Stipa spartea	20	1.12	1.9	2.0	3.9
Conyza canadensis	30	0.33	2.9	0.6	3.5
Helianthemum sp.	28	0.36	2.7	0.7	3.4
Panicum oligosanthes	26	0.45	2.5	0.8	3.3
Tephrosia virginiana	8	1.31	0.8	2.4	3.2
Lespedeza capitata	23	0.41	2.2	0.7	2.9
Lactuca canadensis	17	0.62	1.7	1.1	2.8
Rhus copallina	10	1.00	1.0	1.8	2.8
Panicum virgatum	14	0.73	1.4	1.3	2.7
Croton glandulosus	16	0.42	1.5	0.8	2.3
Carex muhlenbergii	21	0.11	2.0	0.2	2.2
Cassia nictitans	13	0.36	1.3	0.7	2.0
Polygonatum biflorum	7	0.60	0.7	1.1	1.8
Monarda punctata	10	0.20	1.0	0.4	1.4
Rhus glabra	4	0.48	0.4	0.9	1.3
Sporobolus clandestinus	6	0.40	0.6	0.7	1.3
Lithospermum caroliniense	9	0.17	0.9	0.3	1.2
Andropogon gerardii	3	0.45	0.3	0.8	1.1
Phlox bifida	9	0.10	0.9	0.2	1.1
Polygonum tenue	10	0.10	1.0	0.1	1.1
Euthamia gymnospermoides	5	0.20	0.5	0.4	0.9
Physalis virginiana	8	0.07	0.8	0.1	0.9
Eragrostis spectabilis	6	0.11	0.6	0.2	0.8
Hieracium longipilum	5	0.17	0.5	0.3	0.8
**Poa pratensis*	6	0.08	0.6	0.1	0.7
Tradescantia ohiensis	6	0.03	0.6	0.1	0.7
Ambrosia artemisiifolia	3	0.19	0.3	0.3	0.6
Leptoloma cognatum	5	0.08	0.5	0.1	0.6
Aureolaria pedicularia	2	0.18	0.2	0.3	0.5
Fragaria virginiana	2	0.18	0.2	0.3	0.5
Talinum rugospermum	4	0.07	0.4	0.1	0.5
Aster azureus	3	0.07	0.3	0.1	0.4
Oenothera rhombipetala	4	0.02	0.4	---	0.4

Rosa carolina	3	0.07	0.3	0.1	0.4
Commelina erecta	2	0.04	0.2	0.1	0.3
Agrostis hyemalis	2	0.01	0.2	—	0.2
Erigeron strigosus	2	0.01	0.2	—	0.2
Gnaphalium obtusifolium	1	0.03	0.1	0.1	0.2
Rubus flagellaris	1	0.03	0.1	0.1	0.2
Sassafras albidum	1	0.03	0.1	0.1	0.2
**Achillea millefolium*	1	0.01	0.1	—	0.1
Arabis lyrata	1	0.01	0.1	—	0.1
Aster pilosus	1	0.01	0.1	—	0.1
Chenopodium desiccatum	1	0.01	0.1	—	0.1
Lespedeza virginica	1	0.01	0.1	—	0.1
Prunus serotina	1	0.01	0.1	—	0.1
Sporobolus cryptandrus	1	0.01	0.1	—	0.1
Totals		55.18	100.0	100.0	200.0
Average bare ground and litter		37.85			

Leeseville East (Carl N. Becker Savanna)

Table 7. Frequency (%), average cover, relative frequency, relative cover, and importance values (IV) of the ground layer species encountered at Leesville East (Site # 2) at the Pembroke Savanas, Kankakee County, Illinois. (* = exotic species)

Species	Frequency %	Average Cover	Relative Frequency	Relative Cover	I.V.
Carex pensylvanica	88	6.17	9.4	9.3	18.7
Schizachyrium scoparium	64	7.30	6.8	11.0	17.8
Cassia nictitans	62	3.69	6.7	5.6	12.3
Quercus velutina	32	4.43	3.4	6.7	10.1
Rhus copallina	24	4.66	2.6	7.0	9.6
Euphorbia corollata	40	2.97	4.3	4.5	8.8
Lespedeza capitata	42	2.02	4.5	3.0	7.5
Helianthemum sp.	37	1.58	4.0	2.4	6.4
Rosa carolina	36	1.74	3.8	2.6	6.4
Sporobolus cryptandrus	30	2.03	3.2	3.1	6.3
Amorpha canescens	21	2.39	2.2	3.6	5.8
Panicum villosissimum	33	1.53	3.5	2.3	5.8
Viola pedata	32	1.33	3.4	2.0	5.4
Helianthus divaricatus	16	2.35	1.7	3.5	5.2
Rubus hispidus	5	2.63	0.5	4.0	4.5
Solidago nemoralis	20	1.39	2.2	2.1	4.3
Cyperus filiculmis	35	0.40	3.7	0.6	4.3
Tephrosia virginiana	17	1.58	1.8	2.4	4.2
Panicum virgatum	21	0.94	2.2	1.4	3.6
Commelina erecta	24	0.62	2.6	0.9	3.5
Asclepias verticillata	21	0.60	2.2	0.9	3.1
Cassia fasciculata	11	1.27	1.2	1.9	3.1
Rhus glabra	9	1.27	1.0	1.9	2.9
Monarda punctata	10	0.93	1.1	1.4	2.5
Leptoloma cognatum	11	0.74	1.2	1.1	2.3
Hieracium scabrum	12	0.62	1.3	0.9	2.2
Panicum oligosanthes	14	0.42	1.5	0.6	2.1
Conyza canadensis	10	0.56	1.1	0.9	2.0
Quercus alba	4	0.93	0.4	1.4	1.8
Sorghastrum nutans	7	0.57	0.8	0.9	1.7
Stipa spartea	12	0.26	1.3	0.4	1.7
Lithospermum caroliniense	10	0.30	1.1	0.4	1.5
Rubus flagellaris	7	0.40	0.8	0.6	1.4
Tradescantia ohiensis	11	0.13	1.2	0.2	1.4
Andropogon gerardii	4	0.56	0.4	0.9	1.3
Lactuca canadensis	8	0.19	0.9	0.3	1.2
Aster sp.	3	0.45	0.3	0.8	1.1
Quercus palustris	2	0.53	0.2	0.9	1.1
Sporobolus clandestinus	6	0.30	0.6	0.5	1.1
**Poa pratensis*	7	0.14	0.8	0.2	1.0
Antennaria plantaginifolia	4	0.34	0.4	0.5	0.9
Fragaria virginiana	5	0.27	0.5	0.5	0.9
Bouteloua curtipendula	3	0.33	0.3	0.5	0.8
Lechea villosa	5	0.25	0.5	0.8	0.8
Solidago speciosa	3	0.33	0.3	0.5	0.8
Osmunda regalis	1	0.38	0.1	0.6	0.7

Spiraea tomentosa	3	0.21	0.3	0.3	0.6
Carex swanii	4	0.07	0.4	0.1	0.5
Physalis virginiana	4	0.05	0.4	0.1	0.5
Salix humilis	2	0.16	0.2	0.3	0.5
Viola sagittata	4	0.07	0.4	0.1	0.5
Chenopodium desiccatum	3	0.05	0.3	0.1	0.4
Desmodium sessilifolium	3	0.07	0.3	0.1	0.4
Euthamia gymnospermoides	3	0.04	0.3	0.1	0.4
Liatris aspera	3	0.07	0.3	0.1	0.4
Phlox bifida	3	0.04	0.3	0.1	0.4
Polygonum tenue	3	0.04	0.3	0.1	0.4
**Achillea millefolium*	2	0.04	0.2	0.1	0.3
Aureolaria pedicularia	1	0.15	0.1	0.2	0.3
Bartonia virginica	3	0.02	0.3	—	0.3
Erigeron strigosus	2	0.04	0.2	0.1	0.3
Koeleria pyramidata	3	0.02	0.3	—	0.3
Polygala polygama	3	0.02	0.3	—	0.3
Vaccinium angustifolium	1	0.15	0.1	0.2	0.3
Aristida purpurascens	1	0.03	0.1	—	0.1
Carex muhlenbergii	1	0.03	0.1	—	0.1
Erechtites hieracifolia	1	0.03	0.1	—	0.1
Hypericum gentianoides	1	0.01	0.1	—	0.1
Oenothera rhombipetala	1	0.03	0.1	—	0.1
**Mollugo verticillatus*	1	0.03	0.1	—	0.1
Prunus serotina	1	0.01	0.1	—	0.1
Talinum rugospermum	1	0.03	0.1	—	0.1
Toxicodendron radicans	1	0.03	0.1	—	0.1
**Tragopogon dubius*	1	0.03	0.1	—	0.1
Totals		66.39	100.0	100.0	200.0
Average bare ground and litter		38.78			

Liebert (Mskoda Land and Water Reserve)

Table 8. Frequency (%), average cover, relative frequency, relative cover, and importance values (IV) of the ground layer species encountered at Liebert (Site # 3) at the Pembroke Savanas, Kankakee County, Illinois. (* = exotic species)

Species	Frequency %	Average Cover	Relative Frequency	Relative Cover	I.V.
Carex pensylvanica	98	14.05	10.8	22.7	33.5
Schizachyrium scoparium	77	12.11	8.5	19.6	28.1
Euphorbia corollata	77	3.32	8.5	5.3	13.8
Quercus velutina	42	3.51	4.6	5.7	10.3
Rhus copallina	30	4.13	3.3	6.7	10.0
Rhus glabra	24	4.13	2.6	6.7	9.3
Helianthemum sp.	54	1.53	5.9	2.5	8.4
Panicum villosissimum	47	1.61	5.2	2.6	7.8
Tephrosia virginiana	22	3.31	2.4	5.3	7.7
Rosa carolina	31	2.15	3.4	3.5	6.9
Cassia nictitans	36	1.45	4.0	2.4	6.4
Rubus allegheniensis	25	1.73	2.8	2.8	5.6
Conyza canadensis	29	0.71	3.2	1.2	4.4
**Rumex acetosella*	23	0.83	2.5	1.3	3.8
**Poa pratensis*	26	0.38	2.9	0.6	3.5
Sorghastrum nutans	21	0.69	2.3	1.1	3.4
Aristida purpurascens	12	0.43	1.3	0.7	2.0
Hieracium scabrum	15	0.18	1.7	0.3	2.0
Panicum oligosanthes	16	0.13	1.8	0.2	2.0
Lechea villosa	12	0.33	1.3	0.5	1.8
Gnaphalium obtusifolium	11	0.25	1.2	0.4	1.6
Solidago nemoralis	13	0.12	1.4	0.2	1.6
Cyperus filiculmis	12	0.11	1.3	0.2	1.5
Eragrostis spectabilis	7	0.45	0.8	0.7	1.5
Prunus serotina	12	0.14	1.3	0.2	1.5
Asclepias verticillata	11	0.11	1.2	0.2	1.4
Amorpha canescens	7	0.33	0.8	0.5	1.3
Viola sagittata	8	0.21	0.9	0.3	1.2
Antennaria plantaginifolia	6	0.28	0.7	0.4	1.1
Liatris aspera	7	0.21	0.8	0.3	1.1
Hieracium longipilum	6	0.20	0.7	0.3	1.0
Koeleria pyramidata	8	0.04	0.9	0.1	1.0
Lespedeza virginica	5	0.25	0.6	0.4	1.0
Lespedeza capitata	7	0.06	0.8	0.1	0.9
Panicum virgatum	7	0.06	0.8	0.1	0.9
Andropogon gerardii	3	0.31	0.3	0.5	0.8
Polygonatum biflorum	4	0.22	0.4	0.4	0.8
Viola pedata	6	0.06	0.7	0.1	0.8
Robinia pseudoacacia	2	0.30	0.2	0.5	0.7
Salix humilis	2	0.30	0.2	0.5	0.7
Rubus flagellaris	3	0.21	0.3	0.3	0.6
Antennaria neglecta	2	0.18	0.2	0.3	0.5
Hieracium gronovii	4	0.07	0.4	0.1	0.5
Maianthemum racemosum	2	0.16	0.2	0.3	0.5
Agrostis hyemalis	3	0.04	0.3	0.1	0.4
Lactuca canadensis	3	0.07	0.3	0.1	0.4

Lithospermum caroliniense	1	0.15	0.1	0.3	0.4
Oxalis stricta	4	0.02	0.4	—	0.4
Polygala polygama	4	0.02	0.4	—	0.4
Quercus alba	1	0.15	0.1	0.3	0.4
**Achillea millefolium*	3	0.02	0.3	—	0.3
Cassia fasciculata	3	0.02	0.3	—	0.3
Physalis virginiana	2	0.04	0.2	0.1	0.3
Ambrosia artemisiifolia	2	0.01	0.2	—	0.2
Croton glandulosus	2	0.01	0.2	—	0.2
Apocynum cannabinum	1	0.03	0.1	—	0.1
Asclepias syriaca	1	0.03	0.1	—	0.1
Asclepias tuberosa	1	0.03	0.1	—	0.1
Aster azureus	1	0.03	0.1	—	0.1
Aster pilosus	1	0.03	0.1	—	0.1
Fragaria virginiana	1	0.01	0.1	—	0.1
Monarda punctata	1	0.01	0.1	—	0.1
Oenothera biennis	1	0.01	0.1	—	0.1
Polygonum tneue	1	0.01	0.1	—	0.1
Ribes missouriense	1	0.01	0.1	—	0.1
Tradescantia ohiensis	1	0.01	0.1	—	0.1
Totals		62.10	100.0	100.0	200.0
Average bare ground and litter		35.72			

Bentley/Crawford-Jordan (Hopkins Park Savanna)

Table 6. Frequency (%), average cover, relative frequency, relative cover, and importance values (IV) of the ground layer species encountered at Bentley/Crawford-Jordan (Site # 1) at the Pembroke Savanas, Kankakee County, Illinois. (* = exotic species)

Species	Frequency %	Average Cover	Relative Frequency	Relative Cover	I.V.
Helianthus divaricatus	68	7.76	6.6	14.5	21.1
Rosa carolina	67	5.10	6.5	9.6	16.1
Schizachyrium scoparium	53	5.67	5.1	10.6	15.7
Carex pensylvanica	97	2.44	9.5	4.6	14.1
Rhus copallina	21	3.72	2.1	7.0	9.1
Cassia nictitans	58	1.75	5.6	3.3	8.9
Euphorbia corollata	47	1.35	4.5	2.5	7.0
Maianthemum racemosum	20	2.47	2.0	4.6	6.6
Quercus velutina	29	1.76	2.9	3.3	6.2
Potentilla simplex	22	1.93	2.2	3.6	5.8
Rubus flagellaris	21	1.06	2.1	2.0	4.1
Panicum vilosissimum	31	0.56	3.0	1.1	4.1
**Poa pratensis*	27	0.60	2.7	1.1	3.8
Sorghastrum nutans	18	1.09	1.8	2.0	3.8
Comandra umbellata	27	0.41	2.7	0.8	3.5
Conyza canadensis	22	0.70	2.2	1.3	3.5
Aster azureus	17	0.82	1.7	1.5	3.2
Phlox bifida	22	0.41	2.2	0.8	3.0
Rubus allegheniensis	8	0.94	0.8	1.8	2.6
Coreopsis palmata	14	0.61	1.4	1.1	2.5
Helianthemum sp.	17	0.43	1.7	0.8	2.5
Tephrosia virginiana	10	0.80	1.0	1.5	2.5
Artemisia campestris	8	0.79	0.8	1.5	2.3
Aster linariifolius	5	0.98	0.5	1.8	2.3
Helianthus occidentalis	6	0.89	0.6	1.7	2.3
Panicum oligosanthes	17	0.29	1.7	0.5	2.2
Ceanothus americanus	4	0.91	0.4	1.7	2.1
Solidago nemoralis	13	0.41	1.3	0.8	2.1
Cyperus filiculmis	18	0.09	1.8	0.2	2.0
Lithospermum caroliniense	13	0.29	1.3	0.6	1.9
Antennaria plantaginifolia	6	0.61	0.6	1.1	1.7
Parthenium integrifolium	7	0.55	0.7	1.0	1.7
Prunus serotina	10	0.30	1.0	0.6	1.6
Rudbeckia hirta	8	0.34	0.8	0.6	1.4
Andropogon gerardii	5	0.39	0.5	0.7	1.2
Fragaria virginiana	7	0.28	0.7	0.5	1.2
Lactuca canadensis	10	0.10	1.0	0.2	1.2
Aster ericoides	7	0.16	0.7	0.3	1.0
Ambrosia artemisiifolia	3	0.31	0.3	0.6	0.9
Ambrosia psilostachya	6	0.18	0.6	0.3	0.9
Koeleria pyramidata	8	0.07	0.8	0.1	0.9
Leptoloma cognatum	8	0.04	0.8	0.1	0.9
Salix humilis	3	0.33	0.3	0.6	0.9
Sisyrinchium albidum	5	0.22	0.5	0.4	0.9
Solanum carolinense	7	0.11	0.7	0.2	0.9
Euthamia gymnospermoides	5	0.15	0.5	0.3	0.8

Physalis virginiana	4	0.19	0.4	0.4	0.8
Stipa spartea	7	0.04	0.7	0.1	0.8
Viola sagittata	6	0.11	0.6	0.2	0.8
Lupinus perennis	4	0.19	0.4	0.3	0.7
Quercus alba	5	0.13	0.5	0.2	0.7
Tradescantia ohiensis	6	0.08	0.6	0.1	0.7
Galium pilosum	5	0.05	0.5	0.1	0.6
Lespedeza capitata	5	0.08	0.5	0.1	0.6
Liatris aspera	5	0.08	0.5	0.1	0.6
Maianthemum stellatum	4	0.10	0.4	0.2	0.6
Scutellaria leonardii	5	0.03	0.5	—	0.5
Solidago gigantea	2	0.18	0.2	0.3	0.5
Tridens flavus	2	0.18	0.2	0.3	0.5
Triplasis purpurea	2	0.16	0.2	0.3	0.5
Amorpha canescens	3	0.07	0.3	0.1	0.4
Amphicarpaea bracteata	3	0.04	0.3	0.1	0.4
Commelina erecta	4	0.02	0.4	—	0.4
**Dacucus carota*	3	0.04	0.3	0.1	0.4
Gnaphalium obtusifolium	3	0.04	0.3	0.1	0.4
Lespedeza hirta	3	0.07	0.3	0.1	0.4
Viola pedata	3	0.07	0.3	0.1	0.4
Asclepias verticillata	3	0.02	0.3	—	0.3
Oenothera biennis	2	0.06	0.2	0.1	0.3
Solidago speciosa	2	0.06	0.2	0.1	0.3
Sporobolus cryptandrus	2	0.04	0.2	0.1	0.3
Aster pilosus	1	0.03	0.1	0.1	0.2
Baptisia lactea	1	0.03	0.1	0.1	0.2
Carex muhlenbergii	2	0.01	0.2	—	0.2
Eragrostis spectabilis	1	0.03	0.1	0.1	0.2
Rubus occidentalis	1	0.03	0.1	0.1	0.2
**Rumex acetosella*	1	0.03	0.1	0.1	0.2
Vitis riparia	1	0.03	0.1	0.1	0.2
Anemone cylindrica	1	0.01	0.1	—	0.1
Cassia fasciculata	1	0.01	0.1	—	0.1
Erigeron strigosus	1	0.01	0.1	—	0.1
Hieracium gronovii	1	0.01	0.1	—	0.1
Oxalis stricta	1	0.01	0.1	—	0.1
Polygala polygama	1	0.01	0.1	—	0.1
Polygonatum biflorum	1	0.01	0.1	—	0.1
Totals		53.56	100.0	100.0	200.0
Average bare ground and litter		51.70			

Sweet Fern Savanna

Table 10. Frequency (%), average cover, relative frequency, relative cover, and importance values (IV) of the ground layer species encountered at Sweet Fern (Site # 5) at the Pembroke Savanas, Kankakee County, Illinois. (* = exotic species)

Species	Frequency %	Average Cover	Relative Frequency	Relative Cover	I.V.
Schizachyrium scoparium	82	10.16	8.0	16.7	24.7
Carex pensylvanica	95	3.61	9.3	5.9	15.2
Euphorbia corollata	68	2.7	6.7	4.4	11.1
Rosa carolina	50	3.39	4.9	5.6	10.5
Rubus allegheniensis	27	3.90	2.6	6.4	9.0
Quercus velutina	36	2.59	3.5	4.3	7.8
Tephrosia virginiana	17	3.18	1.6	5.2	6.8
Cassia fasciculata	44	1.26	4.3	2.1	6.4
**Poa pratensis*	46	0.58	4.5	1.0	5.5
Sorghastrum nutans	26	1.45	2.5	2.4	4.9
Rhus copallina	15	1.77	1.5	2.9	4.4
Rubus flagellaris	13	1.91	1.3	3.1	4.4
Euthamia gymnospermoides	21	1.32	2.0	2.2	4.2
Andropogon gerardii	11	1.85	1.1	3.0	4.1
Helianthemum sp.	21	0.99	2.0	1.6	3.6
Solidago nemoralis	23	0.88	2.2	1.4	3.6
Helianthus divaricatus	12	1.44	1.2	2.3	3.5
Panicum oligosanthes	25	0.60	2.4	1.0	3.4
Phlox bifida	22	0.80	2.1	1.3	3.4
Stipa spartea	22	0.78	2.1	1.3	3.4
Ceanothus americanus	5	1.68	0.5	2.8	3.3
Sporobolus clandestinus	12	1.20	1.2	2.0	3.2
Conyza canadensis	23	0.56	2.2	0.9	3.1
Lespedeza capitata	24	0.42	2.3	0.7	3.0
Panicum virgatum	16	0.86	1.6	1.4	3.0
Koeleria pyramidata	24	0.35	2.3	0.6	2.9
Fragaria virginiana	7	1.14	0.7	1.9	2.6
Asclepias verticillata	15	0.64	1.5	1.0	2.5
Helianthus mollis	11	0.88	1.1	1.4	2.5
Panicum villosissimum	18	0.46	1.7	0.8	2.5
Aster ericoides	8	0.75	0.8	1.2	2.0
Cassia nictitans	14	0.37	1.4	0.6	2.0
Potentilla simplex	8	0.46	0.8	0.7	1.5
Viola sagittata	12	0.21	1.2	0.3	1.5
Amorpha canescens	7	0.45	0.7	0.7	1.4
Aster azureus	7	0.45	0.7	0.7	1.4
Coreopsis palmata	6	0.40	0.6	0.7	1.3
Cyperus filiculmis	12	0.09	1.2	0.1	1.3
Artemisia campestris	7	0.28	0.7	0.5	1.2
Salix humilis	4	0.46	0.4	0.7	1.1
**Achillea millefolium*	6	0.23	0.6	0.4	1.0
Quercus alba	6	0.25	0.6	0.4	1.0
Lactuca canadensis	7	0.09	0.7	0.1	0.8
Aristida purpurascens	6	0.08	0.6	0.1	0.7
Calamovilfa longifolia	2	0.30	0.2	0.5	0.7
Hieracium gronovii	5	0.10	0.4	0.2	0.7

Physalis virginiana	5	0.13	0.5	0.2	0.7
Rubus hispidus	2	0.30	0.2	0.5	0.7
Antennaria neglecta	3	0.21	0.3	0.3	0.6
Viola pedata	3	0.19	0.3	0.3	0.6
Amphicarpaea bracteata	2	0.18	0.2	0.3	0.5
Chenopodium desiccatum	4	0.07	0.4	0.1	0.5
Eragrostis spectabilis	2	0.18	0.2	0.3	0.5
Gnaphalium obtusifolium	4	0.07	0.4	0.1	0.5
Lithospermum caroliniense	2	0.18	0.2	0.3	0.5
Maiantheumu racemosum	2	0.16	0.2	0.3	0.5
Leptoloma cognatum	3	0.09	0.3	0.1	0.4
Maianthemum stellatum	3	0.09	0.3	0.1	0.4
Tradescantia ohiensis	4	0.02	0.4	—	0.4
Ambrosia artemisiifolia	2	0.06	0.2	0.1	0.3
Anemone cylindrica	2	0.04	0.2	0.1	0.3
Antennaria plantaginifolia	2	0.04	0.2	0.1	0.3
Comandra umbellata	3	0.02	0.3	—	0.3
Monarda punctata	1	0.15	0.1	0.2	0.3
Polygonatum biflorum	2	0.06	0.2	0.1	0.3
**Rumex acetosella*	2	0.06	0.2	0.1	0.3
Scutellaria leonardii	3	0.02	0.3	—	0.3
Veronicastrum virginicum	2	0.06	0.2	0.1	0.3
Apocynum androsaemifolium	1	0.03	0.1	0.1	0.2
Carex bicknellii	2	0.01	0.2	—	0.2
Hieracium longipilum	1	0.03	0.1	0.1	0.2
Hieracium scabrum	1	0.03	0.1	0.1	0.2
Lechea villosa	1	0.03	0.1	0.1	0.2
Oenothera rhombipetala	1	0.03	0.1	0.1	0.2
Physostegia virginiana	1	0.03	0.1	0.1	0.2
Prunus serotina	1	0.03	0.1	0.1	0.2
Rudbeckia hirta	1	0.03	0.1	0.1	0.2
Aster linariifolius	1	0.01	0.1	—	0.1
Bartonia virginica	1	0.01	0.1	—	0.1
Juncus dudleyi	1	0.01	0.1	—	0.1
Liatris aspera	1	0.01	0.1	—	0.1
Polygala polygama	1	0.01	0.1	—	0.1
Sisyrinchium albidum	1	0.01	0.1	—	0.1
Totals		61.01	100.0	100.0	200.0
Average bare ground and litter		38.98			

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APPENDIX C

2020 DATA

Pembroke Savanna (formerly known as Mt. Fraker)

Frequency, coverage, relative frequency, relative coverage, and importance values (IV) of the ground layer species encountered at Pembroke Savanna at the Kankakee Savannas, Kankakee County, Illinois.

Species	Frequency	Coverage	Relative Frequency (%)	Relative Coverage (%)	IV
Schizachyrium scoparium	55	1388	6.6	18.5	12.6
Carex pensylvanica	33	922	4	12.3	8.2
Asclepias verticillata	70	400	8.4	5.3	6.9
Euphorbia corollata	72	252	8.7	3.4	6.1
Bare ground	34	590	4.1	7.9	6
Rhus glabra	28	479	3.4	6.4	4.9
Dichanthelium oligosanthes	54	238	6.5	3.2	4.9
Tephrosia virginiana	16	568	1.9	7.6	4.8
Viola pedata	28	403	3.4	5.4	4.4
Lespedeza capitata	48	123	5.8	1.6	3.7
Tradescantia ohiensis	47	88	5.7	1.2	3.5
Rubus allegheniensis	23	249	2.8	3.3	3.1
Monarda punctata	25	241	3	3.2	3.1
Koeleria macrantha	34	148	4.1	2	3.1
Lechea mucronata	36	123	4.3	1.6	3
Quercus velutina	17	255	2	3.4	2.7
Ionactis linariifolius	25	134	3	1.8	2.4
Lithospermum croceum	23	91	2.8	1.2	2
Erigeron strigosus	23	64	2.8	0.9	1.9
Polygonatum biflorum	5	190	0.6	2.5	1.6
Chamaecrista fasciculata	22	29	2.6	0.4	1.5
Comandra umbellata	8	72	1	1	1
Polygala polygama	11	40	1.3	0.5	0.9
Solidago nemoralis	10	37	1.2	0.5	0.9
Rhus copallinum	3	100	0.4	1.3	0.9
Rosa carolina	7	56	0.8	0.7	0.8
Aureolaria pedicularia var. ambigens	8	39	1	0.5	0.8

Pseudognaphalium obtusifolium	10	23	1.2	0.3	0.8
Liatris aspera	10	20	1.2	0.3	0.8
Chamaecrista nictitans	7	13	0.8	0.2	0.5
Prunus serotina	4	30	0.5	0.4	0.5
Croton glandulosus var. septentrionalis	4	14	0.5	0.2	0.4
Symphyotrichum ericoides	5	15	0.6	0.2	0.4
Cyperus lupulinus	3	5	0.4	0.1	0.3
Dalea purpurea	3	6	0.4	0.1	0.3
Erigeron canadensis	4	8	0.5	0.1	0.3
Commelina erecta	3	4	0.4	0.1	0.3
Hieracium longipilum	2	6	0.2	0.1	0.2
Amorpha canescens	1	15	0.1	0.2	0.2
Artemisia campestris ssp. caudata	2	8	0.2	0.1	0.2
Oenothera rhombipetala	2	5	0.2	0.1	0.2
Physalis virginiana	1	3	0.1	0	0.1
Ambrosia artemisiifolia	1	1	0.1	0	0.1
Lespedeza virginica	1	2	0.1	0	0.1
Phemeranthus rugospermum	1	2	0.1	0	0.1
Lactuca canadensis	1	3	0.1	0	0.1
Achillea millefolium	1	6	0.1	0.1	0.1

Carl N. Becker Savanna (formerly known as Leesville East)

Frequency, coverage, relative frequency, relative coverage, and importance values (IV) of the ground layer species encountered at Carl N. Becker Savanna at the Kankakee Savannas, Kankakee County, Illinois.

Species	Frequency	Coverage	Relative Frequency (%)	Relative Coverage (%)	IV
Carex pensylvanica	41	638	8.8	18.7	13.8
Bare ground	18	635	3.9	18.6	11.3
Rhus copallinum	30	411	6.4	12	9.2
Schizachyrium scoparium	22	297	4.7	8.7	6.7
Chamaecrista nictitans	39	97	8.4	2.8	5.6
Euphorbia corollata	23	60	4.9	1.8	3.4
Lespedeza capitata	21	72	4.5	2.1	3.3
Quercus velutina	14	91	3	2.7	2.9
Amorpha canescens	14	89	3	2.6	2.8
Rubus allegheniensis	17	63	3.6	1.8	2.7
Rubus flagellaris	16	63	3.4	1.8	2.6
Tradescantia ohiensis	15	33	3.2	1	2.1
Dichanthelium acuminatum	12	47	2.6	1.4	2
Helianthus divaricatus	11	44	2.4	1.3	1.9
Lechea mucronata	11	44	2.4	1.3	1.9
Rosa carolina	10	38	2.1	1.1	1.6
Prunus serotina	9	28	1.9	0.8	1.4
Lithospermum croceum	8	31	1.7	0.9	1.3
Rubus hispidus	5	40	1.1	1.2	1.2
Lespedeza bicolor	5	40	1.1	1.2	1.2
Viola pedata	6	26	1.3	0.8	1.1
Amphicarpaea bracteata	7	23	1.5	0.7	1.1
Solidago nemoralis	7	25	1.5	0.7	1.1
Galium circaezans	6	25	1.3	0.7	1
Dioscorea villosa	5	31	1.1	0.9	1
Cyperus lupulinus	6	19	1.3	0.6	1
Lonicera maackii	3	36	0.6	1.1	0.9
Lactuca canadensis	6	18	1.3	0.5	0.9
Elaeagnus umbellata	1	50	0.2	1.5	0.9
Chamaecrista fasciculata	7	9	1.5	0.3	0.9
Potentilla simplex	4	19	0.9	0.6	0.8
Salix humilis	3	32	0.6	0.9	0.8
Antennaria plantaginifolia	3	23	0.6	0.7	0.7

Tephrosia virginiana	3	23	0.6	0.7	0.7
Asclepias verticillata	5	9	1.1	0.3	0.7
Achillea millefolium	4	13	0.9	0.4	0.7
Monarda punctata	4	11	0.9	0.3	0.6
Commelina erecta	4	6	0.9	0.2	0.6
Koeleria macrantha	4	11	0.9	0.3	0.6
Hieracium scabrum	3	6	0.6	0.2	0.4
Galium obtusum	3	7	0.6	0.2	0.4
Anemone cylindrica	3	8	0.6	0.2	0.4
Sorghastrum nutans	2	15	0.4	0.4	0.4
Desmodium sessilifolium	1	10	0.2	0.3	0.3
Quercus alba	1	15	0.2	0.4	0.3
Rhus glabra	2	8	0.4	0.2	0.3
Toxicodendron radicans	2	7	0.4	0.2	0.3
Ambrosia artemisiifolia	2	5	0.4	0.1	0.3
Ceanothus americanus	1	15	0.2	0.4	0.3
Asclepias amplexicaulis	2	3	0.4	0.1	0.3
Liatris aspera	2	5	0.4	0.1	0.3
Symphyotrichum drummondii	2	5	0.4	0.1	0.3
Erigeron canadensis	2	5	0.4	0.1	0.3
Elaeagnus angustifolia	1	4	0.2	0.1	0.2
Erigeron strigosus	1	4	0.2	0.1	0.2
Sassafras albidum	1	3	0.2	0.1	0.2
Pseudognaphalium obtusifolium	1	2	0.2	0.1	0.2
Bidens bipinnata	1	3	0.2	0.1	0.2
Polygala polygama	1	3	0.2	0.1	0.2
Maianthemum stellatum	1	6	0.2	0.2	0.2
Sporobolus cryptandrus	1	4	0.2	0.1	0.2
Vitis riparia	1	1	0.2	0	0.1

Mskoda Land and Water Reserve (formerly known as Liebert)

Frequency, coverage, relative frequency, relative coverage, and importance values (IV) of the ground layer species encountered at Mskoda Land and Water Reserve at the Kankakee Savannas, Kankakee County, Illinois.

Species	Frequency	Coverage	Relative Frequency (%)	Relative Coverage (%)	IV
Carex pensylvanica	67	1467	8.4	21.5	15
Rhus copallinum	62	1033	7.8	15.1	11.5
Tephrosia virginiana	32	716	4	10.5	7.3
Quercus velutina	45	540	5.7	7.9	6.8
Schizachyrium scoparium	32	348	4	5.1	4.6
Dichanthelium acuminatum	31	349	3.9	5.1	4.5
Rubus allegheniensis	42	254	5.3	3.7	4.5
Polygala polygama	48	178	6	2.6	4.3
Euphorbia corollata	48	124	6	1.8	3.9
Aureolaria pedicularia var. ambigens	20	236	2.5	3.5	3
Bare ground	21	222	2.6	3.3	3
Rosa carolina	31	138	3.9	2	3
Chamaecrista nictitans	26	85	3.3	1.2	2.3
Lechea mucronata	18	60	2.3	0.9	1.6
Koeleria macrantha	15	87	1.9	1.3	1.6
Amorpha canescens	13	100	1.6	1.5	1.6
Ambrosia artemisiifolia	15	60	1.9	0.9	1.4
Solidago nemoralis	18	29	2.3	0.4	1.4
Tradescantia ohiensis	17	36	2.1	0.5	1.3
Rhus glabra	9	105	1.1	1.5	1.3
Erigeron canadensis	15	51	1.9	0.7	1.3
Asclepias verticillata	12	32	1.5	0.5	1
Rubus flagellaris	9	38	1.1	0.6	0.9
Hieracium longipilum	11	25	1.4	0.4	0.9
Prunus serotina	8	44	1	0.6	0.8
Lespedeza virginica	8	43	1	0.6	0.8
Liatris aspera	8	19	1	0.3	0.7
Helianthemum canadense	9	21	1.1	0.3	0.7
Monarda punctata	8	29	1	0.4	0.7
Sorghastrum nutans	7	31	0.9	0.5	0.7
Asclepias syriaca	6	21	0.8	0.3	0.6

Hieracium scabrum	7	18	0.9	0.3	0.6
Pseudognaphalium obtusifolium	6	12	0.8	0.2	0.5
Erigeron strigosus	6	10	0.8	0.1	0.5
Galium obtusum	3	21	0.4	0.3	0.4
Lactuca canadensis	4	16	0.5	0.2	0.4
Andropogon gerardii	3	21	0.4	0.3	0.4
Aristida purpurascens	4	19	0.5	0.3	0.4
Lespedeza capitata	5	9	0.6	0.1	0.4
Asclepias tuberosa	3	12	0.4	0.2	0.3
Viola sagittata	2	12	0.3	0.2	0.3
Silene antirrhina	3	9	0.4	0.1	0.3
Sassafras albidum	2	18	0.3	0.3	0.3
Rumex acetosella	3	6	0.4	0.1	0.3
Lithospermum croceum	2	22	0.3	0.3	0.3
Antennaria plantaginifolia	3	12	0.4	0.2	0.3
Asclepias amplexicaulis	3	8	0.4	0.1	0.3
Maianthemum racemosum	3	8	0.4	0.1	0.3
Dichanthelium oligosanthes	3	7	0.4	0.1	0.3
Symphyotrichum pilosum	2	2	0.3	0	0.2
Achillea millefolium	1	15	0.1	0.2	0.2
Polygonatum biflorum	2	4	0.3	0.1	0.2
Chamaecrista fasciculata	2	8	0.3	0.1	0.2
Cyperus lupulinus	2	7	0.3	0.1	0.2
Symphyotrichum oolentangiense	1	5	0.1	0.1	0.1
Salix humilis	1	3	0.1	0	0.1
Helianthus occidentalis	1	3	0.1	0	0.1
Erigeron annuus	1	1	0.1	0	0.1
Vitis riparia	1	3	0.1	0	0.1
Crotalaria sagittalis	1	5	0.1	0.1	0.1
Viola pedata	1	1	0.1	0	0.1
Robinia pseudoacacia	1	2	0.1	0	0.1
Apocynum cannabinum	1	2	0.1	0	0.1
Helianthus divaricatus	1	1	0.1	0	0.1

Hopkins Park Savanna (formerly known as Bentley/Crawford-Jordan)

Frequency, coverage, relative frequency, relative coverage, and importance values (IV) of the ground layer species encountered at Hopkins Park Savanna at the Kankakee Savannas, Kankakee County, Illinois.

Species	Frequency	Coverage	Relative Frequency (%)	Relative Coverage (%)	IV
Schizachyrium scoparium	41	784	5.6	17.8	11.7
Helianthus divaricatus	56	329	7.7	7.5	7.6
Quercus velutina	41	404	5.6	9.2	7.4
Carex pensylvanica	45	374	6.2	8.5	7.4
Rosa carolina	47	166	6.4	3.8	5.1
Chamaecrista nictitans	44	170	6	3.9	5
Rubus flagellaris	28	181	3.8	4.1	4
Euphorbia corollata	42	75	5.8	1.7	3.8
Rubus allegheniensis	21	202	2.9	4.6	3.8
Rhus copallinum	21	194	2.9	4.4	3.7
Ceanothus americanus	15	114	2.1	2.6	2.4
Tephrosia virginiana	12	109	1.6	2.5	2.1
Maianthemum racemosum	17	83	2.3	1.9	2.1
Potentilla simplex	18	73	2.5	1.7	2.1
Prunus serotina	15	91	2.1	2.1	2.1
Solidago nemoralis	15	57	2.1	1.3	1.7
Phlox bifda	17	50	2.3	1.1	1.7
Symphyotrichum oolentangiense	16	54	2.2	1.2	1.7
Sassafras albidum	12	71	1.6	1.6	1.6
Cyperus lupulinus	13	56	1.8	1.3	1.6
Antennaria plantaginifolia	6	85	0.8	1.9	1.4
Lithospermum croceum	10	46	1.4	1	1.2
Coreopsis palmata	11	34	1.5	0.8	1.2
Tradescantia ohiensis	13	19	1.8	0.4	1.1
Liatris aspera	8	38	1.1	0.9	1
Bare ground	7	30	1	0.7	0.9
Lechea mucronata	8	32	1.1	0.7	0.9
Galium pilosum	7	29	1	0.7	0.9
Lespedeza capitata	7	27	1	0.6	0.8
Pteridium aquilinum var. latiusculum	5	38	0.7	0.9	0.8

Dichanthelium oligosanthes	7	26	1	0.6	0.8
Comandra umbellata	9	15	1.2	0.3	0.8
Rumex acetosella	7	15	1	0.3	0.7
Aureolaria pedicularia var. ambigens	4	30	0.5	0.7	0.6
Parthenium integrifolium	4	33	0.5	0.7	0.6
Lactuca canadensis	5	24	0.7	0.5	0.6
Asclepias verticillata	5	7	0.7	0.2	0.5
Ambrosia artemisiifolia	5	10	0.7	0.2	0.5
Helianthus occidentalis	2	25	0.3	0.6	0.5
Hieracium longipilum	5	13	0.7	0.3	0.5
Anemone cylindrica	5	13	0.7	0.3	0.5
Koeleria macrantha	3	15	0.4	0.3	0.4
Ionactis linariifolius	4	12	0.5	0.3	0.4
Salix humilis	2	18	0.3	0.4	0.4
Lupinus perennis var. occidentalis	2	23	0.3	0.5	0.4
Maianthemum stellatum	3	12	0.4	0.3	0.4
Eupatorium altissimum	4	7	0.5	0.2	0.4
Amorpha canescens	2	14	0.3	0.3	0.3
Lonicera maackii	3	8	0.4	0.2	0.3
Viola pedata	2	10	0.3	0.2	0.3
Chamaecrista fasciculata	3	6	0.4	0.1	0.3
Scutellaria parvula	3	4	0.4	0.1	0.3
Erigeron canadensis	4	4	0.5	0.1	0.3
Vitis riparia	3	8	0.4	0.2	0.3
Artemisia campestris ssp. caudata	2	9	0.3	0.2	0.3
Monarda punctata	2	5	0.3	0.1	0.2
Solanum carolinense	2	6	0.3	0.1	0.2
Symphyotrichum pilosum	2	4	0.3	0.1	0.2
Lepidium virginicum	1	4	0.1	0.1	0.1
Achillea millefolium	1	1	0.1	0	0.1
Helianthemum bicknellii	1	5	0.1	0.1	0.1
Pseudognaphalium obtusifolium	1	2	0.1	0	0.1
Oenothera biennis	1	1	0.1	0	0.1
Erigeron strigosus	1	1	0.1	0	0.1
Baptisia alba var. macrophylla	1	3	0.1	0.1	0.1
Toxicodendron radicans	1	6	0.1	0.1	0.1

Sweet Fern Savanna

Frequency, coverage, relative frequency, relative coverage, and importance values (IV) of the ground layer species encountered at Sweet Fern Savanna at the Kankakee Savannas, Kankakee County, Illinois.

Species	Frequency	Coverage	Relative Frequency (%)	Relative Coverage (%)	IV
Schizachyrium scoparium	44	1014	6.2	19	12.6
Carex pensylvanica	41	587	5.8	11	8.4
Rhus copallinum	39	502	5.5	9.4	7.5
Tephrosia virginiana	24	332	3.4	6.2	4.8
Asclepias verticillata	34	218	4.8	4.1	4.5
Rosa carolina	37	193	5.2	3.6	4.4
Euphorbia corollata	42	121	5.9	2.3	4.1
Bare ground	20	277	2.8	5.2	4
Chamaecrista fasciculata	41	108	5.8	2	3.9
Helianthus divaricatus	25	212	3.5	4	3.8
Dichanthelium oligosanthes	24	107	3.4	2	2.7
Solidago nemoralis	25	103	3.5	1.9	2.7
Rubus allegheniensis	20	122	2.8	2.3	2.6
Phlox bifda	21	111	3	2.1	2.6
Rubus flagellaris	18	118	2.5	2.2	2.4
Rhus glabra	13	141	1.8	2.6	2.2
Lespedeza capitata	18	61	2.5	1.1	1.8
Symphyotrichum ericoides	15	68	2.1	1.3	1.7
Coreopsis palmata	13	85	1.8	1.6	1.7
Aureolaria pedicularia var. ambigens	5	109	0.7	2	1.4
Chamaecrista nictitans	14	27	2	0.5	1.3
Achillea millefolium	10	47	1.4	0.9	1.2
Lechea mucronata	9	46	1.3	0.9	1.1
Dichanthelium acuminatum	8	54	1.1	1	1.1
Helianthus mollis	9	47	1.3	0.9	1.1
Amorpha canescens	7	57	1	1.1	1.1
Artemisia campestris ssp. caudata	7	52	1	1	1
Polygala polygama	8	26	1.1	0.5	0.8
Tradescantia ohiensis	9	13	1.3	0.2	0.8
Liatris aspera	8	28	1.1	0.5	0.8
Quercus velutina	5	50	0.7	0.9	0.8

Maianthemum racemosum	7	23	1	0.4	0.7
Rumex acetosella	7	20	1	0.4	0.7
Hieracium gronovii	7	22	1	0.4	0.7
Erigeron strigosus	8	16	1.1	0.3	0.7
Anemone cylindrica	6	19	0.8	0.4	0.6
Erigeron canadensis	6	17	0.8	0.3	0.6
Lithospermum croceum	5	29	0.7	0.5	0.6
Cyperus lupulinus	6	16	0.8	0.3	0.6
Ambrosia artemisiifolia	6	18	0.8	0.3	0.6
Symphyotrichum oolentangiense	4	20	0.6	0.4	0.5
Koeleria macrantha	5	17	0.7	0.3	0.5
Lepidium virginicum	4	16	0.6	0.3	0.5
Monarda punctata	4	10	0.6	0.2	0.4
Dalea purpurea	2	9	0.3	0.2	0.3
Lactuca canadensis	3	11	0.4	0.2	0.3
Galium circaezans	2	4	0.3	0.1	0.2
Amphicarpaea bracteata	2	4	0.3	0.1	0.2
Desmodium sessilifolium	1	5	0.1	0.1	0.1
Ceanothus americanus	1	5	0.1	0.1	0.1
Pseudognaphalium obtusifolium	1	1	0.1	0	0.1
Sorghastrum nutans	1	2	0.1	0	0.1
Andropogon gerardii	1	5	0.1	0.1	0.1
Viola pedata	1	2	0.1	0	0.1
Chenopodium simplex	1	2	0.1	0	0.1
Bartonia virginica	1	2	0.1	0	0.1
Comandra umbellata	1	3	0.1	0.1	0.1
Scutellaria parvula	1	6	0.1	0.1	0.1
Veronicastrum virginicum	1	5	0.1	0.1	0.1

APPENDIX D

PERMISSION TO REPRINT

Hello Megan,

Jenny, Philip, Sam and I enjoyed talking with you last week and learning about your project. DNR is very interested in studies that assess management impacts to vascular flora, and we look forward to reading your final report. Please share a copy of your completed project with us.

IDNR supports your use and replication of the tables in the report titled, Vascular flora of the Pembroke Savannas, Kankakee County, Illinois. Please cite the source when using the tables. During our conversation, you indicated that your Graduate Committee wanted you to have permission from both IDNR and INHS. On this email chain, I'm including one of the original authors, Paul Marcum, and other INHS contacts. Please feel free to follow up with them on any INHS permissions you may need.

In closing, please feel free to contact Philip Cox, IDNR Plant Ecologist, if IDNR can assist you further. Philip would be happy to review your thesis and offer feedback on the management applications of your results or anything else you may need.

Best wishes to you on your project,
Ann

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Megan,

You are welcome to use our report and tables in your work, with proper citation of course. Just wanted to make sure that our sponsor (IDNR) also approved.

Thanks and good luck with your work,
Paul

Paul B. Marcum
Associate Scientist, Botany
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Bachelor of Science, Forestry, May 2018

Thesis Paper Title:

Effects of Fire on Vegetation of the Black Oak Sand Savannas of Kankakee Sands from 2002-2020

Major Professor: Dr. Charles Ruffner