Timberhill Savanna
Assessment of Landscape Management

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Gerould Wilhelm and Laura Rericha
Conservation Research Institute
375 W First Street
Elmhurst, Illinios 60126

and

Iowa Valley Resource Conservation and Development
300 West Welsh Street
Williamsburg, Iowa 52361

Prepared for the Southern Iowa RC&D, 500 East Tailor, Creston, Iowa 50801

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Introduction

"The predominant features in the landscape of Iowa are prairie and timber; the face of the country is beautiful in the extreme. . . . The southern portion of the territory may be termed the most picturesque, abounding with grassy lawns and verdant vales, interspersed with groves and meandering rivulets." John B. Newhall, 1841

Figure 1: View into thinned and annually burned woods at Timberhill

In 1994, shortly after William and Sibylla Brown, of Leon, Iowa, moved into their home on the tract now known as Timberhill, it became evident to them that the wooded tracts were so obviously shaded as to exclude many of the organisms that they traditionally expected to find in woodlands. Mushroom population and diversity, to Sibylla, seemed anemic, a condition that appeared to her strongly correlated with the levels of shade in the woods.

Influenced in part by a familiarity with some of the better woodlands of Germany, and in part by an uncommon perspicacity with respect to woodland health, the Browns began a program of timber management at the landscape scale. To assist the Browns in this effort was the local district forester, Randy Goerndt, who encouraged them to "maintain the [natural] character" of the woods, inasmuch as the timber was unsuitable for production. He prescribed a thinning program, but forestry policy specifically prohibited burning. In spite of these strictures against burning, Pauline Drobney, of Neal Smith National Wildlife Refuge, advised them that only through burning would they discover the full potential of their land. Of all the advice available, the Brown Family chose this combination


Figure 2: Typical head cut near woodland edge

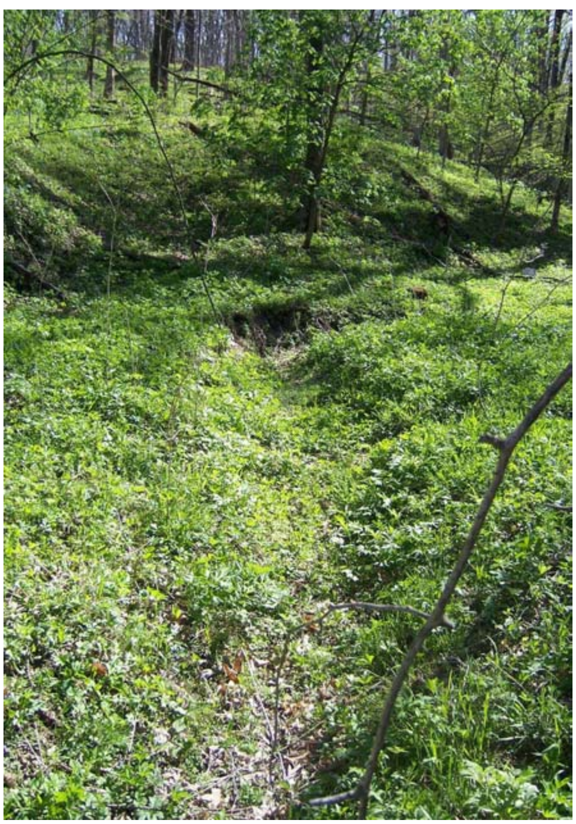
Figure 3: Erosional run at Timberhill, healing

of thinning and burning. It was a bold step inasmuch as nearly all other ecological experts in Iowa deemed such management counter to doctrine.

During the early summer of 2003, when the authors were shown these annually burned and thinned tracts of woodland (Figure 1), the obvious positive impact on biodiversity, fecundity, soil stability, and general physiognomy was profound. Also impressive was that all of the unmanaged ravines were severely down cut and continued to head cut, with each rainfall, at a rate and circumstance completely out of scale with such an ancient landscape (Figure 2). Had this rate of erosion prevailed in the thousands of years prior to settlement, the landscape would be a canyon-ridden badlands today. In the annually burned and thinned ravines it was clear that the ravine bottoms were healing over with native perennial vegetation (Figure 3).

We also knew that the Brown's management approach was in contradiction to prevailing expert opinion all across the Tallgrass Prairie and Forest Border ecoregions, as laid out by The Nature Conservancy. Notwithstanding seminal understandings and impressive management in a few other parts of the country—especially efforts by The Nature Conservancy in Missouri—and in spite of some impressive recent literature (*e.g.* Blackburn and Anderson, 1993; Williams, 2002), contemporary ecological doctrine largely and essentially is one of an apartheid between Man and Nature.

Basically imbedded in Western world view, it holds that "natural" systems operate best when human beings are excluded from them. It is organized around the principle that natural areas "succeed" from fairly unstable seral conditions to conditions characterized by a "climax" of very stable, though sometimes species-poor circumstances. This separateness view is articulated quite well by Botkin (1990):

> "*. . . the common impression about the American West is that, before the arrival of people of European descent, Native Americans had essentially no effect on the land, the wildlife, or the*

ecosystems, except that they harvested trivial amounts that did not affect the 'natural' abundance of plants and animals. But Native Americans had three powerful technologies: fire, the ability to work wood into useful objects, and the bow and arrow. To claim that people with these technologies did not or could not create major changes in natural ecosystems can be taken as Western civilization's ignorance, chauvinism, and old prejudice against primitivism—the noble but dumb savage. There is ample evidence that Native Americans greatly changed the character of the landscape with fire, and that they had major effects on the abundances of some wildlife species through their hunting."

The English linguistics of ecological doctrine also implies that "forests" are large contiguous tracts with well defined edges and vast interiors. This is derived in part from a North European orientation to woodland or, at least to a cultural nostalgia for it. This doctrine is exemplified by the "forest primeval" as a cultural imprint, *a deep dark place beyond the pale where wolves live,* which is illustrated classically in the 1855 painting by Asher Brown Durand, of the Hudson River School of romanticist landscape painters (Figure 4).[1]

Figure 4: *Woodland Glen* by Asher Brown Durand

Such well known images beguile contemporary viewers, who easily forget the context of the painter's style and contemporary artistic influences, as well as the fact that the painting is of a place that already had endured centuries of impacts by European settlers, in this case, of New Hampshire. The view it extolls denies the profound impact of people on their place (MacCleery 1999). The allegorical view is amplified by the fact that ecology, as an empirical discipline, was not formed until the late 19th century, more than two hundred years after European settlement and its impacts on the North American landscape. Ecological questions and answers were, and are still, embedded in this cultural doctrine.

One of the great casualties of this estrangement and disengagement from the North American landscape and its peoples was the cultural memory loss of landscape fire and the purposeful role of people (Pyne 1982). The prevailing view is that fire, if set by Man, is considered a disturbance. Couple this with the fact that the testing of ecological theories in the post World War II era depends

[1] The paradox is that Durand believed that he was painting "an ineffable manifestation of God." In the views of these painters, Man had no role in nature other than to render the "work of God in the visible creation. . . ."

much on the strength of statistical observations and analyses, which requires that all things in nature occur either randomly or at least without the influence of human cultural choices.

Generally, according to doctrine, any human alteration of the landscape is considered "disturbance," irrespective of the motivation, duration, or impact of such "interference". The sustainable management of the landscapes for cultural purposes for thousands of years is not distinguished from commodity resource extraction and harvesting or from corporate-scale tillage and "development". This separateness/disturbance view holds despite numerous papers that have discussed the use of fire by native peoples (*e.g*. Ladd 1991 and McClain and Elzinga 1994).

A concern here is the fact that the entire landscape has been fragmented, with the fragments separated by large tracts of biologically bereft interstitial landscapes, such as those created by commodity crops and other intensive resource extractions. Research on all restoration efforts in such damaged areas across the Midwest informs us that, in serious and carefully monitored programs with at least five years of data, the best *de novo* ecosystem restorations[2] have Mean C_n values of 3.2 ± 0.6 (Wilhelm, unpublished data). No *de novo* attempt has ever achieved the quality represented in the remnant landscape. What currently is unfolding, however, is the extent to which remnants, which have declined since settlement, can have their decline halted and stabilized, or even improved with management that approximates aboriginal cultural practices—with which practices these systems co-evolved.

Woodland edges formed from strong differences in contemporary management and land use exaggerates the spatial effects of fragmentation. Such fragmentation enhancs the vulnerability of bird nests to mammalian predation and Brown-headed Cowbird brood parasitism (Brittingham and Temple, 1983; Lynch and Whitcomb, 1978; Robinson, 1992; Wilcove 1985).

An outgrowth of this phenomenon is the current dogma that states that "woodland" bird diversity is only possible with great tracts of forest interior—as illustrated by 19th century painters—and legitimized by climax theory (Clements 1916). Doctrine asserts that humanly mediated landscape fires must be detrimental to forest integrity and interruptive of natural "climaxes". Such climaxes, as conceived, are only possible if humans stay out of the process.

Couple this view with the observation that certain fire regimes less frequent than annual have been shown to cause at least temporary depressions in insect populations in grassland (Panzer 2002). There are no studies that examine the effects of annual autumnal fire on insects, either on remnant grassland tracts or in timbered tracts.

> *"The Indians know how to fire the prairie with great skill and how to take advantage of a favorable wind. Despite the fact that all around the village the grass was burned, the cornfields nearby were unharmed."* Paul Wilhelm, 1824 (Wilhelm 1973)

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[2] A *de novo* restoration, as we define it here, begins essentially from ground zero, the aboriginal system having collapsed utterly. Restorations in remnant landscapes that have been degraded or neglected are more appropriately described as rehabilitations of relatively intact systems.

"It is also to be observed, that the timber will increase rapidly as soon as the country is sufficiently settled to prevent the fires running annually, and sometimes twice a year over its whole surface. These fires are caused by the great burthen of grass growing spontaneously, ripening, and becoming dry; thereby forming combustibles, when kindled, to keep the fire running. . . ." John Plumbe, Jr. 1839

It is clear that North America's landscape owes much of its Holocene vegetational development and aboriginal biodiversity to choices that human cultures made locally to sustain a diverse array of biological resources for food, shelter, tools, clothing, medicine, and representations of beauty and art.[3] These views most recently have been articulated by Mann (2002). In all of our combined research into presettlement landscape descriptions, there is not a single account of lightening as a source of grassland or timber fire in the Midwest. Nearly all accounts are that the fires were annual, Indian set, and usually autumnal. Dry lightening rarely, if ever, occurs when the prairies are dry, and the annual fires set by people obviated concern over exaggerated fuel build up.

One aspect of natural systems about which most can agree is the importance of managing land to sustain the remaining native biodiversity. Given the fecund and impressive response that was so obviously in display as a result of the thinning and annual burning at Timberhill, we naturally were inspired to pursue an active assessment program to describe, in a disciplined format, the quality and quantity of the biological response.

A proposal, through the Southern Iowa RC&D, was presented to the Environmental Protection Agency to study the impact of annual fire and thinning on the birds, ants, and vegetation of the remnant woodlands at Timberhill. The proposal was received positively, since much unsubstantiated yet vehement rhetoric prevails on the likely negative impacts of woodland burning on our native biodiversity. Another aspect of the study was to provide guidelines with respect to the likelihood that a remnant, but neglected, tract of woods was worth the effort to restore with thinning and burning.

Description of the Presettlement Landscape

"The trees are usually oak and hickory, and the woods are free from under-growth; and no stone is to be found, except siliceous pebbles and granitic boulders. After this, the prairie became much wider; and indeed it cannot be considered of any definite extent; though frequently intersected by strips of woods, of which every stream affords more or less, it may be here considered a part of the Grand Prairie." (Lea, 1836)

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[3]In Medfield, Massachusetts, . . *"and throughout New England, men were chosen each year to 'burn the woods' The old Native-American practice . . . enabled the land to be kept free of trees and provided pasturelands for the cattle. These burnt lands were often called 'herd-walks.' Three men were generally chosen, one from each part of the town-north, south and west. The fires were not allowed to come near buildings and for this reason the areas around the houses themselves soon became surrounded with bushes and small trees. During the Indian attack on Medfield, the Native-Americans would use these bushes and trees as a hiding place before setting fire to the settler houses. In 1654 Peter Adams, John Partridge and Isaac Chenery were chosen to burn the woods. Town records show that this custom was still in practice in 1682."* (Tilden, 1876)

The openness of the woods in Iowa was sustained by fire and by wood harvest by the native people of the area. Such fires usually preceded the autumnal hunt that secured meat for the tribes over the winter. After the fire, the prairie sward greened up during the "Indian Summer," which provided palatable forage for the elk, bison, and deer over that long north-temperate winter. Although contemporary conditions have resulted in lightening fires, there are no such accounts at or before the time of settlement, in part because as soon as the prairie was flammable the Indians burned off the duff of the season, the fire scudding through the fine, elevated fuels of the season; dry lightening was rare during that time. The following reports are from Illinois, but they are typical of those recorded for Iowa and Missouri:

> "*The Indians and hunters annually set fire to the prairies, in order to dislodge the game: the fire spreads with tremendous rapidity, and presents one of the grandest and most terrible spectacles in nature. . . . Nothing can be more melancholy than the aspect of a burnt prairie, presenting a uniform black surface, like a vast plain of charcoal. . . . From whatever cause the prairies at first originated, they are undoubtedly perpetuated by the autumnal fires that have annually swept over them from an era probably long anterior to the earliest records of history.*" (Ellsworth, 1837)

> "*It has already been observed that fire passes annually over the prairies, . . . At this advanced period of the season, the coarse withered grass seemed unpalatable to animals, and the cattle were, generally browsing on parts which had been burned, with a view of affording a succession of nutritious food."* (Shirreff, 1835)

> "*In regard to the origin of prairies, an opinion has been expressed by Mr. Jefferson and others, that all prairies have been produced by the Indian practice of firing the herbage annually, . . .*" (Featherstonhaugh, 1844)

> "*Prairie growth is undergoing a considerable spontaneous change with the progressing settlement and cultivation of the country. Since the prairie grass is no longer burnt off annually, as it used to be by the Indians . . .* " (Engelmann, 1863)

There is no evidence that the Indians waited for two or more years to burn off the landscape within which they lived. To do so would have been an irrational quirk of behavior that would have hindered their effort to hunt through the tall grass of the season. Many of the "women's" plants—medicinal plants, dye plants, tuberous plants, basketry plants, and spirit plants languish during years the prairie does not burn. Such management, however, was not confined to the Midwest. William Wood (1634), in some of the earliest descriptions of New England's forests, wrote:

> *"And whereas it is generally conceived, that the woods grow so thick, that there is no more clear ground than is hewed out by labour of men: it is nothing so: in many places divers acres being clear, so that one may ride a hunting in most places of the land, . . . there is no underwood, saving in swamps and low grounds that are wet . . . for it being the custom of the Indians to burn the woods in November . . ."*

The principle landscape feature that governed the location of timbered tracts in the Tallgrass Prairie and Forest Border ecoregions was not fire, but wetness of the soil. Most of the flatter uplands were too poorly drained, largely because of sustained inputs of soil organic matter (SOM) that originate partly from decomposition of the dead, deeply penetrating fibrous root systems (Brady and Weil 2002) ; such wetness is limiting to the growth of most upland tree species. In the deeper loams along the major streams, the soils also were too wet. Trees were best developed on the drift plain dissections where the vadose waters were deeper below grade, and the abundant ground-cover sedges produced enough soil organic carbon (SOC) in root mass degradation to keep in balance with the oxidation rate, which is important in sustaining good soil tilth.[4]

Moisture needs of landscapes in general, whether remnant or *de novo*, during the growing season, are usually in excess of the amount of rain falling at that time, particularly in continental climates where rainfall is irregular during the growing season. The soil must act as a storehouse that sustains water during both the growing season and dormant period. To make this possible, two requirements must be met: the precipitation that falls must enter the soil in a process called infiltration, and the soil must have a large water-holding capacity that is able to retain much water. Both these requirements require a well aggregated soil (Kohnke and Franzmeier, 1995).

Since the suppression of fire, absence of thinning for heating, cooking, and infrastructure, and dewatering of the landscape, the density of trees has increased substantially and the spread of trees into areas that once were prairie has been extensive. Throughout, grazing has much reduced the productivity of groundcover sedges, which accordingly has inhibited the production of SOM. This loss of SOM relates to an increase in soil bulk density, which leads to the land's progressive inability to absorb rainwater. The result is chronic increases in rainwater runoff and soil erosion. The succession of aerial photographs presented in Plate 4 shows the rapid closure of the woods at Timberhill in the modern era, particularly since the release from grazing after World War II.

Timberhill

The Brown's property at Timberhill, east of Leon, Iowa, along with neighboring properties, includes tracts of land that represent a gradient of management with fire and other restoration approaches. It was proposed that a study of specific sampling plots at Timberhill be established in areas that include no management, those with annual fire only, and those with annual fire with thinning.

[4]Tilth refers to the soil's general suitability to support root growth; characterized by large pore spaces (macropores) for air infiltration and small pores (micropores) for water infiltration, movement, and storage. It is a factor of soil texture, structure, fertility, and organic content and the living soil organisms that make of the rhizosphere ecosystem. Every gardener knows that mulch and soil organic matter are crucial elements in healthy garden soils. Our western views of agriculture and horticulture, however, are born of an experience in mostly annual crops, where manure is stirred back into a turned soil, or mulch is placed regularly around perennials. Aboriginal, remnant landscapes are perennial in character and with soils too complex and integrated with ambient soil layers, water, oxygen, and hypogaeic habitats of a multitude of stratified and interlinked organisms. The only way to sustain a balanced level of soil organic matter in such systems in the North Temperate Zone is for graminoid root systems to pervade the rhizosphere, die constantly, and then partially decomposed in accordance with a system's inherent redox environment. When all this is in balance and stable a soil can be said to be healthy.

The Timberhill woodland is located in Decatur County in the low but dissected Southern Iowa Drift Plain, which is underlain primarily by pre-Illinoisan glacial drift, mantled with various thicknesses of Wisconsinan loess. The drift plain of southern Iowa has been subjected to erosional processes for over 500,000 years, so along the nose slopes and ravines are represented younger substrates than the Sangamonian-aged soils of the more gently rolling uplands (Anderson 1998).

No longer evident are the ice-contact features, such as kames, depressions, glacial lakes, bogs, and fens that are characteristic of the much more recent Wisconsinan till plain seen in the Des Moines area and northward in central Iowa (Prior 1991). Southern Iowa is characterized by a well-drained dissected landscape with a dendritic pattern of drainage relief. It is upon these dissections that timbered landscapes in Decatur County are well-developed, since tree roots of oaks and hickories do not grow well in the wet soils of undrained prairie.

Early descriptions of the Midwestern landscape provide a context within which one can begin to grasp the nature of the Holocene-aged plant communities that post-settlement activities began to dewater, overgraze, and convert to row crop agriculture in the middle 19th century. A description written in the early1820's by the Duke of Wurttemberg depicted the region in the general area situated around Timberhill (Wilhelm 1973):

> *"For a distance of three or four miles our way from the Platte to the larger village of the Otos led continuously through the prairie. From the first village to the second one finds neither a creek nor any other watering place . . .* [5] *On all sides the Indians had set the prairie afire, such fires running over vast stretches with unbelievable speed, causing dense smoke to darken the sky. Especially pretty were the valleys of tall grass . . . where surging flames advanced amid extraordinary crackling.*
>
> *"Since the prairie fire surged all around the great village of the Otos, we were obliged to ride through the fire in the manner of the Indians. This cannot be called a dangerous undertaking, for the burning region is usually not very wide, and one rides against the wind to cross the flames. Mine, a gentle horse accustomed to this kind of thing, galloped through the fire without suffering the least damage. My companions, however, could not all boast of the same good luck. One of the soldiers, a poor rider and mounted on a mule, was thrown into the burning grass, but escaped with only his hair and clothes singed.*
>
> *". . . My preparation for the return journey was soon made. I had reason to be in a hurry, for the autumnal storms, fog, the smoke spread by the burning prairie, and the low water level made the journey down the river not only tedious but dangerous as well. . . . On October 2, I left the Bluffs. . . . For the first six days no hindrance stood in the way of our journey, and since the wind was favorable, about noon the fog, a*

[5] This lack of surface water was not a result of a paucity of rain, but born of the fact that the prairies absorbed nearly or quite all of the water that fell upon them; it remained in the deep, organic-rich topsoil or moved slowly but inexorably to the water table. In areas of outwash along prairie streams, it could emerge or discharge as springs. In the more morainic hinterland, the water table seeped all along the way into the streams. For this reason, such streams sustained a continuous base flow, flooding only during spring rains over snow or frozen ground. Such waters were cool and well-filtered by the time they reached a major stream.

daily occurrence morning and evening, disappeared. The ship's master, a certain Mr. Francis, knew the river intimately. In the vicinity of the Nandawa, however, the burning prairie flashed to the right bank, setting the forest on fire. From then on a mighty and almost impenetrable smoke filled the air, while the fire, extending with giant strides and consuming the timber with a terrible crackling, sprayed sparks for miles around.

"The Indians living to the east also set the dry ground on fire, and since the delta between the Missouri and the Mississippi produced tall grasses, weeds, and vast stretches of forest, both banks of the Missouri soon witnessed this mighty struggle of the elements, which man had loosed for the destruction of organic matter.

"Drifting in the middle of the river and watching the giant Missouri bordered by a mass of fire for miles, we saw a truly horrifying but magnificent sight. Particularly at night, the spectacle defied description and the boldest imagination would seek in vain to depict it in true and vivid colors. The burning of the prairie and forests is practiced more and more [in the autumnal season] by the aborigines and the settlers."

In contemporary terms, Timberhill is included within Sections 5 and 6 of Woodland Township [T68N R24W], east of Leon, Iowa. The land is bordered on the north and east by Brush Creek, which flows into the Weldon River; West Creek is on the west. The dissections are timbered prevailingly by oak and hickory, with some prairie openings.

Other than the original land survey notes, there are no written descriptions of the flora of Woodland Township as it existed prior to European settlement. There are, however, some residents of the area who are descendants of the original European settlers. Interviews with them have yielded family oral history accounts. One such account describes Section 6 "covered with scattered White Oaks and Bur Oaks that spread over a carpet of prairie grasses and flowers," and that "there was no mid-story layer."

When the Browns purchased the land, the bulk of the timbered areas consisted of pole-sized Shingle Oak, White Oak, and Black Oak trees, with a distinct understory layer of Black Cherry, Red Cedar, Prickly Ash, Hop Hornbeam, and Hazelnut. The Browns began thinning the woodlands in 1993, and began an annual burn program in 1995. In order to determine the impact of this management, a sampling program was laid out in 2005 to compare side-by-side treatments of thinned and annually burned, burned only, and unmanaged areas.

Materials and Methods

A suite of survey and sampling protocols was developed to answer the following three questions, as proposed to EPA:

What has been the impact of nearly a decade of annual landscape burning on the vascular plants and ants of the wooded tracts of Timberhill?

Has the opening of the “forest interior” due to burning and thinning diminished the richness and fecundity of the bird population?

From the analysis of an unmanaged system, what is the recovery potential for remnant wooded systems?

While there was no specific requirement to analyze the response of epigaeous fungi, careful observations were made by Sibylla Brown, and their sum and substance is included here as well.

To understand the natural vegetation of the Timberhill area within a presettlement context, the notes of the General Land Survey Office were examined to determine the character of the land at the time of European settlement. Upon this information, a general description of the land use since settlement was gleaned from the recollections of family members who owned the tracts up until the time when purchased by the Brown Family.

Four pairs of sample plots were laid out in the wooded tracts of Timberhill. Each was 25 × 50 meters (0.125 ha). An attempt was made to match as well as possible plots that likely were similar at the time of settlement. Every acre of the property has been variously grazed and logged in the past, so complete analogs were impossible to find. All eight plots, however, are of remnant quality. It was hoped that any differences in the data among them are most reasonably assumed to be related to recent management decisions. Plate 1 depicts the location of each of the four paired sample plots.

Pair 1: Sampled in May
- Plot #1 is a west-facing slope that has been burned and thinned.
- Plot #2 is a west-facing slope that has been unmanaged in the modern era.

Pair 2: Sampled in May
- Plot #3 is prevailingly a north-facing slope that has been burned and thinned.
- Plot #4 is prevailingly a north-facing slope that has been burned, but not thinned.

Pair 3: Sampled in May
- Plot #5 is a north-running nose slope that has been burned and thinned.
- Plot #6 is a north-running nose slope that has been burned, but not thinned.

Pair 4: Sampled in June
- Plot #7 is a north-running nose slope that has been burned and thinned.
- Plot #8 is a north-running nose slope that has been unmanaged in the modern era.

Within these plots, several sampling protocols were implemented that characterized the existing tree demography, recorded incident light levels near the ground, determined floristic composition and quality, assessed the spring bird population, and described the various guilds of ants.

For tree demography, in each plot, every tree 4" in diameter at breast height (DBH) or larger was identified and measured. The total number of trees in each size class was noted and density and basal area values were calculated for each tree species.

For each plot, twenty-five light readings were taken at mid-day, in August, in a stratified random sampling as described below for the vegetation. Foot candles were measured throughout the plot with an Extech Digital Light Meter, Model 401025. In each case, the ambient amount of light in full sun was taken to allow the calculation of the percent of light reaching the groundcover vegetation. The practitioner wore blue denim trousers and a khaki shirt. The meter was held well remote from his own shadow, at breast height. The average number of foot candles near the ground was calculated and represented as a percent of ambient light.

Figure 5: Edge between plots 1 (left) and 2 (right)

The vascular flora of each plot was surveyed and sampled in order to gain perspective on the character and quality of the vegetation. In each plot, a 30-minute meander inventory was conducted in both spring and fall. In spring, each plot was stratified into a grid of twenty-five square sections, within each of which one 0.25-m^2 quadrat was placed in a random manner. An inventory of each quadrat was conducted for 2 minutes, during which each vascular plant species was noted and a Braun-Blanquet cover-abundance coefficient from 1-5 was applied.

For both the inventory and the quadrat sampling, the floristic quality metrics were calculated following the protocol outlined in Wilhelm & Masters (2006), with coefficients of conservatism following the application for Iowa; nomenclature and species concepts approximate those given in Eilers & Roosa (1994).

Figure 6: View from Plot #3 into Plot #4

The plot inventories were analyzed to determine if there was a difference in the blooming phenology among the sample plots. The blooming ranges for each species were derived from Swink and Wilhelm (1994). The mid-blooming date for each species was determined and applied as a coefficient. The number of species in bloom during any given week of the season was determined for each plot.

Birds were recorded through visual and auditory observations; the principal observer (Laura Rericha) used Leica 10×42 roof-prism binoculars for visual examination. The birds represented here are only those heard or seen during the four days of sampling, and do not represent a comprehensive list of all the birds known from the Timberhill complex.

A sampling of the ants was conducted for each of the eight plots with the same stratified random protocol described for the plants, and was conducted concurrently. The first to occur was a 30-minute ant inventory, during which the total number of ant species in the plot was recorded. Both nests and foraging workers were recorded. Immediately thereafter, in each of the same twenty-five, 0.25-m^2 quadrats within which plants were sampled, both workers and nests were recorded. Voucher samples of all of the ants were collected and placed in 95% ethanol. Nomenclature approximates Bolton (1995, 2003); concepts generally follow Buren (1944) and Creighton (1950), but with *Aphaenogaster,* Umphrey's work (1996) is the primary source; Francoeur (in prep.; in press) is the source for *Myrmica;* Francoeur (1973) for *Formica* (*F. fusca* group); and Trager et al. (in press) for *Formica* (*F. pallidefulva* group).

Results and Discussion

The results of the assessment and sampling are presented below. It is abundantly obvious that much has happened to diminish the biodiversity of Timberhill since settlement. Recent management efforts by the Brown Family have had a profound positive impact on the recovery[6] of the land, which clearly is on a renewed trajectory toward sustained health and system integrity.

General Land Survey Notes

The land around Timberhill was surveyed during the 1845 survey season by a survey team headed up by the 33-year old, Caesar Augustus Dodge, who later became a delegate and senator from the state of Iowa. In addition to land survey, the principal interest of the survey teams was to describe the tracts from a perspective that was important to frontier real estate at the time, namely the presence of springs and runs, availability of wood, and quality of the soil from the standpoint of farming.

Mr. Dodge's description of the landscape is shown in Plate 2. Plate 3 is a graphic laid over a 2002 aerial photograph that shows the section lines traversed and described by the survey team. The blue outline includes the property currently owned by the Brown Family. From what we can discern from Mr. Dodge's account, all of the plots were in an area that was at least sparsely timbered at the time of settlement, principally with Black Oak and White Oak, with some hickory and elm.

It is of interest to note that no line trees were recorded along the section lines, even in the timbered areas. Their instructions were to name and measure any tree that fell right along the survey line. Inasmuch as there can be nine or more trees per mile along a section line in today's woodland

[6]Recovery as used here means that there is an observed burgeoning of native biodiversity in associations and assemblages that represent stable circumstances.

remnants (Wilhelm 1991)[7], where 500 to 700 4-inch trees per hectare are not uncommon, it is clear that the timbered districts of Decatur County were characterized by widely scattered, open-grown trees, through which one could perceive a treeless line for mile after mile.

PLOT HISTORY

At the time the Brown Family purchased the bulk of the timbered area, it was composed of pole-sized *Quercus alba* and *Quercus macrocarpa*, with an understory of *Prunus serotina, Juniperus virginiana, Zanthoxylum americanum, Ostrya virginiana,* and *Corylus americana*. Woodland management began with thinning of the woodlands in 1993. Prescribed burning was begun in 1995.

Plots 1, 5, 6, and 7 are on land that William and Sibylla Brown purchased from Doyle Butcher and his sister, Marcia Hickman, in 1985. Their father, Jim, had purchased the land in 1930, before which time two pioneer houses were located on the property. One of the houses burned down before World War I and was never rebuilt. Doyle and his father dismantled the other house in 1935. On the property, they pastured fifteen head of cattle. They also harvested trees for fuel and fence posts. Doyle claimed that this regular use of wood maintained an open character to the woodlands of Timberhill.

About **Plot #1,** Doyle said, remembering in 2004 and looking over the restoration effort, "It was more shaded in here then, There used to be more White Oak here. My dad thinned them a lot for posts. Some of them were pretty good sized . . . He would trim them down, make six-foot cuts . . . We would get three, sometimes four cuts on a tree. Each cut was 6'1". . . . you could make six posts on the first cut."

Before restoration, this plot consisted of scattered White Oaks with large spreading crowns over an understory of *Carya ovata* and *Carya cordiformis*, with *Prunus serotina, Juniperus virginiana, Ostrya virginiana,* and *Zanthoxylum americanum*. In 1997, all trees with stem diameters of 4 inches or less were removed. To prevent resprouting, the stumps of all elm and ironwood were treated with Tordon RTU immediately following the cutting. In 1995, the Browns completed the first prescribed burn on this plot. It has burned every year since then except for 2001.

Plots 2 and 8 are on an adjoining property. These plots have received no management since they were harvested for timber in 1924, during which nearly all of the trees were removed. In 2004, Doyle Butcher noted that "That timber used to be much smaller. It's grown some. It doesn't grow very fast. These trees are ones that have grown up since the 1924 timber harvest. They cut off the good sized trees. I suppose it had been cleared maybe even before that. You know, trees get so big!"

Plot #3 is on property that the Brown Family purchased from Mike Whitfield in 1986. His family had purchased it from the Madison Theater Corporation in 1968. Before that, it was part of a twenty-acre tract owned by Julian Harris, who had used it as a woodlot. Doyle Butcher cannot remember it having been grazed.

[7]This study occurred in an area that had no line trees reported during the general land survey of 1840. In the numerous surveys that we have studied, the greatest number of line trees reported along a section line was three, in Iowa City, just east of the bend of the Iowa River, an area that the surveyor described as "heavy timber."

In 1986, there was a heavy stocking of *Ostrya virginiana*. Since then, it has been thinned twice. The first thinning, in 1993, included the removal of all stems of *Ostrya virginiana* down to 0.5" in diameter. The stumps were treated with Tordon RTU. In 2004, the oak-hickory overstory was thinned to less than 60% stocking. Thinning favored dominant and co-dominant oaks and hickories as crop trees. Trees too large to fell safely were killed by double chainsaw girdles. Mid-story intermediate, suppressed and sapling-sized trees were also thinned to one inch in diameter. It was burned in 1996, 1998, 2001, 2002, 2003, and 2004.

Plot #4 was on land purchased from Wayne Whitfield in 1986, the tract is separated from Plot #3 by a barbed wire fence; which no doubt limited heavy grazing to this side. It has not been manually thinned, but it burned each year Plot #3 was burned, and some degree of thinning has resulted.

On **Plot #5**, according to Doyle Butcher, they ". . . used to haul wood down the ridge that runs through the center of the plot. Then we used to turn and go down on the flat. We had a crossing over [Brush Creek] . . . and we had one where the creeks come together. It looks like that creek has changed since you've been here. There also used to be more trees. . . . We couldn't drive a tractor down here. Its too steep." So they would haul the wood in a wagon pulled by a team of horses. He noted that the ground was "much spongier" now that the restoration had occurred.

The Browns thinned this plot extensively in 1997. To favor development of the White Oak stand, all trees that appeared to compete directly with the large White Oaks were removed. The remaining trees were spaced 16 to 20 feet apart. The west section was a dense thicket of young trees of *Quercus imbricaria*, which were thinned "severely." The *Ostrya virginiana* saplings were cut at ground level and treated with Tordon RTU.

The ridge down which Doyle Butcher used to haul wood was covered with a sward of *Schizachyrium scoparium* when the Browns purchased the property. There were very few forbs in this tract. After thinning and several prescribed burns, the forb population increased notably. It was burned over in 1995, 1997, 1998, 1999, 2002, 2003, and 2004.

Plot #6 has not been thinned, but it was burned in 1995, 1996, 1997, 1998, 1999, 2001, 2002, 2003, and 2004. A horse trail, which early settlers used to drive horse-drawn buggies to Leon, wound through this lot. At that time, Brush Creek[8] was shallow enough through which to drive a horse and buggy. In 1948, the U. S. Army Corps of Engineers channelized and straightened Brush Creek, after which it has cut more deeply each passing year. It is now much too deep to cross on horseback, much less in a wheeled vehicle.

Plot #7 was thinned in 1997, with the same protocol described from Plot #1. The first prescribed burn was completed in 1998, then repeated in 1999, 2002, 2003, and 2004.

[8]Dodge (Plates 2 and 3) noted that Brush Creek, near the time of settlement was about 9 feet wide. At the present time, this creek is considerably wider and deeper.

Tree Demography

The tree demography is a physiognomic representation of the woody structure of each timbered plot. Generally, the larger overstory trees were retained in the thinned plots. The “dog-hair” flush of pole-sized trees, which was released after grazing had ceased, was removed. It is the intense shade caused by the dense development of understory that so strongly diminishes the light energy that can reach the herbaceous ground layer.

Table 1: Demography of canopy trees in management plots at Timberhill (basal area = in^2)

Plot #	1 burned and thinned		2 unmanaged		3 burned and thinned		4 burned only		5 burned and thinned		6 burned only		7 burned and thinned		8 unmanaged	
metric	no.	basal area	no.	basal area	no.	basal area	no.	basal area	no.	basal area	no.	basal area	no.	basal area	no.	basal area
Carya ovata			6	124	10	520	2	25	9	206			6	591	6	297
Carya cordiformis							3	89			4	114			1	50
Fraxinus americana							8	611			13	494				
Juglans nigra							1	64							1	79
Juniperus virginiana									2	127	6	285	1	20		
Ostrya virginiana			4	50			15	210			24	363			7	9503
Prunus serotina									1	28	2	25				
Quercus alba	19	3548	58	3122	19	3464	9	2418	3	1813			20	4176	25	1639
Quercus x bebbiana							1	20								
Quercus imbricaria							10	298	14	348	16	324				
Quercus macrocarpa											1	28			2	83
Quercus rubra	6	656	15	1154	2	454	12	1469					1	227	28	2793
Quercus velutina									2	32	5	771	1	113	9	1245
Tilia americana							6	203			3	362				
Ulmus americana			1	13												
Ulmus rubra			1	13							2	25			2	1023
Totals	**25**	**4204**	**85**	**4475**	**31**	**1009**	**67**	**5406**	**31**	**2555**	**76**	**2791**	**29**	**5126**	**81**	**6382**

All of these trees remain in the system in burned woodlands, but the fire sustains them at a low density. In those plots that were burned, but not thinned, there has been some decline in sapling and pole-sized trees (see Table 2); the impact on light levels is yet only marginal. If such trees had been densely disposed at the time of settlement, they most certainly would have been noted by the general land surveyors, since the presence of wood was of critical interest.

Table 2: Trees per hectare in sampling plots at Timberhill

Thinned and Burned: plots 1, 3, 5, 7	Burned Only: plots 4 and 6	Unmanaged: plots 2 and 8
232 ± 20	572 ± 36	664 ± 16

LIGHT AVAILABILITY

The amount of light energy that reaches the ground in each plot is directly related to management. It is quite clear from Table 3 that the plots that were thinned (1, 3, 5, and 7) have much more light energy than the non-thinned plots at the ground level, with 14.3% ± 6.8 foot candles. The light levels of the unmanaged plots (2 and 8) receive 1.8% ± 0.4 foot candles. Plots 4 and 6 averaged 2.3% ± 0.0 foot candles of available light. The amount of light relates to the amount of graminoid root system tissue that can cycle into SOM, which then relates to soil permeability, stability of soil moisture, and soil temperature. See also Table 8.

Table 3: Light levels (fc) and canopy tree density in management plots at Timberhill

Plot #	1 burned and thinned	2 not managed	3 burned and thinned	4 burned only	5 burned and thinned	6 burned only	7 burned and thinned	8 not managed
Light Levels								
AVG	532	88	886	152	1316	120	636	142
STD.	132	38	959	149	1170	70	737	59
% Ambient	8.4	1.4	13.2	2.3	25.7	2.4	10.0	2.2
Trees per/ha	200	680	248	536	248	608	232	648

It is probable that sustained and balanced levels of SOM are related to the ability of the timbered soils to maintain moisture levels in summer sufficient to sustain active hyphae of soil fungi. Plots that were burned regularly, but not thinned, generally have more light than the unburned plots. Under the canopy of a spreading oak tree, light levels are about 10% of that available in the open at mid-day. This appears to be an optimal level throughout most of the timbered plant communities of the eastern United States, if sustained biodiversity and stability of water and soil are considered positive attributes.

VEGETATION

It is clear from an examination of the General Land Survey records, aerial photography, demography, light analysis, and interviews with previous land owners that various exaggerated land uses have occurred at Timberhill in recent history. These include heavy grazing, extensive timber harvest, system fragmentation, and fire suppression. As can be seen from the floristic data shown in Plate 6 and Appendix B, the *Mean Coefficient of Conservatism* (C_n) levels determined from a 30-minute inventory for each 0.125 ha plot averaged 4.2 ± 0.2, with *Floristic Quality Indices* (I_n) 40 ± 2. The number of native vascular plants per plot averaged 93 ± 9. While all of the land at Timberhill has been impacted negatively since the time of settlement, much of it remains as a natural remnant, with Mean *C* values over 3.8. Prior to settlement, it is probable that for similarly sized areas, the C_n, I_n, and the number of native species was somewhat higher.

The inventory metrics account for most of the remnant floristic diversity and its aggregate quality. It is difficult to determine, however, over a relatively short period of time, the degree to which a diversity of conservative species is well-distributed in the plots. Analysis of quadrats that represent a sampling of what is present, in an array of 0.25 m^2 samples, provides information on system quality at a finer level than can be discerned at larger scales. Consequently, we see system changes sooner in quadrat analyses than in inventory analyses.

The data in Table 4 demonstrate that, from quadrat analysis, the C_n is less variable, and may even be on an upward trajectory in the thinned plots. More definitively, it is clear from the number of native species and I_n values that these metrics are notably higher in the thinned plots. Since these metrics are up and the C_n is stable, it is evident that the thinned systems are providing a habitat for a greater number of conservative species.

Table 4: Quadrat analysis between thinned and not thinned 0.125 ha plots at Timberhill

	Not thinned plots 2,4,6,8	Thinned plots 1,3,5,7
Mean C (C_n)	4.5 ± 0.4	4.6 ± 0.2
Native species	7.5 ± 1.1	10.8 ± 1.0
Floristic Quality Index (I_n)	12.2 ± 0.6	15.1 ± 0.5

Table 5 shows an analysis of all the species that appeared in the entire transect of 25 quadrats. The trend is similar to that shown from the quadrat analysis, but with no evident movement in the C_n metric.

Table 5: Transect analysis between thinned and not thinned 0.125 ha plots at Timberhill

	Not thinned plots 2,4,6,8	Thinned plots 1,3,5,7
Mean C (C_n)	4.3 ± 0.2	4.3 ± 0.2
Native species	48.0 ± 11.8	64.5 ± 11.0
Floristic Quality Index (I_n)	30 ± 1	34 ± 3

General observations over the years with a hand-held photometer have left us with the impression that the bunch sedges of Midwestern timbered lands begin a resurgence in the ground layer as light levels register higher than 5% of ambient. Tables 6 and 7 show that, while perennial forbs may have responded to the fire, the bunch sedges so crucial to soil development and SOM maintenance have not yet responded. Light levels in those tracts still remain well under 5% of ambient.

An analysis of all the species that appeared in the burned versus unmanaged plots (Plate 6) suggests that the more dramatic difference among them is in the C_n, which is notably lower in the burned plots. It is also commonly the case, however, when fire is reintroduced to long unburned remnant woodlands, the species that respond first are non-conservatives, such as *Circaea lutetiana* var. *canadensis* and *Geum canadense.* Given the low number of species per quadrat, such a flush of non-conservative species can have a negative impact on the C_n metric. In addition, we know that plots 4 and 6 have endured more grazing than plots 2 and 8. The latter plot has suffered less grazing and therefore is less likely to have suffered compacted soils.

Table 6: Quadrat analysis of Braun-Blanquet Cover/Abundance Values and Floristic Quality Indices between unburned and burned 0.125 ha plots at Timberhill

Cover/Abundance	Unburned plots 2,8	Burned plots 4,6
Perennial sedges	52 ± 7	58 ± 22
Perennial forbs	118 ± 7.5	172 ± 1.0
Floristic Quality Index (I_n)	12.6 ± 0.4	11.8 ± 0.4

Table 7: Transect analysis Braun-Blanquet Cover/Abundance Values and Floristic Quality Indices between unburned and burned 0.125 ha plots at Timberhill

Cover/Abundance	Unburned plots 2,8	Burned plots 4,6
Perennial sedges	15.2 ± 5.7	16.3 ± 0.8
Perennial forbs	44.8 ± 5.3	51 ± 0.3
Floristic Quality Index (I_n)	29 ± 0.0	30 ± 1.5

At the quadrat level, if the species are present in the system, the C_n generally begins to rise to original levels (Wilhelm and Masters 1994). One of the discouraging aspects of restoration is the fact that increases in C_n are very slow. All that we have seen up to this time, in the history of restoration is that, once a system has been damaged, it is probable that many conservative species have been lost forever (Swink and Wilhelm 1994). Consequently, the C_n metric becomes a dramatic reminder that loss of floristic diversity is a non-trivial event. At the transect level, Table 7 indicates that the same phenomenon is at work, but at a larger scale.

In addition to changes in quantitative metrics between and among sampling plots, significant changes also are occurring that suggest why the qualitative metrics are rising generally in the managed plots. We have observed throughout eastern North America that the preponderance and fecundity of perennial sedges in remnant woodland relate to the floristic diversity of plant taxa conservative to stable soil conditions.

The cover and abundance of shrubs and trees is also a reflection of system structure and substrate diversity. Their presence in the system is important, as it is for all native species, irrespective of physiognomy. If the woody physiognomic elements grow to proportions or dimensions that are out of scale with the system, excessive shade causes catastrophic decline of its aboriginal biodiversity. Generally the decline is gradual above the 5% light threshold, but becomes much more dramatic below this light level.

In the North Temperate Zone, shrubs and trees, as physiognomic entities, sort imperfectly into definitive groups. Shrubs are defined generally as woody plants that branch from the base and have no strong central leader. Tree species are defined generally as woody plants that do not branch profusely from the base and tend to produce a woody axis with a strong central leader. Shrubs proliferated extensively in the thinned and burned plots at Timberhill. The annual fires have sustained them as low sprouts of fast-growing shoots, in effect perennials with woody caudices. Trees remained about the same in terms of cover and abundance, although the oaks and hickories tended to be manifested more as basally sprouted shoots.

Figure 7: Unmanaged groundcover in Plot #2

As can be seen from the data shown in Table 8, all physiognomic groups demonstrated an increase in cover and abundance. What is not apparent from the data, but empirically from general observation, is that all of the surfaces and reliefs are replete with sedge-dominated nearly continuous swards and an interspersion of forb species. Compare figures 7 and 8. Such conditions as seen in Figure 8 are rarely seen in contemporary landscapes today, irrespective of geologic age.

Figure 8: Thinned and annually burned groundcover, Plot #1

One can infer from the proliferation of sedges that soil quality has improved. This suggests that the soil's increased water holding capacity and associated thermal integrity have become more stable. It also suggests that rainwater is progressively more able to infiltrate and be utilized as a resource and less able to wash over the sloped soil surface. Erosion, in addition to head-cutting and soil loss, moves seeds, bulbs, larvae, and various diaspores down hill, away from the habitats to which they are adapted.

In most of our unmanaged woods today, the bulk of the flowering occurs in the spring, either before the leaves have fully expanded on the trees or for only a short time beyond; by fall, there is little or no flowering in the woods. The proliferation of forbs at Timberhill suggests that flower and fruit diversity is on the rise, which means that critical substrate diversity for numerous insects is also on the rise. Not only has forb richness increased, but the phenological distribution of flowering forbs throughout the growing season has greatly increased (Plates 5a and 5b).

One can infer from this that seeds and flowers are more available during the latter half of the season, which provides substrate and sustenance for a more diverse array of insects, birds, and other animals. Species that flower and fruit in the latter part of the growing season, in most areas, are now restricted to the better lit areas that exist along woodland paths and woodland edges. Examples of those that have moved back into the system and proliferate under high light conditions at Timberhill include *Agalinis gattingeri, Aster azureus, Aureolaria grandiflora pulchra, Cirsium altissimum, Eupatorium purpureum, Helianthus divaricatus, Helianthus strumosus, Lespedeza virginica, Liatris squarrosa, Prenanthes alba, Solidago ulmifolia,* and *Vernonia baldwinii.*

Table 8: Transect analysis between thinned and not thinned 0.125 ha plots at Timberhill

Cover/Abundance	Not thinned plots 2,4,6,8	Thinned plots 1,3,5,7
Perennial sedges	55 ± 16.6	101 ± 7.9
Perennial forbs	120.0 ± 65.8	225 ± 35.4
Shrubs	9.3 ± 9.6	26.0 ± 10.1
Trees	23.5 ± 6.3	25. 5 ± 7.4
Percent of available light	2.1 ± 0.4	14.3 ± 6.8

BIRD OBSERVATIONS

Inasmuch as Timberhill was never a contiguously forested ecosystem, the breeding birds that have been recorded from it are denizens of wooded ecosystems in the Midwest, where the woodlands tended to form along bluff and ravines. The birds recorded in the sampling plots have been described traditionally as either nesting in open or closed woodlands. In the literature, the utilization of the words, open or closed, when woodland bird habitat is discussed or described, is an artifact of our contemporary understanding of today's woodlands, which prevailingly are abused second-growth wooded landscapes. These are not necessarily words that should be used to describe the woodlands that once existed in presettlement North America.

With recent management, Timberhill has become progressively more similar to the aboriginal, timbered landscapes described by early settlers and the general land survey notes in this portion of Iowa. This similarity is expressed measurably in the increased forb densities and diversities that provide the necessary foods and infrastructure needed to sustain a complex population of bird species.

Prior to management at Timberhill, the landscape was heavily timbered and with a dense understory layer. Consequently it was without a thick layer of herbaceous groundcover. The low plant diversity of the ground layer and associated woodland stratigraphy evidently was a consequence of a suppression of sunlight levels to below those that are needed to sustain forb and sedge growth.

From the standpoint of bird habitat, Timberhill possesses narrow zones of upland dry-mesic White Oak woodland that transitions on its slopes to a more mesic, discharge-fed timbered plant community. Prairie is well-represented on some of the upland ravine nose-slopes, on south and west facing slopes, as well as in the valley at the toe of these uplands adjacent to West Creek. Historically, the interdigitating woodland, along the dissected bluffs and some of the associated nose-slopes were always within several hundred meters of open prairie. The open interior and narrowness of these woodland systems rendered them effectively edgeless from the standpoint of opportunistic ground-foraging mammalian predators.

Table 9: Birds of Timberhill. Birds marked by an asterisk were likely to be breeding in or immediately about the managed sampling plots at Timberhill. Those shown in bold are neotropical migrants; those shown in *italics* are not native to Decatur County.[9]

American Crow
American Goldfinch*
American Redstart*
American Robin*
American Woodcock
Baltimore Oriole
Barn Swallow
Barred Owl*
Belted Kingfisher
Black & White Warbler
Black-capped Chickadee*
Blackpoll Warbler
Blue Jay*
Blue-gray Gnatcatcher*
Bob White
Brown Thrasher
Brown-headed Cowbird*
Cape May Warbler
Carolina Wren*
Cedar Waxwing*
Chestnut-sided Warbler
Chipping Sparrow*
Common Grackle
Common Nighthawk
Common Yellowthroat
Dickcissel
Downy Woodpecker*
Eastern Towhee
Eastern Bluebird*
Eastern Kingbird
Eastern Phoebe
Eastern Wood Peewee*
Field Sparrow
Grasshopper Sparrow
Gray-cheeked Thrush
Great-crested Flycatcher*
Grey Catbird*
Hairy Woodpecker*
Henslow's Sparrow
House Finch
House Wren*
Indigo Bunting*
Least Flycatcher*
Mourning Dove
Northern Cardinal*
Northern Flicker*
Northern Mockingbird
Northern Parula Warbler
Northern Rough-Winged Swallow
Ovenbird*
Red-bellied Woodpecker*
Red-eyed Vireo*
Red-headed Woodpecker*
Red-winged Blackbird
Rose-breasted Grosbeak*
Ruby-throated Hummingbird*
Scarlet Tanager*
Song Sparrow
Summer Tanager*
Swainson's Thrush
Tennessee Warbler
Tree Swallow*
Tufted Titmouse*
Turkey Vulture
Whipporwill*
White-breasted Nuthatch*
Wild Turkey*
Wood Thrush*
Yellow Warbler
Yellow-billed Cuckoo*
Yellow-breasted Chat*
Yellow-rumped Warbler
Yellow-throated Vireo*

The cessation of fire prevented the persistence of the open woodland physiognomy and consequently an abrupt edge developed between prairie and woodland, which could be described more aptly as a habitat barrier than an ecotone. The plant species that formed the elemental structure and substrate for bird life decreased abruptly in density and diversity. The soil that formed the essential substrate for a thrifty and diverse array of plants, became thin, dispersed, and erodible. This circumstance could no longer support its former plant diversity and densities. Logically, as in all ecosystems, the basic elemental branches or parts that have declined consequently affect other higher level biota, such as the birds.

[9] A neotropical migrant is defined as a species in which part or all of its population breeds north of the Tropic of Cancer and winters south of that line (Rappole 1995). Given that many of these birds breed outside of the tropics, the preservation of North Temperate forests is as important to the sustained existence of these birds as their wintering grounds.

In the annually burned and thinned upland woodland sections of the property, in those areas where widely spaced White Oaks grow, no fewer than 37 bird species were recorded to be of that guild that typically nests in open oak woodland throughout the Midwest. Birds noted here included the Least Flycatcher, Yellow-throated Vireo, Red-bellied Woodpecker, Red-headed Woodpecker, Blue-gray Gnatcatcher, Great-crested Flycatcher, Indigo Bunting, Summer Tanager, Scarlet Tanager, Tufted Titmouse, Eastern Wood Peewee, Black-capped Chickadee, Chipping Sparrow, Indigo Bunting, White-breasted Nuthatch, Downy Woodpecker, Hairy Woodpecker, Northern Flicker, and Red-eyed Vireo.

Several breeding pairs of Chipping Sparrow and Indigo Bunting also were noted. The Indigo Bunting nested in saplings and young sprouts of White Oak and Shingle Oak. Several Eastern Bluebird pairs were observed nesting in the poled, upright Bluebird boxes. Some of the Bluebird boxes also were used by House Wrens. Wood Thrush breeding activity was noted during May and June. One male Wood Thrush was noted incessantly singing at the toe of a wooded slope in a ravine in one of the managed woodland areas south of the study plots. Although the cryptic ground nests of the Whippoorwill were not observed, this species was extremely vociferous in all of the managed wooded sections. The din of singing that emanated from these areas in the crepuscular dusk period was impressive in May and June.

Two male American Redstarts were noted counter-singing from a fixed position in a White Oak, on May 19, 2005, in Plot #1 for several hours. One of the males continued to sing incessantly for two days after that observation, from a fixed perch, on a 15-foot high White Oak branch from this same plot. This behavior was indicative of territorial establishment, but it was inconclusive whether this male attracted a female.

Several Ovenbird males were noted singing during the migration period in the managed mesic wooded ravine area, but singing commonly occurs during this period. It is unknown if these birds would be able to nest successfully in the fragmented woodland landscape of south central Iowa—a region where pastures and farms commonly abut second growth, isolated woodland tracts. The management of Timberhill, however, has created a situation where the Ovenbird may be able to nest successfully because of the increase in nest microsite diversity (see Table 8), which has been created by the thinning and annual implementation of fire.

The leaf litter that the Ovenbird requires in adequate quantities for nesting is not burned completely when fire is annual (see Figure 8). Annual fire promotes a patchlike fire pattern because of the lack of thick and contiguous fuel buildup. Other potential nest microsite structures such as unburned erect dead plant stems still remain intact because a thick layer of combustible leaf litter has not accumulated and cannot provide the combustible potential that otherwise would affect every inch of ground. This is in contrast to an area that is burned sporadically. If burning were to occur every 5-10 years or even every 2-3 years, then there would be a low potential for complex woodland structure to develop. The fuel that is left idle for several years becomes detrimental for this type of ecosystem, because everything in the wake of a fire can be burned or cooked. Annual fire does not have the potential to cook the ground because the fuel is sparser and not contiguous where it does occur. The effects of annual fire have the potential to sustain the necessary structure in these managed woodland systems that can support a diverse compliment of woodland nesting birds.

Adjacent to the managed, upland White Oak woodland, on steep, wooded moist slopes, which have been thinned and annually fired, certain breeding bird species such as, Yellow-billed Cuckoo, Yellow-breasted Chat, Rose-breasted Grosbeak, Gray Catbird, Northern Cardinal, Indigo Bunting, Ruby-throated Hummingbird, and Red-eyed Vireo were recorded. The Yellow-billed Cuckoo and Yellow-breasted Chat were most concentrated, however, near the edge of the managed area, in young pole-sized trees of Hop Hornbeam and Shingle Oak that grew in denser aggregations at the toe of these slopes. This ecotone gently transitions to low, wet prairie along Brush Creek.

All of the birds, except for the White-breasted Nuthatch, Red-throated Vireo, and Downy and Hairy woodpeckers were absent in the unmanaged adjacent timbered areas. In fact, except for the above named birds, the unmanaged woodland tracts supported a depauperate avian fauna. This comparison was striking when compared side by side. Of the 73 bird species recorded from the Timberhill property (this figure includes migratory birds), 51% (37) of that number nested in the managed woodland plots. Only 11% (4) of the breeding birds recorded in the managed woodland plots also nested in the adjacent non-managed woodland plots.

It was evident that in the managed timbered areas, a diverse heterogeneity of bird species was present. The ecological management at Timberhill has facilitated the habitat requirements for a number of different bird species that breed in Midwestern deciduous woodlands. A diversity of microsites have been created by the implementation of fire and managed thinning, which has resulted in marked increases in native plant densities and diversity; consequently, insect density and diversity is enhanced. The management-induced complexity of the managed study plots not only has attracted a diverse array of bird species, but also has altered the typical breeding densities in this type of habitat by enhancing the substrate and foods found on such substrates that birds require in adequate amounts to facilitate breeding and brood-rearing.

The narrowness of the woodland tracts, albeit contiguous, could possibly encumber the breeding success of several "forest" inhabiting bird species that are sensitive to the effects of fragmentation and require large blocks of woodland to sustain breeding success. Some coincidental effects of fragmentation of woodlands include an increased susceptibility to predation by predators that concentrate along woodland edges and by Brown-headed Cowbird brood parasitism. Such breeding birds as, Ovenbird, American Redstart, Yellow-throated Vireo, and Least Flycatcher are sensitive to the effects of fragmentation (Herkert *et al.* 1993) and need large blocks of such habitat to breed successfully.

The managed woodland area at Timberhill is approximately 150 acres. The preservation an appropriate management of adjacent, remnant woodland habitat on neighboring private properties could provide a connective habitat corridor for forest-sensitive bird species and increase the potential size of the woodland breeding habitat for such species. The woodland tracts outside of the Timberhill property limits are very low in quality, however, since these areas currently are unmanaged and therefore limited in bird life and bereft of plant diversity and densities.

Certain nesting bird species were recorded outside of the study plots, at Timberhill, in remnant, annually burned, wet and wet-mesic prairie along West Creek. These birds include the Field Sparrow, Eastern Kingbird, Grasshopper Sparrow, Henslow's Sparrow, Song Sparrow, Red-winged Blackbird, Common Yellowthroat, and Yellow Warbler. Breeding activities of American Robin, Baltimore

Oriole, Chestnut-sided Warbler, Indigo Bunting, Eastern Towhee, Gray Catbird, Northern Mockingbird, and Brown Thrasher were recorded from the ecotone between the upland timber and the prairie, as well as the isolated tree copses in the managed prairie area. Because of regular fire, there are no abrupt edges typical of unburned woodland.

On June 30, 2006, a pair of Northern Parulas, one male and one female, was studied for over an hour in a thick stand of *Quercus imbricaria* that has been burned regularly in recent years and that abuts a high-quality remnant prairie.[10]

The difference in breeding bird diversity was remarkable when the non-managed woodland plots were compared to the managed

Figure 9: Thinned and annually burned landscape replaces edge with contiguous open woodland

[10]The Northern Parula is very rare summer resident in the State of Iowa; there are no positive nest records for the state (Jackson et al. 1996). The pair foraged closely together and communicated by a simple contact call. Their constant propinquity in a defined small area suggests that these birds represented a breeding pair.

woodland plots. There was more than three times the number of breeding bird species in the managed plots versus the non-managed plots. The diversity and number of birds that concentrated in the study plots seem to indicate that the birds selected high-quality managed habitat for breeding. Breeding success, however, was not recorded.

Fire and thinning are the management tools used at Timberhill that have enhanced these areas to attain this fecund condition. A complex vegetative stratigraphy is created when annual fire is implemented. This structural complexity is essential for breeding bird habitat selection. Habitat structural complexity and quality are each a vital criterion that promotes avian species diversity in woodlands in south-central Iowa and elsewhere in the Midwest.

ANT SAMPLING

In the Midwest, there are five identifiable guilds that describe the circumstances under which ants build nests in timbered plant communities: soil, decomposed wood, tree nuts, leaf litter, and bark. The ant guilds at Timberhill, as described below, categorize where ants build their nests. Only a few of the ants at Timberhill are obligate to a particular nesting guild. Most nesting behavior, however, is flexible, if not facultative in accordance with the ant's response to local habitat variation.

Soil: Ants of the soil nesting guild are those species that nest in well-developed organic-rich soil independent of an exterior covering (*i.e.* rock, branch or trunk). Soil nesting ants often live in branching burrows and chambers excavated among well-developed root zones of native forbs, and bunch-forming grasses and sedges. We find that the bunch-forming grass and sedge component is vital for soil-nesting ant species throughout the glaciated Midwest. Table 10 is an account of the soil nesting ants at Timberhill.

Table 10: Guild of soil-nesting ants at Timberhill

	Sample Plots: N = nest, W = workers only, ! = nest found after study							
Ant Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Aphaenogaster N22a	N		N			N	N	
Brachymyrmex depilis	N				N	N	N	
Camponotus subbarbatus	N	W	W		N		W	
Crematogaster lineolata	N							
Formica neogagates							W	
Formica pallidefulva	N				W		W	
Formica pergandei	N							
Formica subsericea					W		W	
Hypoponera opacior			W					
Lasius alienus	N!	W	N	N	N	N	W	W
Lasius claviger					N		W	
Lasius flavus	N				W		N	
Lasius umbratus					N			
Myrmecina americana	W							
Myrmica pinetorum	N				W			
Myrmica sculptilis	N	W	W		W	W	N	W
Myrmica smithana						N		
Myrmica hamulata trullicornis					N			
Paratrechina parvula					N			
Ponera pennsylvanica	N		N		N	N	N	
Prenolepis imparis	N!			N		W		
Stenamma brevicorne						W		
Stenamma schmitti	W							
Temnothorax ambiguus					W			

While grasses compose the principle root mass of most of our prairies, it is sedges of the genus *Carex* that provide this root architecture in woodlands. The great bulk of the sedges in our woodlands are in the *Carex* sections Phaestoglochin, Careyanae, Laxiflorae, Phyllostachyae, and Montanae. It is the stoloniferous and strongly rhizomatous weft-forming sedges of the Montanae that provide microsites for soil nesting ants in our Midwestern woodlands and even some prairies. Other sedges of the listed sections above form strong tussocks with short rhizomes and generally do not form contiguous wefts. The Montanae at Timberhill is represented by *Carex pensylvanica.* Where light levels are high, this guild of ants also nests in bunch grass species such as *Danthonia spicata, Schizachyrium scoparium*, and *Andropogon gerardii*.

Where a well-developed rhizosphere exists, the soil layer has a high water-holding capacity, which is a feature that provides stable moisture and relatively stable temperature that are attractive to ants. In moist woodland, some species in this guild nest in organic-rich soil that has accumulated and developed beneath thick moss mats of *Mnium cuspidatum, M. affine, Taxiphyllum deplanatum, Bryhnia graminicolor, B. novae-angliae, Leucobryum glaucum,* and *Pleurozium schreberi.*

One of the primary requisites to sustain ant inhabitancy and diversity is the presence of a stable context for brood rearing throughout the “growing season,” in a habitat that is not vulnerable to periods of dryness and extreme diurnal temperature changes. In regularly burned remnant woodland landscapes, the soil-nesting ant guild is the most frequently encountered and species-rich category of ants recorded. The diversity of soil-nesting ants is strongly related to increased amounts of sunlight and native plant cover (see Tables 3 and 8, Plate 6). Increased soil moisture and temperature and stability are an abiotic consequence of the implementation of landscape management through burning and thinning.

In degraded remnant habitats, some species in the soil nesting guild nest by default in other media, such as decomposed wood, tree nuts, and leaf litter. The ecological attributes that cause soil nesting ants of high-quality habitats to nest in other nest media in degraded, but remnant, low-lit woodland systems, become clearer when ambient landscape management practices are studied and compared.

Our study at Timberhill and other sites throughout the Midwest indicates that a distinction must be made between *de novo* woodlands and aboriginal woodland remnants. The *de novo* woodlands are those where there are flushes of tree growth that, in the contemporary era, exist along hedgerows, untended portions of pastureland, industrial sites, plantations, and agricultural areas; such sites, whatever their age, do not support most species of the soil nesting guild of ants. The importance of Timberhill is that it is a true remnant woodland that is exceedingly rare in Iowa. It supports a rich array of species not found in the *de novo* woodlands that typify the contemporary Iowa landscape.

Decayed Wood: Ants of the decayed wood guild, listed in Table 11, nest within the decomposed wood of fallen branches, tree trunks, and stumps. The wood varies in softness, which is dependent in part upon age, and can have a relatively high moisture content. This creates a suitable nest medium for certain ant species. Typically, this is an alternate nest medium in degraded woodlands for ants otherwise recorded as soil nesters in highly productive, frequently burned woodland throughout the glaciated Midwest. If decayed wood is the only potential nesting substrate in a woodland that has lost its forb and graminoid groundcover, the soil nesting species are excluded unless they have a secondary adaptation to nest in decayed wood.

Table 11: Guild of ants that nest in decayed wood at Timberhill

	Sample Plots: N = nest, W = workers only							
Ant Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Decayed wood								
Aphaenogaster N22a		N	N	N				N
Aphaenogaster tennesseensis	N						W	W
Camponotus subbarbatus								N
Camponotus chromaiodes								W
Camponotus pennsylvanicus					W		W	W
Lasius alienus				N				W
Myrmecina americana			W		W			
Myrmica punctiventris								N
Ponera pennsylvanica	N							
Tapinoma sessile			N					
Arboreal								
Aphaenogaster mariae	W						W	
Camponotus nearcticus							W	

Often, there can be species partitioning within a decomposed branch or trunk. A good example of partitioning is *Aphaenogaster* N22a, *Myrmica punctiventris,* and *Myrmecina americana*. The former is a species that frequently nests within the soft, decomposed wood of fallen branches and felled trunks in degraded low-lit woodlands. In this study and elsewhere, however, *Aphaenogaster* N22a nests in soil, in the root-zone of *Carex pensylvanica*, particularly when light levels are above 5% of ambient. Nests of *Myrmica punctiventris* typically are found just below loose bark and shallowly within moist, soft wood; it also nests in over 1-year acorns. The small nests of *Myrmecina americana* are often in these same locations, but this latter species, in high-quality remnants throughout the Midwest, nests in soil. Often the nests of each of these species occur within the same decayed wood medium, but each partitioned within a unique microsite, which differs from other sections of the decayed wood substrate by moisture and decomposition differences.

Aphaenogaster tennesseensis, Camponotus pennsylvanicus, C. chromaiodes, are obligate wood-nesting ant species. The nests of these ants occur in decomposed wood of fallen trees and branches in both open and deeply shaded woodland remnants. These nests often extend into the soil, if for example the decomposed wood medium were prostrate upon the ground, or occurs as a stump. This group additionally nests in the decayed heartwood of standing living trees, because whether in deeply shaded or in open woodland, the living root zone of the tree provides moisture and temperature stability. In this circumstance, the nests of these species penetrate down into the soil and are associated with the respiring root-zone core of the tree in which it is nesting. This nest adaptation could be considered a strategy in densely shaded woodland environs that have lost its herbaceous groundcover. We consider this an analog to the nesting strategy employed by soil-nesting ants, in open remnant woodland.

The arboreal subguild is typified by *Aphaenogaster mariae* and *Camponotus nearcticus* at Timberhill, which nest in decomposed wood, usually in the trunk and dead branches in the canopy. The former is a very rare ant throughout its range. It is conservative to high-quality oak woodlands with widely spaced trees and a well-developed herbaceous ground layer. The latter species nests additionally in prairie and in woodland verges in plant galls, fistulose stem interiors, and various other woody substrates.

Acorns and other nuts: This includes, at Timberhill, the fruits or seeds of *Quercus rubra, Q. alba, Juglans nigra, Carya ovata,* and *C. cordiformis*. Ants of the nut nesting guild (Table 12) are those species that nest within the decomposed interior of >1 year old nuts. Nests are concentrated within the nut's interior and surround the shriveled, desiccated endosperm. Occasionally, the nest spreads out to the narrow space between the friable layers of the nut.

The acorn or nut rests upon the soil's upper surface. If the acorn is partially or entirely buried, it may be occupied by soil-nesting ants, such as *Myrmica pinetorum* and *Lasius alienus*. The parameters that seem to influence the ant's choice for a suitable nest site location is correlated to the landscape management practices within each plot. In the less managed plots, where fire and thinning have been infrequent or non-existent, common soil nesting ants, if present at all, were recorded as default nesters in acorns or nut cavities or decomposed wood. Even *Temnothorax curvispinosus*, an ant that regularly nests in the interior of acorns and other tree nuts, has been recorded, in well-lit, regularly fired woodlands in the Midwest, to nest within very short lengths (<2 cm) of narrow-diameter, hollow twigs that are embedded in thick growths of *Carex pensylvanica.*

Table 12: Guild of ants that nest in various nuts at Timberhill

	Sample Plots: N = nest, W = workers only, ! = nest found after study							
Ant species	1	2	3	4	5	6	7	8
Camponotus subbarbatus		N		N				
Crematogaster lineolata			N					
Lasius alienus			N	N	N			
Myrmica pinetorum	N			N				
Myrmica punctiventris						W		N
Myrmica sculptilis				N				
Protomognathus americanus	N!							
Tapinoma sessile	N!		N				W	
Temnothorax curvispinosus	N	W	N	N	N		W	

Table 13: Minor guilds of ants that nest in timbered communities at Timberhill

Ant Species	**Sample Plots: N = nest, W = workers only**							
Guilds	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Bark								
Temnothorax schaumii	W						W	
Leaf Litter								
Aphaenogaster N22a								N
Formica neogagates								N
Tapinoma sessile		N		N	W			W

Leaf Litter: Ants of the leaf litter guild (Table 13) nest within layers of moist, accumulated leaf litter. Their nests occasionally penetrate beneath into the soil. This is the default nest substrate in degraded woodland for ants that otherwise nest in soil, such as *Formica neogagates, Aphaenogaster* N22a*,* and *Tapinoma sessile*. The main portion of the nest, which is centralized around the nursery, is lined with a shallow layer of finely shredded plant parts.

Conservative leaf litter dwelling ant species sampled on the Timberhill property include *Pyramica pilinasis* and *Pyramica dietrichi.* These ants were not recorded during the study inventory, largely because the sampling method did not select for them. Rather, they were collected later in moist leaf litter in 2006, in annually burned woodland, near plots 5 and 6, on a northeast-facing slope. The nests of these species are usually found in other substrates, but are most easily sampled during leaf litter analysis. *Pyramica dietrichi* is known to nest in logs and stumps in the latter stages of decay, while *Pyramica pilinasis* is known to nest in soil, decomposed wood, and under stones. Although these are species that do not nest in leaf litter, they are often collected in this substrate because springtails are a primary food source.

Bark: At Timberhill, this ant nesting guild is typified by *Temnothorax schaumii*, which nests in the thick cork or bark of oak trees and other such trees that possess this essential nest substrate (Table 13).

In Table 14 it is evident that ants are responding positively to the rhizosphere and habitat microsite conditions in the thinned and burned area.

ANTS IN PLOTS 1 AND 2

The differences in ant populations between plots 1 and 2 were remarkable (Table 14). Of all eight sampled plots, Plot #1 has been thinned and annually burned for the longest period of time (12 years) and, as it happens, has the highest nest guild diversity and number of ant species. As a comparison, Plot #2, which is situated immediately adjacent to Plot #1, has never been managed and sustains a very low ant species richness and associated nest guild diversity.

Table 14: Ant sampling in thinned and not thinned 0.125 ha plots at Timberhill

Plots	Species per Inventory				Species per Quadrat				Nests			
	General		30-Minute		Total		Per Quadrat		Total		Per Quadrat	
1 vs 2	18	6	13	6	13	6	2.5	0.9	10	2	1.1	0.2
3 vs 4	10	8	9	5	9	5	2.6	1.1	6	7	0.9	0.5
5 vs 6	18	12	11	7	11	7	2.0	1.4	7	4	0.5	0.3
7 vs 8	18	11	15	7	15	7	2.0	1.5	6	4	0.4	0.2
AVG	**16**	**9.3**	**12**	**6.3**	**12**	**6.3**	**2.3**	**1.2**	**7.3**	**4.3**	**0.7**	**0.3**
STD	**3.5**	**2.4**	**2.2**	**0.9**	**2.2**	**0.9**	**0.3**	**0.2**	**1.6**	**1.8**	**0.3**	**0.1**

The number of ants in Plot #1 was more than twice that of Plot #2 (Table 14). Plot #1 also possessed a relatively high number of conservative ant species, such as *Aphaenogaster mariae, Brachymyrmex depilis, Camponotus subbarbatus, Lasius flavus, Myrmica pinetorum, Myrmica* "*sculptilis*" (name yet unpublished, Francoeur, in prep.), and *Stenamma schmitti.* The differences in the number of nests recorded per quadrat were remarkable. Plot #1 had 1.0 nests per quadrat and Plot #2 had 0.2 nests per quadrat.

Although we are still developing indices of conservatism for ants, after the manner detailed for vascular plants in Swink & Wilhelm (1994), it is evident that the guild of ants present in Plot #1 is higher in faunistic quality than in Plot #2. During the 30-minute inventory in Plot #1, thirteen ant species were recorded, during which, several workers of *Aphaenogaster mariae*, a rare arboreal-nesting ant in eastern North America, were collected, as well as the uncommon soil nesting species *Stenamma schmitti*. Many conservative soil-nesting species were recorded in Plot #1. These include: *Aphaenogaster* N22a, *Brachymyrmex depilis, Camponotus subbarbatus, Lasius alienus, L. flavus, Myrmecina americana, Myrmica pinetorum, M. sculptilis*, and *Ponera pennsylvanica.*

The nests of these species were noted in the well-developed rhizosphere of *Carex pensylvanica* and other vascular plant species within the quadrats. The nests of *Myrmica pinetorum* frequently were noted in the root-zone of Elm-leaved Goldenrod (*Solidago ulmifolia).* *Brachymyrmex depilis* and *Lasius flavus* are indicators of organic-rich soil in productive, dry-mesic woodlands throughout the glaciated Midwest. Their frequent presence as nesting ants in the randomly placed quadrat study of Plot #1 can be regarded indicative of healthy soil conditions.

In the adjacent, unmanaged Plot #2, during the 30-minute inventory, only six ant species were recorded. In this plot, there were no soil nesting ants. *Aphaenogaster* N22a, however, a common soil nesting ant in well-lit woodland, was recorded nesting in decomposed wood, in Plot #2. This species, as will be seen in other degraded plots at Timberhill, nests by default in other substrates when light levels and healthy soil conditions are diminished. This concept can be demonstrated further by the species, *Camponotus subbarbatus*, which nested in soil throughout Plot #1, whereas in Plot #2, it nested within >1 year old acorns of *Quercus rubra*, just beneath thick leaf litter. The soil nesting habit of this species in plot one is rare, since it typically nests in decomposed wood embedded in soil. We have recorded it frequently, however, nesting in soil, exclusive of other nest media, in regularly burned woodland landscapes throughout the glaciated Midwest. This is the facultative response that this ant exhibits within remnants when striking contrasts of habitat quality are measurable in the form of light levels (see Table 3), plant coverage (see Table 8 and Plate 6), and its associated good soil tilth.

Tapinoma sessile was most notable in being the least conservative of all the ants recorded from the Timberhill study, and is an inhabitant elsewhere in the Midwest in various permutations of wetland, prairie, and woodland. This species has been described as opportunistic and is a ubiquitous species that exhibits only the most incidental inhabitancy in remnant systems. It is, however, a species that specializes on available nest substrates within landscapes that differ in gradients of habitat quality.

It is remarkable that *Tapinoma sessile*, in regularly burned woodland tracts throughout the Midwest, nests in soil, whereas in low-quality woodland tracts that are bereft of light and associated plant diversity and coverage, it nests in thick accumulations of leaf litter, >1 year old acorns, decomposed wood in the latter stages of decomposition, and various other prosthetic contexts. In Plot #2, several nests of this species were recorded in thick leaf litter.

Myrmica pinetorum, and *Lasius alienus,* outside of the study period, were recorded nesting in soil in Plot #1. In high-quality remnants, these species also nest in acorns that have at least three-quarters of their diameter buried in soil. This phenomenon was recorded from within Plot #1, even though the bulk of acorns that were available for nesting were superficially resting upon the soil surface and occupied primarily by *Temnothorax curvispinosus*. In theory, the partially buried acorn microsite, attractive to soil nesting ant species in high-quality remnants, is not available in shaded out woodlands with thick leaf litter that prevents acorn/soil contact.

The contrasts between the plots become clearer when measurable differences in habitat quality and the attendant differences in substrate availability yield observable facultative nesting substrate choices that ants exhibit in degraded versus high-quality remnant systems. In the managed plot, there is an assortment of different nest microsites that has developed from the implementation of annual fire (see Tables 10, 11, 12, and 13). One common denominator that has increased the number of nesting ant species is the presence of a well-developed sward of bunch-forming grasses and sedges (see Table 8 and Plate 6). This habitat feature alone stabilizes soil and soil moisture, thus sustaining an isothermic environment that is critical to ectothermic organisms conservative to these conditions.

In degraded remnant woodland systems, a meager number of soil nesting ants will be present. Some of these species nest by default in other substrates such as decomposed wood, tree nuts, and beneath rocks, a completely distinct circumstance from that which is observable in a flourishing, high-quality remnant system. The presence of a thick layer of leaf litter in Plot #2, and an evident lack of a contiguous sward of bunch-forming grasses and sedges to promote soil tilth development has led to a deficiency in ant diversity.

The number of ant species in Plot #1 increased outside of the study limits, since this and other plots were visited many times. *Prenolepis imparis*, an ant that is rarely recorded during the warmer days of summer or late spring was absent during our study, but the soil nests of this species have been collected several times from this plot outside of the study period. *Protomognathus americanus*, a rare dulotic species that is parasitic on the nests of, *Temnothorax curvispinosus*, was recorded from Plot #1, but this collection occurred three months after the study inventory. Although a single ergate of *Myrmica sculptilis* was recorded in Plot #2, it may well have been a foraging visitor from Plot #1, where its nests were not uncommon.

ANTS IN PLOTS 3 AND 4

Unlike the disparities in ant species richness and quality in plots 1 and 2, the ant species richness differences of plots 3 and 4 are not as striking. The reasons become clearer, however, when the types of landscape management implemented within each plot are identified and analyzed with respect to ant species richness. Plots 3 and 4 lie adjacent to each other on north-facing slopes. Plot #3 has been burned annually and thinned, whereas Plot #4 has been burned, but not thinned. During the 30-minute inventory, 9 ant species were recorded from Plot #3, and 5 species from Plot #4.

Similar species richness trends also were recorded at the quadrat level, where there was an average of 2.6 ants per quadrat in Plot #3, and 1.1 ants per quadrat in Plot #4. The quantity of nests recorded from each quadrat also indicates that Plot #3 possesses more nest microsites and consequently more fecundity in comparison with Plot #4. The number of nests per quadrat in Plot #3 (0.9) was almost twice that recorded for Plot #4 (0.5).

The most interesting aspect of the nest guild comparison between plots 3 and 4 is that in Plot #4, ants typical of soil nests in other plots, *Camponotus subbarbatus, Lasius alienus, Myrmica pinetorum,* and *M. sculptilis*, were recorded nesting in acorns. This suggests that because of the lack of well-developed graminoid groundcover (see Plate 6) and low light levels (see Table 3), the ants of Plot #4 nested by default in another nest medium type. This also suggests that the soil conditions in this plot are not conducive to soil nesting ants. The acorn, not just at Timberhill, but throughout the Midwest in woodland remnants, has been recorded to provide an alternative, relatively stable nest medium when soil conditions are no longer sustainable.

Lasius alienus, an ant that nests in soil in mesic sections of >40 year post-agriculture old field, wetland, all wetness permutations of prairie, and remnant woodland throughout the Midwest, was recorded nesting in soil in light-rich Plot #3.[11] In light-diminished Plot #4, this species nested in decomposed wood, and acorn nest substrates, and infrequently in soil. The phenomenon of nesting habitat response to divergent qualitative conditions with respect to various levels of light in each plot is exemplified in deeply shaded Plot #4 (burned only), where *Lasius alienus* nested both inside decomposed wood and the soil beneath it. In light-rich (burned and thinned) Plot #3, however, this species nested prevailingly in soil, but utilized the decayed wood substrate as a nest covering only.

One can view this apparently facultative nesting behavior as a tradeoff nesting strategy that is dependant upon the presence or absence of certain nesting materials and their thermal and moisture properties. The nesting strategy employed by many Midwestern ant species seems to be influenced by opposing habitat quality factors, such as light levels. Here and elsewhere in the Midwest, for example, *Lasius alienus* does not singularly nest beneath just any rock, or inside just any decomposed woody substrate, in just any habitat. Rather, a particular nest site choice is born out of the aggregate of soil, light, water, temperature, nest substrate availability, biotic interactions, and the collective adaptation of the organism's ability to utilize these abiotic and biotic conditions. An organism's collective suite of adaptations to these factors originated from there existence in particular components of the aboriginal landscape; such arrays and options are not available in the prevailing contemporary landscape.

This same concept also applies to those ants that nest in decomposed wood in degraded woodland habitats, but which nest in soil in open woodland. *Aphaenogaster* N22a is a classic example in the region.[12] This species nests in soil, independently of an external nest covering such as decomposed wood or stones, in open, remnant woodland situations that have >5% ambient light. It was recorded nesting in soil in light-rich Plot #3, where measured light levels were 13% of ambient; in Plot #4, light levels were measured at approximately six times less. *Aphaenogaster* N22a also was recorded nesting in decomposed wood in both plots. This suggests that a diversity of potential nest substrates, such as soil, acorns, and decomposed wood, relate to increased ant diversity in managed systems. It is our view that soil, in presettlement woodland habitats was the prevailing aboriginal nest microsite for a diverse cadre of ant species, which in the present day are noted commonly to nest in marginal nest media.

Although *Prenolepis imparis* is common at Timberhill, during the sampling only one occurrence was recorded from Plot #4. Generally, this species is scarce during seasons when ambient air temperatures are very warm. It was recorded in the early morning hours, after a heavy overnight rain, and when the air temperature was near 21^{o} C. Because of *Prenolepis imparis'* evident physiological constraints with increased air temperatures, this species definitely was ill-sampled during our study at Timberhill.

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[11]The reference to a "nest" in Plot 3 in Table 12 is analogous to the situation discussed for *Lasius alienus* for plots 5 and 6.

[12]In northeast Illinois, for example, *Aphaenogaster* N22a nests in soil in dry-mesic sand prairie, in the root-zone of *Carex pensylvanica.*

One worker of *Hypoponera opacior* was collected in leaf litter, in one quadrat of Plot #3. This is the first time that this species was collected at Timberhill. Its distribution in North America is more southerly and Timberhill is near its northern range limit.

ANTS IN PLOTS 5 AND 6

Plots #5 and #6 are both situated on north-facing nose slopes. Plot #5 has been burned and thinned and Plot #6 has been burned only. The plots were compared and analyzed because of their differences in management, side-by-side placement, and exposure similarity. There were evident differences in ant species inhabitancy, however, because prairie (typified by well-developed swards of the bunch grass, *Schizachyrium scoparium*) was well-represented in Plot #5, on the apex of the nose slope. This plot also had twelve times the amount of light than light levels in Plot #6 (see Table 3), which also was moister and had less topographic relief. In retrospect, the two plots pair less well than initially was apparent during plot selection.

In Plot #6, a nest of *Myrmica "smithana"* (name yet unpublished, Francoeur, in prep.) was recorded. This species is rare at Timberhill and uncommon in the Midwest. Elsewhere in the Midwest, it nests in soil in open, remnant woodland and dry-mesic prairie, in the root-zone of *Carex pensylvanica*. A nest of this species was recorded in soil beneath a shallow layer of leaf litter. In unmanaged, degraded remnants, the persistence of conservative ant species suggests that habitat conditions have not yet become completely unfavorable for species such as this, which otherwise are restricted to rare conditions in high-quality remnants.

One ergate of *Stenamma brevicorne* was recorded during the quadrat study in Plot #6, and is the only area at Timberhill where this species was collected. This ant is uncommon in dry-mesic woodland and found occasionally in wet prairie throughout the Midwest. In both systems, this species nests in soil in habitats with high light levels and apparent soil stability.

Uniquely in Plot #6, the nests of several species, such as *Aphaenogaster* N22a, *Lasius alienus,* and *Brachymyrmex depilis*, were recorded in raised, organic-rich soil hummocks beneath dense moss mats of *Mnium cuspidatum* and *Bryhnia graminicolor*. It would appear that this substrate, in this light-depauparate remnant, provides a suitable nest medium for certain soil nesting ants that nest in the combined medium of soil coupled with roots, in open, light-rich woodland remnants. Plot #6 also has a high watertable due to groundwater discharge, and the raised soil-moss hummock may provide a well-drained, but moist nest substrate for the soil nesting guild.

In Plot #5, seven soil nesting ants were recorded, plus six additional potential soil nesters. The soil nests of *Myrmica hamulata trullicornis*, were recorded in the open prairie areas, in the root-zone of well-developed *Schizachyrium scoparium* tussocks. This ant is rare throughout its range. Several soil nests of *Paratrechina parvula*, an ant of dry prairie, also were recorded from Plot #5. The presence of *Lasius flavus* indicates healthy soil conditions, since it occurs in high-quality, remnant, mesic, and dry-mesic woodland and remnant prairie throughout its range; the presence of a well-developed organic soil layer is an important habitat requisite for this ant.

Lasius flavus also was collected in plots 1 and 7, which were thinned and burned and are very open and light-rich. The relative openness that Plot #5 possesses is a feature that Plot #6 does not have because it is shaded greatly and overgrown with saplings of *Ostrya virginiana.* The presence, however, of several open-grown settlement-aged White Oaks suggests that Plot #6 at one time was much more open. It will be interesting to monitor changes in ant species inhabitancy and richness in Plot #6. In both plots, no ants were recorded in decomposed wood, but an extensive soil nest of *Lasius alienus* was recorded, which extended to two, above-grade, separate White Oak acorns immediately adjacent to the entrance/exit hole of the main nest in soil. This nest condition is not unique to *Lasius alienus.*

The larvae and pupae of a variety of soil nesting ants may be tended by the nest's worker caste in external nest media, such as acorns, when thermal conditions are not optimal for metamorphosis in soil. This strategy is employed by many soil nesting ant species, and is evident if one is careful to ascertain if external nest media, such as logs, acorns, plant galls, etc, are being utilized as ant nurseries only. Such nurseries are utilized by the ants only when brood-rearing takes place.

On the well lit discharge slope of Plot #5, a nest of *Lasius umbratus* was recorded that consisted of a soil mound that surrounded a very decomposed 2-meter-long fallen oak branch. Moisture-loving species, such as *Lasius umbratus* are able to nest in microsites of well-drained, but yet moist wooded environs that can provide and sustain such a substrate. The decomposed wood nucleus also provides a stable, moisture-rich medium in shaded habitats such as these.

ANTS IN PLOTS 7 AND 8

Plot #7 and Plot #8 are both situated on north-facing, gentle nose slopes. Plot #7 has been burned and thinned and Plot #8 is unmanaged. In Plot #7, during the 30-minute inventory 15 ant species were recorded; in Plot #8, only 7 were recorded. The greater than double number of ant species in Plot #7 (Table 3) is not surprising since there was measurably more sunlight and a well-developed herbaceous groundcover is quite apparent (Table 8). One of the more unusual differences between plots 7 and 8, apart from management practices, was the presence in Plot #8 of copious downed trees that supported a disproportionate number of decomposed wood nesting ant species and a complete absence of soil nesting ants.

In Plot #8, one ant, of the decomposed wood nesting guild, was *Camponotus chromaiodes*. This is a rare species in Iowa. A nest was not recorded in this plot, but single workers were noted frequently during the 30-minute and quadrat sampling. A nest of this species, however, was recorded in the annually burned and thinned woodland immediately south of and adjacent to Plot #8 in June, 2006, where a soil mound was built up and around the base of a large-diameter *Carya ovata* stump.

The lack of soil nests in Plot #8 rests heavily on the decreased level of sunlight that is unable to support a well-developed ground flora. In Plot #7, the soil nesting ant guild flourished. Five soil nesting species were recorded, plus an additional six potential soil nesting ants. Soil was not the only nest substrate attractive to ants in Plot #7, however, since species of the arboreal, bark, decomposed wood, and acorn nest guilds also were recorded. Habitat management enhanced potential nest substrates at all scales in Plot #7. The presence of a lush lawn of sedges interspersed with bunch-forming grasses creates a moist circumstance for soil-nesting ants.

It is no surprise that there were no soil nesters in Plot #8. The ground was nearly bare of vegetation, except for an anemic tuft or two of sedge and grass. Ant nests in this plot were noted in decayed wood, leaf litter, and acorns. These nest microsites were the only suitable substrate within which ants might nest. Plot #8, has the potential to support greater abundance and richness of ants, but can only attain this state if landscape management is implemented to let in more light and permit filling-in of the herbaceous ground layer.

Species such as *Formica neogagates*, which nest in thick accumulations of leaf litter and decomposed wood in chronically unburned, degraded woodland systems throughout the Midwest, were recorded nesting in leaf litter in Plot #8. In light-rich, high-quality woodland remnants, this species nests in soil, most commonly in the root-zone of *Carex pensylvanica.*

If the large quantity of felled trees in Plot #8 were not present, then all residual ant quality would be lost. This plot would then compare to unmanaged Plot #2, which had only a paltry number of ants recorded during the 30-minute and quadrat inventories. Plot #8, like Plot #2, has no soil nesting species, which is the nesting guild that has the highest diversity potential in woodland ecosystems within the glaciated Midwest.

ANT SUMMARY

The ant species in the region are conservative to conditions, now quite rare, and their associated properties, which exist more often in remnants and rarely in *de novo* landscapes. Some of these conditions can be measured and analyzed with respect to habitat "quality". This doctrine can further enable one to tease out some of the conservative limiting factors unique to each species and unique to certain habitats whether "*de novo*" or "remnant". In our observations at Timberhill, and throughout the glaciated Midwest, it is apparent that there are four critical elements that must be in place if aboriginal ant diversity is to be restored and sustained.

- The majority of native ant species in the region occur in remnant systems.
- Within remnant landscapes, light intensity at the ground level must be close to 10% of that available in full sun.
- The ground layer must sustain a well-developed herbaceous ground layer, particularly a strong sward of bunch-forming sedges and grasses.
- The native species must be somewhere residual in the system or its immediate purlieus.

At Timber Hill, as in most areas, remnant landscapes have floristic Mean *C* values of 3.8 or higher. Remnant quality is derived from the extent to which the aboriginal context of the area sustains, which is a consequence of the integrity of the original hydrology, geologic substrate and soils, fullness of biodiversity, process regimes, appropriate human cultural choices, or fortuitous benign neglect. While we will not, in this paper present the data in its entirety, it is everywhere apparent throughout the Midwest that in non-remnant systems or *de novo* habitats, there is a guild of non-conservative ant species. In the Timberhill study plots these include: *Formica pallidefulva, Formica subsericea, Prenolepis imparis, Camponotus pennsylvanicus,* and *Tapinoma sessile*. These species also are found in remnant landscapes, but as analogized with the plants, these ants would have coefficients of conservatism that range between zero and three: perhaps 1, 2, 3, 1, and 0, respectively.

Species richness is one metric from which one can ascertain habitat quality (Agosti, et. al. 2000), but the ubiquity of non-conservative species make their presence in a list of ants uninformative insofar as habitat quality. In addition to species richness, however, is the insight that can be obtained from the application of a species quality index for ants, such as is described for vascular plants (Swink and Wilhelm 1994). A coefficient of conservatism (*C*) assigned to each species, represents the degree of confidence that a species occurs in a remnant. The Mean *C* value, or aggregate quality, focuses not upon an individual within a system, but instead on clusters of conservative species, which in fact represent core habitat quality.

It is important to bear in mind that a coefficient of conservatism, as conceived by Swink and Wilhelm, is only incidentally related to rareness or abundance within a system. The crucial operative idea is the confidence one has that a species is likely to live in a remnant. The extent to which a species lives regularly in "made" or "new" ground is the extent to which its *C* value approaches zero. Those species that live prevailingly in remnant habitats have values of 5 or higher. Those that are restricted to high-quality remnants, for which circumstance one has supreme confidence, have a value of 10. Individuals of such species can be quite common in such habitats and even common within their geographic range as long as such conditions are common.

In the remnant landscapes of Timberhill, there is a cohort of species that essentially is found only in remnants in the region. Even in these remnant habitats remnant dependant (Panzer *et al.* 1995) species may be scarce due to the anemic or unhealthy state of these systems. It is those species, which sort along a habitat quality gradient within remnants, that have coefficients of conservatism of 5 or higher. Such examples at Timberhill, with likely coefficients for the Midwest, include, *Aphaenogaster* N22a (7), *A. mariae* (10), *Brachymyrmex depilis* (7), *Lasius flavus* (8), *Camponotus chromaiodes* (8), *C. subbarbatus* (7), *Myrmecina americana* (8), *Myrmica pinetorum* (8), *Myrmica punctiventris* (7), *Myrmica sculptililis* (7), *Myrmica smithana* (9), *Myrmica hamulata trullicornis* (10), *Protomognathus americanus* (10), *Pyramica dietrichi* (10), *P. pilinasis* (10), *Stenamma brevicorne* (10), *S. schmitti* (10), *Temnothorax ambiguus* (8), *T. curvispinosus* (6), and *Temnothorax schaumii* (7).

Our data strongly suggest that in remnant woodland systems, species richness does not increase until light levels exceed 5% of ambient. Even at light levels such as these the presence of a strong sward of bunch-forming sedges and grasses that sustains soil moisture and dampens soil temperature changes is important; it is under these circumstances that the greatest diversity of ants is likely to be recorded. This is especially the case with the soil-nesting guild of ants. Conversely, some ant species of the soil-nesting guild at Timberhill, and throughout the Midwest (unpublished data), are able to nest by default in other substrates when light levels drop below a 5% threshold and the groundcover sward of sedges grasses has collapsed.

Given sufficient diaspore presence, a timbered remnant that has become degraded due to the loss of light and dissipation of the ground layer sedge and grass component, has a high potential when managed with fire to be restored over time to a high-quality context that somewhat resembles its aboriginal condition. Data at Timberhill suggest that the process can be accelerated with appropriate levels of mechanical thinning. Elsewhere, we have recorded that this high-quality context may take longer to achieve in remnants with severely compacted soil that was grazed in the past. A remnant system, however, when restored with management, is replete not only with non-conservative organisms, but more importantly, with a great proportion of conservative species, whose existence and population is limited and sustained by a very narrow suite of ecological variables. These variables are operative in the form of certain thresholds such as light and soil moisture, and sustained cultural input, most important of which is fire.

Just as with vascular plants, ants are indicators of system health. This phenomenon is demonstrated throughout the Midwest and at Timberhill. *Myrmica sculptilis,* for example, is a species conservative to remnant woodland. If the remnant becomes degraded and critical resources such as light levels and soil quality are diminished, this species can sustain in alternate nesting substrates, such as acorns and decomposed wood. In light-rich woodland remnants with over 5% ambient light, it nests in soil, usually in the root-zone of *Carex pensylvanica.* This is just one example of the substrate spectrum that may be exploited facultatively by ants in remnants when functional thresholds of habitat quality, measurable in the form of plant coverage and diversity, and percentage of ambient light are analyzed. Knowledge of the life history of the species is important, because without this perspective it is very difficult to ascertain the habitat quality with simple species lists alone.

In the Midwest, another species with facultative nesting behavior in different habitats, whether open or closed, is *Lasius umbratus.* This species creates large soil mounds in wet and wet-mesic prairies, and sedge meadows. If environmental conditions allow, this species nests in wet, shallow soils hydrated by discharge, beneath rocks that lie on impermeable surfaces, such as limestone beds, while nearby it may build large mound nests in deep soils of wet prairie fed by discharge. It also nests in decomposed wood, in remnant mesic woodland, especially those on either shaded discharge slopes or in openings in remnant dry-mesic woodland, which have well-developed sedge and bunch-forming grass cover.

Other conservative species, such as *Lasius flavus* and *Brachymyrmex depilis*, in remnant, upland woodlands replete with high levels of light, nest shallowly in organic-rich soil, in the fibrous root-zone of bunch-forming grasses and sedges. Similarly, these species nest in this exact circumstance, in remnant wet, wet-mesic, and the moister end of dry-mesic prairie. The open, light-rich aboriginal woodland and prairie within which these species nest, when critical requirements, such as soil stability and moisture are met, is the conservative facet that this broad suite of habitats exhibits. Here is where the conservatism of a species is manifest, when the identification of a critical resource, if absent or present, causes the species potentially to flourish or languish. This, of course, is not to imply that just because a critical resource is present, the species will be present. It ties back to the initial point made in the summary discussion: if aboriginal ant diversity is to be restored and sustained, the native species must be somewhere residual in the system or its immediate purlieus.

Simple coinage or naming of a habitat is not adequate to explain why a species is present. Species are not necessarily conservative to habitats as described in various plant community classification systems. More importantly, species presence is more reliably discerned from the perspective of the organism, itself, which utilizes critical resources perceptible at a scale not apparent to plant community oriented schools of thought. Several native ants in the Midwest, for example, find congenial habitat in ancient hummocks of *Carex stricta* in sedge meadows, as well as in logs in the latter stages of decomposition in dry upland woods, provided both systems have high remnant quality. Examples in the Midwest include *Camponotus noveboracensis, Lasius alienus, L. pallitarsis*, and *Myrmecina americana.* The sedge hummock is the nesting analog in a fen or wet prairie to the decomposed log in a moist woodland, two otherwise very different habitat types. When the widespread distribution of an ant species is questioned and analyzed, it is critical to take into account the ant's demonstrated ability to exploit similar properties of analogous nest media between habitats.

Summary and Conclusions

The landscape at Timberhill is among the last remnants of prairie and woodland in the Southern Drift Plain in Iowa. It has endured much change since settlement, including high-grade timber harvest, clear cuts, tillage, fire suppression, and grazing. As is evident from Plate 7, Timberhill is embedded in a highly fragmented landscape, much of which is pasture or row crop, with remnant landscapes disposed diffusely across the southern part of the state.[13]

The literature is full of observations concerning the impact of fragmentation on the loss of habitat, gene flow, and population integrity (Debinski, VanNimwegen, and Jakubauskas, 2006). The woodlands at Timberhill comprise a relatively large fragment, inasmuch as it represents a significant remnant of the Iowa natural landscape, albeit degraded. It is important to all North Americans to know and understand how and why this refuge of biodiversity and Midwestern heritage is managed.

Although Wilhelm (1987) appealed for this view as early as the 1980's, the Brown family are the first to implement management at this scale in Iowa, and they did so for non-theoretical reasons.[14] Since our first impression of the landscape and its fecundity in 2003 was one of extreme pleasure, we asked Sibylla Brown to draft an explanation as to what inspired her actions. She wrote:

> *"My interest in mushrooms began when I was a young child living in post-World War II Germany. Food was in short supply . . . [so] I used to accompany my mother on her treks to the alpine foothills to gather wild mushrooms for the table. The Pfifferling (*Cantharellus cibarius*) and Steinpilz (*Boletus edulis*) that we gathered made feast out of our meager rations. However, the wild food foraging ended when my family moved to the U. S. in 1947, and the produce counter at MeToo supermarket replaced the Bavarian countryside. It wasn't long before I forgot how Pfifferling and Steinpilz tasted.*

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[13]The isolation of remnant fragments is one issue. Note that immense areal coverage of the earth now is occupied by monocultures of annual crop plants that only respire and photosynthesize for half the growing season. There is no natural selection for recombinant genes in response to subtle changes in the earth's geologic and climatic changes. For the other half of the growing season, the soils are hot, dry, erodible, and bereft of life. Water that used to go into the ground and nurture living systems, now carries measurable quantities of soil and resource to the streams, lakes, and seas. Such an imbalance in a natural system cannot proceed indefinitely without consequences that are likely to be unbearable to organisms such as ourselves. What can resemble a "green space" corridor at the resolution of an aerial photograph, may be quite empty of life.

[14]Elsewhere, especially in Missouri, such as at Bennett Spring State Park, an annual fire program has been underway since the middle 1980's, and its positive attributes have been well documented by Douglas Ladd of the Missouri Chapter of The Nature Conservancy.

"Those early memories were reborn when my husband and I moved to a wooded acreage in south central Iowa. After we began restoring the degraded oak savanna by thinning and prescribed burns, I found Cantharellus cibarius *and* Boletus edulis *fruiting in the open woodland. But those weren't the only species I found. Each year, as we restored more of the woodland, the species diversity of the mycoflora increased. My interest in fungi expanded beyond mycophagy. I wanted to learn to identify the mushrooms that fruited so abundantly outside my door.*

". . . As my taxonomic skills increased, I was amazed at how many species I collected. Even in the late fall, after a hard frost, I was able to collect ten different species of Hygrophorus. And wherever I collected fungi, I observed an increasing species diversity of forbs."[15]

Sibylla Brown's reasons for managing the woods harkened back far further than the 200 years since we have developed the science known today as *ecology.* Like the native peoples who lived with and depended on the land throughout the Holocene, prior to Henry Chandler Cowles, young Sibylla (Lippisch) Brown, in Bavaria, was participating in a practice that had endured in Europe through the millennia. The richness of the woodlands of that time had brought the Europeans through thick and thin for millennia, provided the woodlands were managed to do so; woodlands in the New World sustained the "first nation" people as well, so long as the peoples managed them to do so.

Had the management of European woodlands caused the diminishment of these and other resources, the people of the towns would long-since have had to look elsewhere. So also would be the case in North America, where it is evident the several great nations disappeared, although for reasons not really known. Even as Sibylla became disengaged from the land and "forgot" the taste of fecundity, so also have the people of the modern era. Our estrangement from place and the contemporary apartheid imposed by western ecological[16] doctrine coincided with the implements of the "industrial revolution:" its steam ships, trains, planes, and mechanized agriculture.

At Timberhill, the data show that the great bulk of diversity and fecundity lies in the annually burned and thinned districts of the property. The areas excluded from consideration and management were clearly languishing and in a condition described more accurately as unstable

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[15]In a collateral study of the same 0.125 ha plots described here, Sibylla Brown recorded that there were 9.3 ± 3.3 species of epigaeous macrofungi in the thinned annually burned plots, as compared with 6.5 ± 1.5 in the plots that were not thinned or burned only. Each plot was and visited between 24 May through 20 July 2006 and again from 16 August through 28 September 2006. The difference in species richness is evident, but less easily quantified was the obvious abundance and frequency of sporophores in all the thinned and burned plots. Species heretofore unrecorded for the state of Iowa included *Arachnion album, Boletus rubroflammeus, B. inedulis, Leccinum luteum, L. rugosiceps, Hygrophorus paludosus,* and *Phylloporus rhodoxanthes. Gastroboletus tubinatus* was unvouchered from this part of the United States until it was found in light-rich Plot #5, in 2005. A number of species are yet to be determined, such as in the poorly known genus, *Cortinarius,*

[16]It is unlikely that Francis Bacon head could have imagined how his inductive reasoning would lead to the contemporary fragmentation of scholarly thought into a plethora of compartmentalized disciplines: ecology, biology, geology, ichthyology, ornithology, with all the -ists. Aristotle most probably would have been quite uncomfortable in the empiricism of our time. E O. Wilson (1998) discusses this phenomenon at length.

and disassembling than by "climax." In an initial floristic survey of the area, in June of 2003, we noted 206 native vascular plant species (Appendix A). Such a number is rarely recorded in a single survey outside of the Indiana Dunes National Lakeshore. By September of 2005, we had added 191 additional vascular plant species.

It was empirically evident that opening the timbered tracts, paradoxically, created a great tract of timber without distinct edges. The intervening prairie noses and the ambient dissections blended into the whole. The overall effect was to link ravines, bluffs and nose slopes to create a more continuous tract of timbered habitat.

The birds at Timberhill were more concentrated in the well lit interiors of these seemingly narrow, albeit high-quality woodland habitats, where they prospered from the relatively luxurient ground layer growth for food, nest material and substrate, and brood rearing. Our observations also suggest that the birds were much less concentrated in the nearby dark, unmanaged areas inasmuch as these areas lacked a diversity of physiognomic strata and other critical resources; in addition, territorial sizes must be larger in such low-resource systems to sustain successful brood rearing.

The number of recorded ant species at Timberhill, including the ambient prairies, is at least 56 (see Appendix C). This richness in species is rare and, except in the highest quality remnants of the glaciated Midwest is rarely recorded. Nests have been recorded for three-quarters of the species collected at Timberhill, and it was clear that their overwhelming preponderance was in the thinned and burned areas.

The impact on the landscape is largely as was described in Wilhelm (1991). When Midwestern timbered tracts close in from fire suppression, light levels tend to drop from about 10% of ambient to about 1%.[17] Given the descriptions of presettlement timbered areas in most of the Midwest, it is probable that most of our woodland species have at least a Holocene-aged physiological adaptation to about 10% of available light. The thinning of pole-sized timber at Timberhill increased the levels of light that reach the ground by about an order of magnitude.

Prior to settlement, the luxuriant growth of prairie grass, in full sun, facilitated a growth of fibrous root system that fostered, in most areas of Iowa and Illinois, a net accumulation of soil organic carbon each growing season. Weaver and Noll (1935) documented the absorption capabilities of prairies and their unique relationship of water, vegetation, and soils, during their grassland studies.

> *"The porosity of . . . moist grassland soil into which the water sinks is impressive. It accounts for the fact that on fully vegetated lands practically no erosion occurs except, possibly during storms of unusual violence, and even then erosion is seldom serious."*

In the glaciated districts, the flat to gently rolling prairie uplands generally were too wet to sustain the growth of most trees (Samson 1921). In Illinois and eastern Iowa, the wetness of the

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[17] As one moves from full sun to just beneath the canopy of a spreading oak tree, light levels drop by an order of magnitude. In the shade of pole-sized copses and thickets, light levels scarcely exceed 1% of ambient.

prairie was a limiting factor in the distribution of trees. Trees tended to develop along bluffs and nose slope along streams, above the cone of depression that formed where the lateral flow of prairie surface ground waters descended toward the inverts of the dissections. In such areas, the soils were much more oxidized. Each year, the reduced light levels under the trees allowed about as much of the active fraction of SOM (Brady and Weil 2002) formation as was oxidized, so the topsoil horizon soon stabilized and did not accumulate.

The timbered system appears to have operated at about 10% of available light energy. As with the prairies, when the dried foliar material of the season burned off in the fall, there was an optimum production of photosynthetic surface developed in the following season. When this photosynthetic capacity is notably diminished by intense and chronic shade or by over grazing, the system's energy levels become insufficient to sustain the requisite production and replacement of active SOM.[18]

As SOM oxidizes, the clay and silt particles come closer together and the bulk density of the soil increases. The hydric discontinuity between the surface leaf litter and the mineral soil beneath becomes progressively unable to connect the surface water, oxygen, and nutrients to the life zone below. The "humus layer," or more importantly, the colloidal fraction of SOM, becomes diminished. A simple layer of leaf mold and desiccated plant parts lying atop the mineralized soil layer beneath it becomes little more than an insulating layer. Consequently, rain water cannot infiltrate and be incorporated into the system; oxygen is less available and ion exchange is obstructed.

As water accumulates over the surface and combines into rivulets, surface resources such a diaspores, seeds, larvae, nutrients, and soil itself are eroded from their aboriginal location and transported to remote districts. The biota cannot endure in the new habitat; abiotic elements are too much in abundance and too much in a state of flux. A system that once was biologically diverse and much interwoven with the mineral elements begins to disassemble, both biologically and geologically.

This process can occur in prairie if grazing is too heavy for too long a period of time, but the impact in timbered lands is dramatic. Timbered areas had little topsoil to begin with and commonly were associated with slopes of 3-4:1, which exaggerates the erosional issues.

Annual fire in the system is related to energy availability as well. If annually burned, the proliferation of year-old, not yet woody seedlings is much controlled. In addition, the fire stimulates a luxuriant growth of graminoid photosynthetic surface, which optimizes the production of root mass. Rainfall interception and infiltration is maintained and levels are sustained accordingly. As in the prairie, night air can condense on the bunch sedges and grasses and small but steady inflows of moisture to the system can buffer the effects of extended periods without rain.

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[18]For grassland systems in full sun, Johnson and Matchett (2001) note that root production is much diminished by grazing and correlate this diminishment to availability of nitrogen. They note also that annual burning, in their study in Kansas, enhanced the production of root system. In tallgrass prairie, periods of fire suppression can diminish root production to the levels seen in "light grazing."

Soil that sustains its moisture is also a system in which diurnal temperature changes are diminished. The strong development of green blades on native bunch sedges can enhance greatly the amount of water that enters the soil each night, even during extended periods of rainlessness (Went 1955). It would appear that the balanced consilience of light, fire, and water render a salubrious habitat for the species of plants and animals adapted to the timbered tracts of the later Holocene.

Sibylla Brown's observations on the proliferation of fungi are in accord with the idea that, with management, the return of fire and light to the ground layer has restored steady soil temperatures and SOM levels to the point where soil mycchorhizae can be hydrated and sustained in the rhizosphere, even through the summer months. It is probable that the queens of many ant species are better able to sustain their complex social structures and brood relationships in soils that remain relatively stable with regard to soil moisture and temperature. The ants are a perennial entity in those systems that can sustain relatively stable rhizosphere conditions. Although seeds and flowers specifically, were not measured, the diversity of flowers and seeds throughout the growing season is overwhelmingly obvious in the thinned and annually burned areas. Such substrates and food sources are keys to the inhabitancy of a diverse array of birds and in this study, ants.

Samson (1921) viewed prairies from the ecological dogma of his day: he conceived of "climax prairie" as a vegetation optimum, and that fire, an unnatural disturbance killed insects and caused "course herbs" to grow in the otherwise solid stand of *Andropogon gerardii,* the prairie analog to *Acer saccharum* of the "climax forest." At the present time, practitioners who acquiesce to the idea that fire is important in Midwestern ecosystems, and that "coarse herbs" are desirable, frame their understanding in various ways. Some believe that fire should only occur if it is started by some "natural" means, such as lightening. Others believe that fire should only occur in "prairies." A few acknowledge that even woodlands should burn, but remain discomfited by nagging fears about "climax" disruption. Almost all believe that fire should occur in some frequency notably less than annual.

All of these views are belief systems that have emerged from a reliance on traditional opinion, particularly the opinions of those who articulate views that fire is infrequent and only necessary because the target remnants are so fragmented and remote that they are no longer subject to the "patch dynamic" that most certainly operated, at least at some scale, prior to European settlement. The source of traditional opinion, however, is of historical interest.

In the upper Midwest, most of our remnant prairies endured fire suppression for decades prior to the rediscovery in the early 1960's, largely by Ray Schulenberg, Robert Betz, and Peter Schram, that fire was a critical component in the stability and integrity of prairies. They also noted that, since dry lightening was quite rare during the brief periods of time that the landscape will carry a fire, the fires needed to be administered by people.

These three men persisted in their efforts to rehabilitate and restore prairies. It was the late Ray Schulenberg, who having started his restoration effort in 1962, by 1970 already had discovered the efficacy of annual fire in his prairie restoration at the Morton Arboretum. Consequently, his restoration soon became and remains the most species rich effort in the Midwest—297 native species sustaining in the system by 1990. By 1995, a transect of twenty 0.25

m^2 quadrats through “the Acre,” registered a Mean C_n of 6.3 ± 0.3 and mean FQI of 21.3 ± 1.9. Such values, otherwise, have only been recorded from high-quality remnant prairies.

Even as we write this in 2007, some ecologists and biologists are of the belief that prairie should not burn at all, but most biologists and ecologists have acquiesced to the idea that prairies should burn once in a while, maybe as often as every three years. Panzer (2002) suggests that at least some groups of insects are seen to have suffered population diminishment after a burn in a prairie that has not burned for a year or more. He has observed, however, after another year or so of fire suppression, the population can recover to its pre-burn levels. After many years of studying several different permutations of fire frequency, none of them annual and autumnal, Dr. Panzer is of the opinion that, although fire is damaging to insects, the insects need the prairie, and that prairie needs to burn. His data have been interpreted to suggest that fire is necessary but should not be used too frequently.

While progress certainly has been made in our understanding of the management needs of prairie, and even its embedded timbered areas, the gradation of opinion varies along a scale of frequent but not annual fire, to no fire. This gradient of opinion prevails in spite of the fact that 100% of all presettlement accounts that record the frequency with which Indians burned in Iowa, Illinois, and Missouri, use the term “annual.” All but one account, one near Carlisle, Illinois, record the season as autumn, usually right after the first hard frost, which generally occurred in mid-October. The Carlisle writer was sufficiently impressed by the dilatory event that he commented on it (Blane 1922).

The thinned and annually burned landscape at Timberhill is rivaled in fecundity and beauty only by a few other annually burned systems. The senior author has been shown, by an Ojibwe elder, a large Indian Reservation in southern Ontario, Walpole Island, where the people of the three fires, Potawatomie, Ottawa, and Ojibwe, have been burning the entire island annually for thousands of years. While the author did no transects, he can say that the landscape was Edenic. Most of the listed species of plants and animals of Southern Ontario have health populations at Walpole Island.

Other places visited by the senior author, where fire has been an annual occurrence for decades or longer, are U. S. military reservations. The two 35 km^2 bombing ranges at Fort Bragg, North Carolina are burned annually by the Army; that which does not burn naturally from exploded ordnance originating near the center, is burned off annually by the EOD unit to expose unexploded ordnance. These ranges are as impressive and Edenic as Walpole Island. The McRidge Bombing range is the only location in the world for the St. Francis Satyr, which only occurs in the annually burned sedge meadow ecotones. This site is rich and fecund beyond description. With the exception of *Polypremum procumbens,* the pan-temperate weeds that are so abundant in the adjacent cantonment and interstitial areas are essentially confined to the perimeter roads of the ranges.

The artillery range at Camp McCoy, Wisconsin, which also is burned off annually, is a little smaller than the bombing ranges at Fort Bragg, but just as impressive. The LaCrosse River, which enters the northern verge of the range, lined with Reed Canary Grass, is actually scrubbed of this weed after a few thousand yards of traverse into the range, gathering weeds again only after it reenters the cantonment on the south.

The observations by some biologists that insect populations are depressed after a burn, are logical and explanatory. The derivative inference, however, that annual fire would be worse is not logical. Historically, when the native peoples lit the fire annually the first suitable day after the first hard frost, the fire scudded through the elevated fine fuels of the season, the heat held well above the ground. The wind advanced the flames and left thousands of stubby culms and stems per acre, many "patches," more at a scale as perceived by insects than as perceived by human-scaled thinkers contemplating aerial photographs.

To deprive the system of fire, even for a single year, enables the duff of previous growing seasons to accumulate and to be laid down, interlaced into a thick combustible mat. For an entire season or more, flower and fruit diversity and fecundity have been less available to local insect populations, which must then stabilize at a minimal level. The dried vegetable matter lies within different moisture levels and exposures to oxygen. The eventual fire then is more likely to produce heat that can linger longer and lower; living tissues can cook and parboil.

It would seem that those who hold to a vague fire frequency theory is founded in a western cultural mind set that fears fire, a singular word of German origin. Fire is commonly inimical to our culture's highly structural support system, so the linguistic baggage that is embedded in the word has more influence on our views than actual observation on North America's biota and native cultures.

Virtually every measured index at Timberhill is congenial with other empirical observations and circumstantial evidence with regard to fire, light, water, native biodiversity, and human culture. It is evident, from the literature as well as from the effort at Timberhill, that human cultural choices need also to be in harmony with the system. Simply removing ourselves from the fragmented "natural areas," and confining our impacts to the areas interstitial to the fragments is counterproductive. That human beings now have, and have had for millennia, a role in the landscape is inarguable. Our struggle must be to discover the most congenial relationship between ourselves and the warp and woof of life such that we assure the continuance of both.

Most Useful Survey Metrics

When the Brown Family came to Timberhill, all of the landscape was in the condition described in the unburned and un-thinned plots. The non-managed plots in this study had an average Mean *C* value, obtained from a thirty-minute survey, of 4.3 ± 0.1, while those of the managed plots rendered, even after management, a Mean *C* value of 4.2 ± 0.2. The floristic quality indices at the gross inventory level showed little difference as well, 36 ± 1 for the unmanaged plots, 37 ± 2 for the managed plots.

For the last 30 years of Floristic Quality Assessment, it has been our observation that one of the more stable metrics is the Mean *C* value, which reveals the fundamental quality of a site, even if its general appearance is less than impressive prior to management. It was only at the quadrat and transect level that the metrics showed differences among the plots. We know of very few circumstances in which tilled out fields, of any age, have "succeeded" on their own to produce a Mean C value of 3.5 or a Floristic Quality Index of 35. Once diminished, significant Mean *C* value increases are rarely seen without an intense program of species enhancement.

If one were interested in discovering the fundamental quality of a remnant tract of landscape, the most reliable way to determine it is to conduct a floristic inventory that includes all groups of vascular plants: trees, shrubs, sedges, grasses, forbs, and ferns. Calculate the Mean *C* values for the inventory. If that metric registers in the middle to high three’s or better, it is most surely likely that appropriate management will produce positive and important results. Nearly as indicative is the Floristic Quality Index, which should register in the middle to high 30's or higher.

Ants would be a powerful metric in monitoring woodland development in the years following the implementation of management, but even high-quality remnants, if neglected and beset by intense shade, likely will present no more than 5 species during a casual inventory. In addition, too few people are sufficiently skilled in ant taxonomy to render its application in woodland evaluation useful at this time.

Acknowledgments

No effort of this kind is wholly and completely the work of the listed authors. All throughout, Sibylla and William Brown have been utterly supportive, gracious, and expansive, having extended comforts and assistance beyond measure—all this in the inspiring landscape that their perspicacious stewardship has produced. Christopher Bair, of the Iowa Valley RC&D was involved throughout, from the writing of the grant to the taking of light readings and DBH records. Careful reviews of early versions of the document were rendered by Chris Anchor and Theodore Anchor, for whose suggestions and discussions we are so very grateful.

James Trager reviewed thoughtfully the entire document as well, but provided detailed comments, including hours of phone conversations, most especially on the treatment of the ant data and presentation. Douglas Ladd also reviewed the entire document, but in many ways was there throughout the effort, inasmuch as his management and monitoring in both glaciated and non-glaciated Missouri have been integral to the evolution of our collective understandings over the last quarter century.

We also would like to acknowledge the U. S. Fish and Wildlife Service and the Natural Resources Conservation Service for their contributions.

Literature Cited

Agosti, Donat, Jonathan D. Majer, Leeanne E. Alonso, and Ted R. Schultz. 2000. Ants: standard methods for measuring and monitoring biodiversity. Smithsonian Institution Press, Washington, D. C. 280 pp.

Anderson, Wayne I. 1998. Iowa's geological past: three billion years of change. University of Iowa Press, Iowa City. 424 pp.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience. 33: 31-35

Blackburn, Thomas C. and Kat Anderson. 1993. Before the Wilderness: Environmental Management by Native Americans. Ballena Press, Banning, California.

Blane, William. 1822. A tour in southern Illinois in 1822. In Pictures of Illinois One Hundred Years Ago. Milo Milton Quaife, Editor. The Lakeside Press. Chicago. 1917.

Bolton, Barry. 1995. A new general catalogue of the ants of the world. Harvard University Press, Cambridge, Mass. 504 pp

Bolton, Barry. 2003. Synopsis and classification of Formicidae. Memoirs of the American Entomological Institute, Volume 71, 370 pp

Botkin, Daniel B. 1990. Discordant harmonies: a new ecology for the twenty-first century. Oxford University Press. New York, New York.

Brady, Nyle C. and Ray R. Weil. 2002. The nature and properties of soils. 13th ed. Pentice Hall, Upper Saddle River, New Jersey. pp 960.

Buren, William F. 1944. A list of Iowa ants. Iowa State College Journal of Science 18: 277-312.

Clements, Frederick. 1916. Plant succession: an analysis of the development of vegetation. Carnegie Institute of Washington 242: 1-512.

Creighton, William Steel. 1950. The ants of North America. Harvard College Museum, Cambridge, Mass. 585 pp + 57 plates.

Debinski, D.M., R.E. VanNimwegen, and M.E. Jakubauskas. 2006. Quantifying relationships between bird and butterfly community shifts and environmental change. Ecological Applications 16:380-393.

DeGraff, Richard M. and John H. Rappole. 1995. Neotropical migratory birds. Comstock Publishing Associates, Ithaca and London.

Eilers, Lawrence J., and Dean Roosa. 1994. The vascular plants of Iowa. University of Iowa Press, Iowa City.

Ellsworth, H. L. 1837. Illinois in 1837; a sketch descriptive of the situation, boundaries, face of the country, prominent districts, prairies, rivers, minerals, animals, agricultural productions, public lands, plans of internal improvement, manufactures &c.. of the State of Illinois: also suggestions to emigrants, sketches of the counties, cities, and prinicpal towns in the state; together with a letter on the cultivation of the prairies. Augustus Mitchell & Grigg & Elliot, Philadelphia, Penn.

Engelmann, H. 1863. Remarks upon the causes producing the different characters of vegetation known as prairies, flats and barrens in southern Illinois, with special reference to observations made in Perry and Jackson counties. American Journal of Science and Arts 86 [Second series, 36] (108):384–396.

Featherstonhaugh, G.W. 1844. Excursion through the slave states from Washington on the Potomac to the frontier of Mexico; with sketches of popular manners and geological notices. Harper & Brothers.

Francoeur, André. 1973. Révision taxonomique des espèces néarctiques du groupe fusca, genre *Formica.* Memoirs of the Entomological Society of Quebec. 316 pp.

Francoeur, André. (In prep.). Key to the northeastern species of *Myrmica,* based mainly on ergates; (Formicidae, Hymenoptera).

Francoeur, André. (in press). *Myrmica punctiventris* and *Myrmica crassirugis* species groups in the nearctic region. Memoirs of the American Entomological Institute.

Herkert, James R., Robert E Szafoni, Vernon M. Kleen, and John E. Schwegman. 1993. Habitat establishment, enhancement and management for forest and grassland birds in Illinois. Division of Natural Heritage, Illinois Department of Conservation, Natural Heritage Technical Publication #1, Springfield, Illinois. Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/birds/manbook/index.htm (Version 16JUL97).

Johnson, Loretta C. and John R. Matchett. 2001. Fire and grazing regulate belowground processes in tallgrass prairie. Ecology 82: 3377-3389.

Ladd, Douglas. 1991. Reexamination of the role of fire in Missouri oak woodlands. Proceedings of the Oak Woods Management Workshop. Eastern Illinois University, Charleston: 67-80.

Lea, Albert Miller. 1836. Notes on Wisconsin Territory, particularly with reference to the Iowa District. State Historical Society of Iowa.

Lynch, J. F., and R. F. Whitcomb. 1978. Effects of the insularization of the eastern deciduous forest on avifaunal diversity and turn over. Pages 461-489 in A. Marmelstein, ed., Classification, inventory, and analysis of fish and wildlife habitat. Obs-78/76. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, D.C.

Jackson, Laura Spess, Carol A. Thompson, and James J. Dinsmore. 1996. The Iowa breeding bird atlas. University of Iowa Press, Iowa City.

Kohnke, Helmut and D. P. Franzmeier. 1995. Soil science simplified. Waveland Press, Inc. Long Grove, Illinois. 162 pp.

McClain, William E. and Sherrie L. Elzinga. 1994. The occurrence of prairie and forest fires in Illinois and other Midwestern states, 1679 to 1854. Erigenia 13:79-90.

MacCleery, Doug. 1999. Forest primeval: when is a landscape natural? Forest Landowner. Jan-Feb.: 28-31.

Mann, Charles C. 2002. 1491: New revelations of the Americas before Columbus. Alfred A. Knope, Random House. New York, Toronto.

Newhall, John B. 1841. Sketches of Iowa, or the emigrant's guide. J. H. Colton, New York.

Panzer, Ron. 2002. Compatibility of prescribed burning with the conservation of insects in small, isolated prairie reserves. Conservation Biology 16:1296-1307.

Panzer, Ron, D. Stillwaugh, R. Gnaedinger, and G. Derkovitz. 1995. Prevalence of remnant dependence among the prairie and savanna-inhabiting insects of the Chicago region. Natural Areas Journal 15: 101-116.

Plumbe, John, Jr. 1839. Sketches of Iowa and Wisconsin, taken during a residence of Three Years in those Territories. Chambers, Harris & Knapp, St. Louis.

Prior, Jean C. 1991. Landforms of Iowa. University of Iowa Press. Iowa City.

Pyne, Stephen J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton University Press.

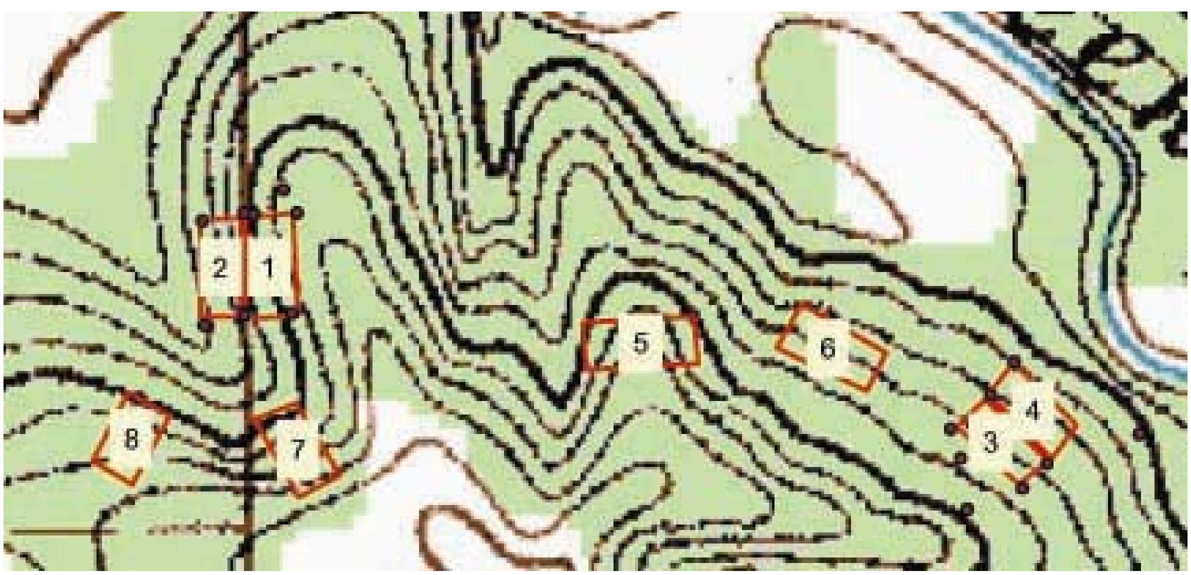
Rappole, John H. 1995. The ecology of migrant birds. Smithsonian Institution Press, Washington and London.

Robinson, S. K. 1992. Population dynamics of breeding Neotropical migrants in a fragmented Illinois landscape. Pages 408-418 in J. M. Hagan III and D. W. Johnston, eds., Ecology and

conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. 609 pp.
Samson, H. C. 1921. An ecological survey of the prairie vegetation of Illinois. Illinois Natural History Survey, Bulletin 13: 519-577.
Shirreff, Patrick. 1835. A tour through North America; together with a comprehensive view of the Canadas and the United States as adapted for Agricultural emigration. *In* Angle, Paul M., ed. Prairie State: Impressions of Illinois, 1673-1967 by travelers and other observers. The University of Chicago Press, Chicago & London, 1968.
Swink, Floyd A. and Gerould S. Wilhelm. 1994. Plants of the Chicago region. 4th ed. Indiana Academy of Sciences, Indianapolis.
Tilden, William. 1876. History of Medfield. Courtesy Richard DeSorgher, historian. Medield, Massachusetts.
Trager, James C., Joe A. MacGown, and Matthew D. Trager. (in press). Revision of the nearctic endemic *Formica pallidefulva* group. Memoirs of the American Entomological Institute.
Umphrey, Gary J. 1996. Morphometric discrimination among sibling species in the fulva-rudis-texana complex of the ant genus *Aphaenogaster* (Hymenoptera: Formicidae). Canadian Journal of Zoology 74: 528-559.
Weaver, J. E. and W. Noll. 1935. Measurement of run-off and soil erosion by a single investigator. Ecology 16: 1-12.
Went, F. W. 1955. Fog, mist, dew, and other sources of water. *In* Water: the yearbook of agriculture. United States Department of Agriculture, Washington, D. C. p. 103-109.
Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66: 1211-1214.
Wilhelm, Gerould S. 1987. The arboretum’s East woods: are they forever? Morton Arboretum Quarterly 23: 54-62.
Wilhelm, Gerould S. 1991. Implications of changes in floristic composition of the Morton Arboretum’s East Woods. Proceedings of the Oak Woods Management Workshop. Eastern Illinois University, Charleston: 31-54.
Wilhelm, Gerould S. and Linda Masters. 1994. Floristic changes after five growing seasons in burned and unburned woodland. Erigenia 13: 141-150.
Wilhelm, Gerould S. and Linda Masters. 2006. Floristic quality assessment and computer applications. Conservation Research Institute. Elmhurst, Illinois.
Wilhelm, Paul, Duke of Wurttemberg. 1973. Travels in North America, 1822-1824. University of Oklahoma Press, Norman.
Williams, Gerald W. 2002. References on the American Indian use of fire in ecosystems. U. S. D. A. Forest Service. Washington, D.C. 94 pp.
Wilson, Edward O. 1998. Consilience: the unity of knowledge. New York: Alfred A. Knopf, 332 pages.
Wood, William. 1634. New England prospects (1634) quoted in Daniel C. Thompson and Ralph H. Smith, “The Forest Primeval in the Northeast—A Great Myth?” Tall Timbers Fire Ecology Conference Proceedings 1-15, (Tallahassee 1962-1976)

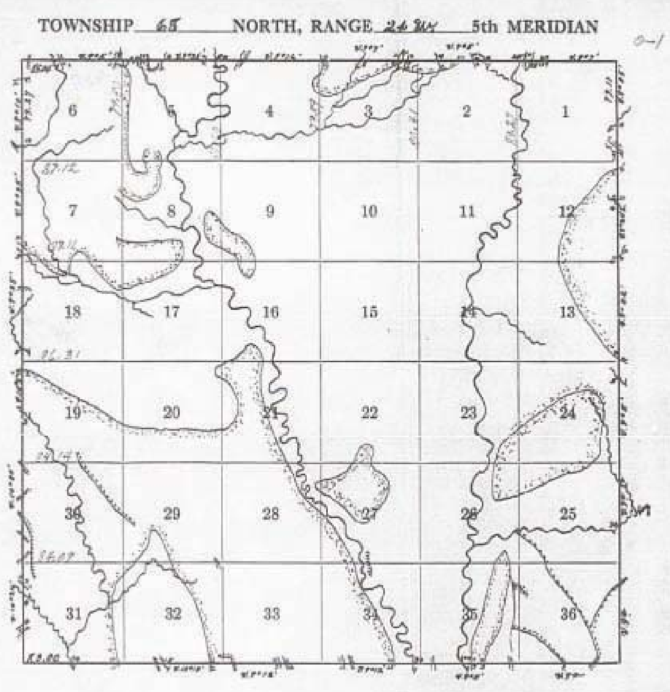
Plate 1: 0.125 ha Sample Plots

Plots over 2002 Aerial



Plots over USGS Topography

Plate 2: Notes from the general land survey of 1845



T 68 N R 24 W 5 M

East   Random between
       Sections 5 & 8
       Variation 9°20' E
80.12 Intersected N & S line
       10 links North of post

West   Corrected between
       Sections 5 & 8
       Variation 9°16' E
40.06 Set quarter Section post
       Bur Oak 18 S 69 E 26
       Hackberry 10 N 51½ W 14
43.00 Grand river 1.00 S E
49.00 Enter prairie S.W.N.W.
72.00 Enter Timber S.E.N.E.
78.00 Enter prairie N W S E
80.12 Section corner
       Soil first rate
       Timber Wht & Blk Oak
       Hickory & Elm

T 68 N R 24 W 5 M

West   Random between
       Sections 6 & 7
       Variation 10°5'
87.12 Intersected West boundry
       60 South of post

East   Corrected between
       Sections 6 & 7
       Variation 9°40' E
10.00 Branch 6 S.W.
47.12 Set quarter Section post
       in mound pit 8 links
       East of post
87.12 Section Corner
       Second rate prairie

T 68 N R 24 W 5 M

East   Random between
       Sections 5 & 8
       Variation 9°20' E
80.12 Intersected N & S line
       10 links North of post

West   Corrected between
       Sections 5 & 8
       Variation 9°16' E
40.06 Set quarter Section post
       Bur Oak 18 S 69 E 26
       Hackberry 10 N 51½ W 14
43.00 Grand river 1.00 S E
49.00 Enter prairie S.W.N.W.
72.00 Enter Timber S.E.N.E.
78.00 Enter prairie N W S E
80.12 Section corner
       Soil first rate
       Timber Wht & Blk Oak
       Hickory & Elm

South Corrected between
       Sections 5 & 6
       Variation 12°4' E.
3.00   Creek 15 N E
39.80 Set quarter Section post
       Wht Oak 10 N 16 W 28
       Wht Oak 10 S 54 E 39
*   Soil second rate
       Timber Wht & Blk Oak
       & Hickory
       Under Groath
       Oak & Hazle
*
77.80 Leave timber S.E. & W by N.
79 80 Sec. corner

Nov 10 12 o clock

I A. C. Dodge
Deputy Surveyor do solemnly swear that in pursuance of a contract with Geo. W Jones Surv-eyor General of the United States for Wisconsin and Iowa bearing date the 22d day of September, 1847 - and in strict conformity to the Laws of the United States and the instructions of the said Surveyor General I have regularly surveyed Township 68 North Range 24 West of the 5th Meridian in the State of Iowa. And I do further solemnly swear that the foregoing are the true and orriginal field notes of said Survey Executed as aforesaid

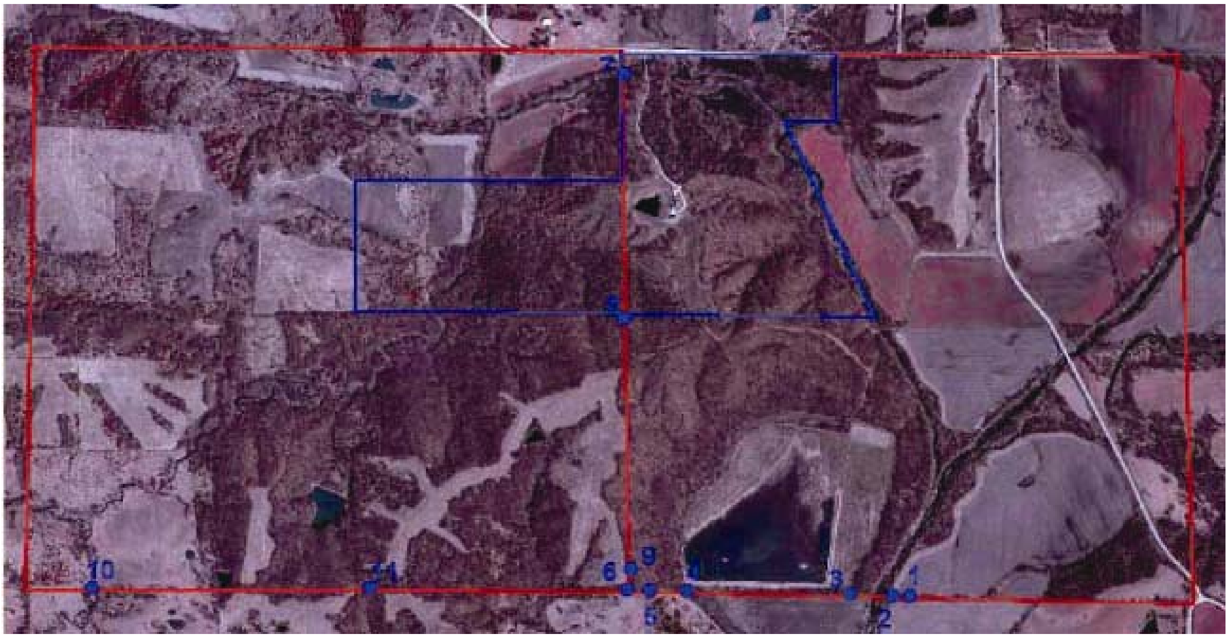
A. C. Dodge
Deputy Surveyor

Jno Lewis)
W. J. Loughary) Chainmen
W Wooderd, Marker
T Jones, Flagman

The within affidavit was subscribed by said A.C. Dodge Deputy Surveyor, and sworn to before me this 29th day of December 1847 -
Geo. W. Jones

Surveyor General

Plate 3: Aerial, 2002; sections 5 and 6 are delineated in red, Timberhill property is delineated in blue



Between sections 5 and 8, westward:

1. Quarter section post: witness trees were an 18" bur oak and a 10 inch hackberry.
2. Grand River, 1 chain wide [66 feet]
3. Entered prairie
4. Entered timber
5. Entered prairie
6. Section corner, soil "first rate;" timber white and black oak, with hickory and elm.

Between sections 5 and 6, southward:

7. Creek, six links wide [about 9 feet]
8. Quarter section post, two 10" white oaks; soil "first rate" timber white and black oak, with hickory and elm
9. Left timber, southeast and west by north

Between sections 6 and 7, eastward:

10. Branch, 6 links wide [4 feet]
11. Quarter section post; in mound pit [with charcoal] [no trees available, the whole area being "second rate" prairie.

Plate 4: Aerial Photographs of the Brown property at Timberhill

Figure 1: 1941

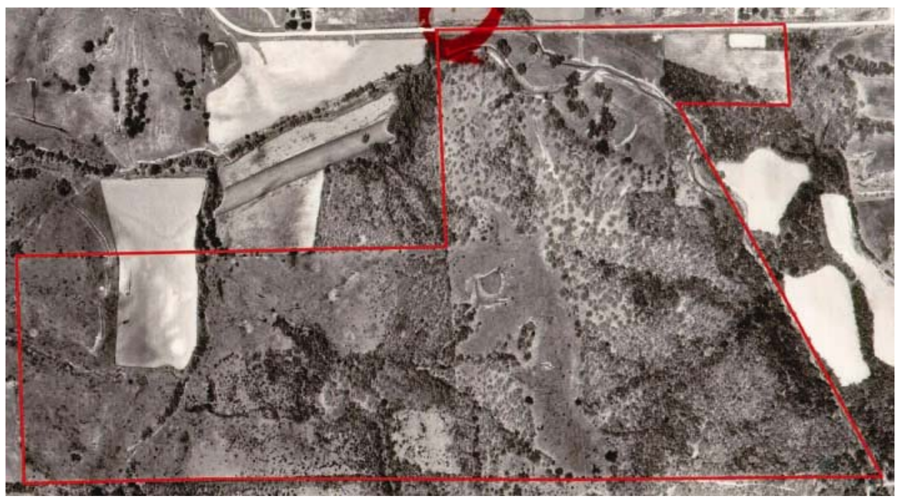
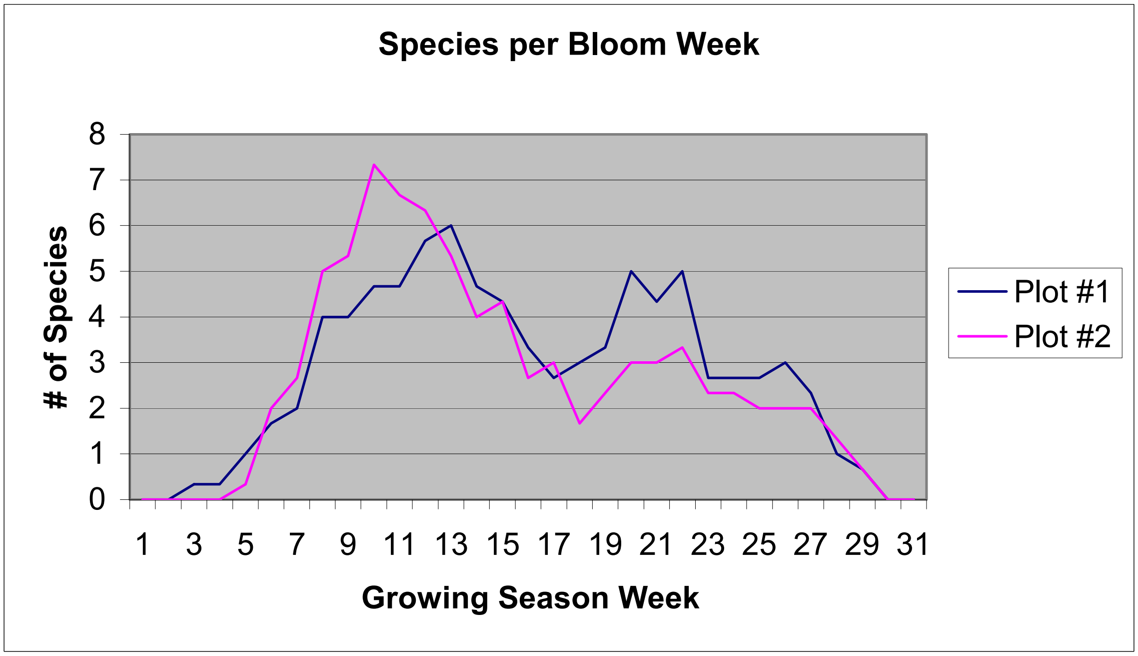


Figure 2: 1967

Figure 3: 1994

Plate 5a: Flowering phenology comparison between management plots at Timberhill, Plots 1-4



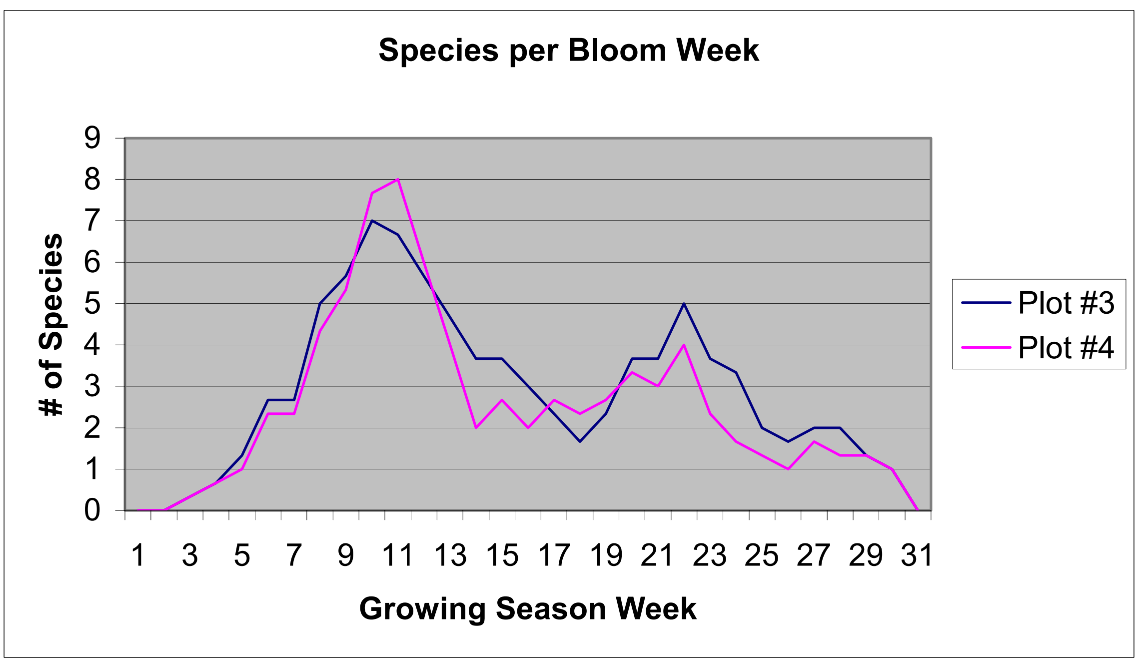
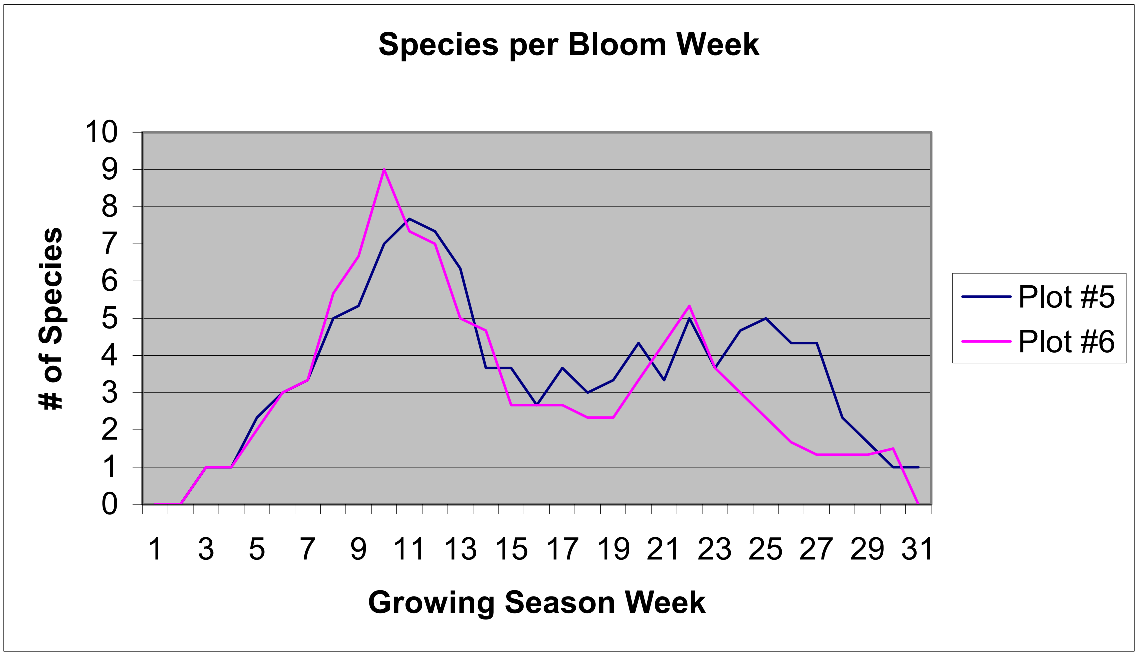


Plate 5b: Flowering phenology comparison between management plots at Timberhill, Plots 5-8



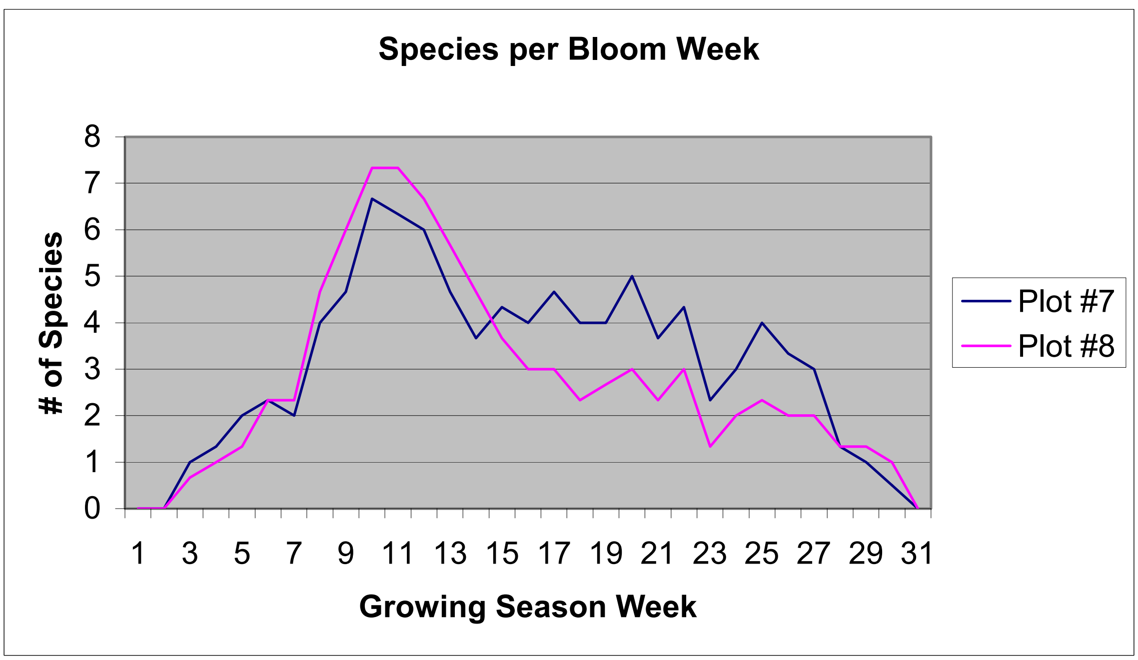


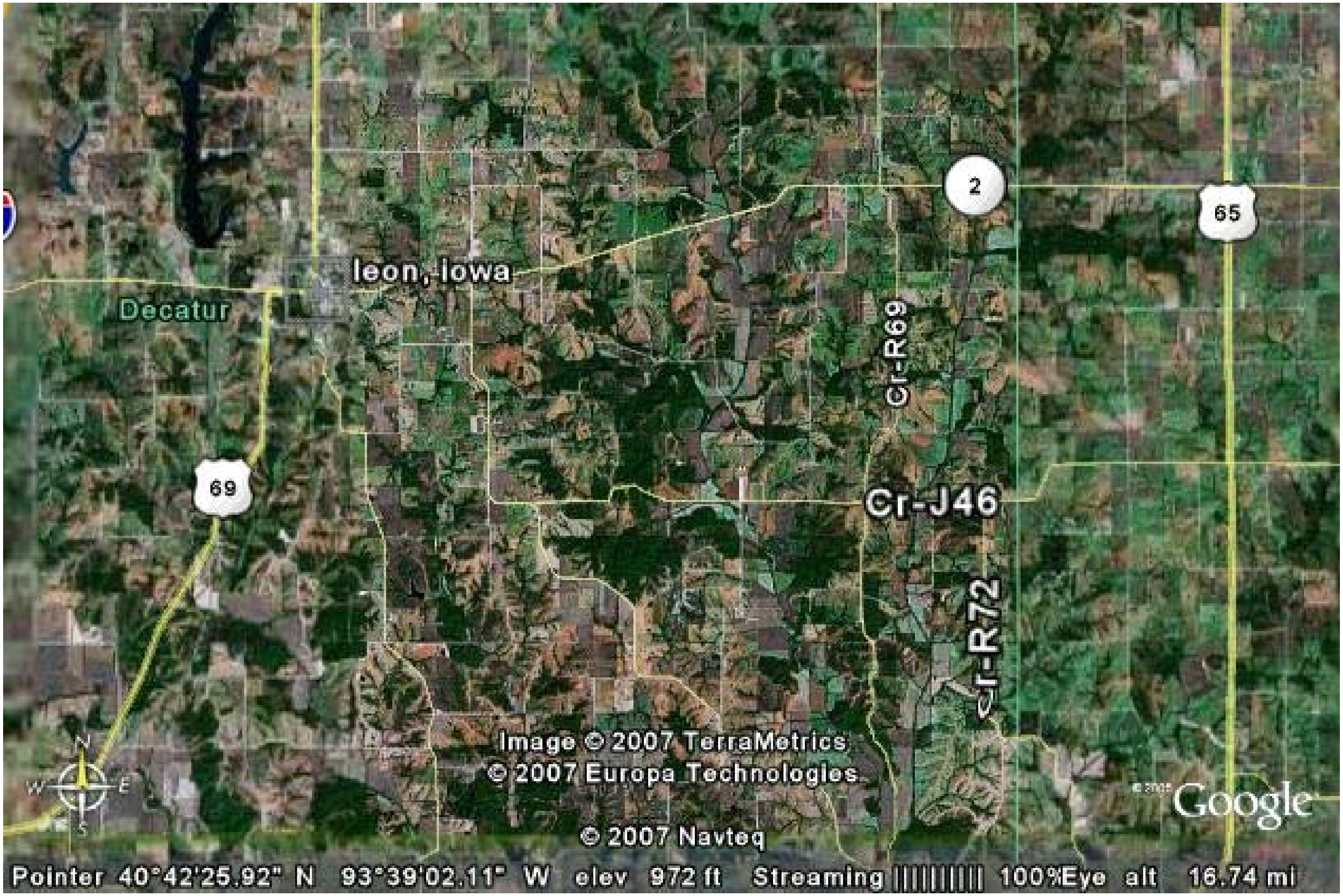
Plate 6: Timberhill Plant Sampling: Summary and Plot Comparison Data, with Cover/Abundance

Floristic Metrics: N = number of native species; C = mean Coefficient of Conservatism; I = Floristic Quality Index

Total Braun-Blanquet cover/abundance coefficient: PS = perennial sedges; PF = perennial forbs; S = shrubs; T = trees

	30-Minute Inventory							Transect Inventory							Transect Quadrat						
PLOT #, MANAGEMENT	N	C	I	PS	PF	S	T	N	C	I	PS	PF	S	T	N	C	I	PS	PF	S	T
Plot 1, Burned/Thinned	67	4.4	36	7.0	53.5	8.5	11.3	58	4.6	35	6.7	56.7	8.3	11.7	9.6	5.0	15.2	90	165	17	36
Fall Inventory	53	4.7	34																		
Aggregate	86	4.3	40																		
Plot 2, Unmanaged	65	4.4	35	10.6	47.0	9.1	15.2	42	4.4	29	9.5	50.0	7.1	19.0	7.2	4.9	13.0	59	125	5	34
Fall Inventory	44	4.6	31																		
Aggregate	82	4.5	40																		
Plot 3, Burned/Thinned	69	4.2	35	11.0	52.1	8.2	15.1	53	4.3	31	14.8	46.3	9.3	13.0	10.2	4.5	14.3	100	238	14	15
Fall Inventory	51	4.1	29																		
Aggregate	90	4.2	40																		
Plot 4, Burned	67	4.4	36	13.0	55.1	4.3	13.0	41	4.5	29	17.1	51.2	2.4	12.2	6.7	4.4	11.4	36	173	1	17
Fall Inventory	38	4.4	27																		
Aggregate	78	4.3	38																		
Plot 5, Burned/Thinned	94	4.3	42	9.4	54.2	10.4	10.4	82	4.2	38	9.3	53.5	4.7	10.5	12.2	4.4	15.8	103	254	35	25
Fall Inventory	54	3.9	29																		
Aggregate	111	4.2	45																		
Plot 6, Burned	79	3.9	35	12.2	43.9	8.5	13.4	69	3.9	32	15.5	50.7	9.9	8.5	9.4	4.0	12.1	80	171	25	22
Fall Inventory	44	4.0	27																		
Aggregate	99	3.9	39																		
Plot 7, Burned/Thinned	80	4.1	37	6.1	46.3	11.0	14.6	65	4.1	33	10.4	41.8	13.4	11.9	11.1	4.6	15.1	112	245	37	26
Fall Inventory	56	4.0	30																		
Aggregate	97	4.1	40																		
Plot 8, Unmanaged	73	4.2	36	12.0	44.0	6.7	14.7	42	4.4	29	20.9	39.5	7.0	14.0	6.6	4.8	12.2	45	110	9	21
Fall Inventory	47	4.3	29																		
Aggregate	86	4.2	39																		

Plate 7: View of the Leon Area. Timberhill is part of the dark green mass near the middle of the frame.



Appendix A: Comprehensive Vascular Flora of Timberhill

Site: Timberhill Savanna
Locale: Leon, Decatur Co., Iowa
Date: September 24, 2005 4 hours
May 17-20, 2005 24 hours
August 20, 2004 .25 hours
July 18, 2004 8 hours
July 17, 2004 8 hours
September 2, 2003 10 hours
June 1, 2003 5 hours
By: Gerould Wilhelm, Laura Rericha, Sibylla Brown, Chris Bair, Doug Ladd, Wayne Petersen
File: c:\FQA\studies\Timberhill.inv
Notes: An initial survey of this area, conducted in June of 2003, discovered 206 native species, which was considered impressive for a single meander inventory over one day. In September that year, 59 additional species were noted during another day in the field; the mean C value for native species stood at 4.4, with an index of 71. It was becoming more than clear that this area was of great significance insofar as its importance as a Midwestern natural area. Another survey, over two days in July of 2004, revealed another 71 native species, with the mean C value remaining at 4.4 and the index now 80. In the interim period, a significant prairie remnant was added to the property, the floristic elements of which are now included within the overall assessment, although many of the newly added taxa came from the timbered tracts as well. As annual fire is continued as a management tool, it is inevitable that future inventories will add numerous additional species.

Also noted on the property, but not recognized in the Iowa flora are *Amphacarpaea bracteata* var. *comosa* and *Scirpus georgianus*, which is lumped with *Scirpus atrovirens*. A Paronychia was seen August 20, 2004, but I did not look to see which one it was. The May, 2005, visit occurred during our sampling of the woodlands for an NRCS grant. During this latter period, we noted *Smilax illinoensis*, which is not in the Iowa data base used here.

FLORISTIC QUALITY DATA						
397 NATIVE SPECIES	Native	397	92.1%	Adventive	34	7.9%
431 Total Species	Tree	31	7.2%	Tree	1	0.2%
4.3 NATIVE MEAN C	Shrub	26	6.0%	Shrub	1	0.2%
3.9 W/Adventives	W-Vine	5	1.2%	W-Vine	0	0.0%
85.2 NATIVE FQI	H-Vine	6	1.4%	H-Vine	0	0.0%
81.8 W/Adventives	P-Forb	194	45.0%	P-Forb	13	3.0%
1.4 NATIVE MEAN W	B-Forb	11	2.6%	B-Forb	2	0.5%
1.4 W/Adventives	A-Forb	40	9.3%	A-Forb	7	1.6%
AVG: Faculative (-)	P-Grass	34	7.9%	P-Grass	6	1.4%
	A-Grass	3	0.7%	A-Grass	4	0.9%
	P-Sedge	37	8.6%	P-Sedge	0	0.0%
	A-Sedge	1	0.2%	A-Sedge	0	0.0%
	Fern	9	2.1%			

ACRONYM	C	SCIENTIFIC NAME	W	WETNESS	PHYSIOGNOMY	COMMON NAME
ACAGRA	4	Acalypha gracilens	5	UPL	Nt A-Forb	Slender three-seeded mercury
ACARHO	6	Acalypha rhomboidea	3	FACU	Nt A-Forb	Three-seeded mercury
ACAVIR	0	Acalypha virginica	3	FACU	Nt A-Forb	Three-seeded mercury
ACENEG	0	Acer negundo	-2	FACW-	Nt Tree	Box elder
ACHMIM	0	ACHILLEA MILLEFOLIUM	3	FACU	Ad P-Forb	Common yarrow
ACHMIL	0	Achillea millefolium ssp. lanulosa	3	FACU	Nt P-Forb	Western yarrow
ADIPED	7	Adiantum pedatum	1	FAC-	Nt Fern	Northern maidenhair fern
AESGLA	4	Aesculus glabra	-1	FAC+	Nt Tree	Ohio buckeye
AGAGAT	10	Agalinis gattingeri	5	UPL	Nt A-Forb	Round-stemmed false foxglove

AGANEP	4	Agastache nepetoides	3	FACU	Nt P-Forb	Yellow giant hyssop
AGRGRY	3	Agrimonia gryposepala	2	FACU+	Nt P-Forb	Tall agrimony
AGRPAR	3	Agrimonia parviflora	-1	FAC+	Nt P-Forb	Swamp agrimony
AGRPUB	4	Agrimonia pubescens	5	UPL	Nt P-Forb	Soft agrimony
AGRGIG	0	AGROSTIS GIGANTEA	-3	FACW	Ad P-Grass	Redtop
AGRHYE	4	Agrostis hyemalis	1	FAC-	Nt P-Grass	Tickle grass
AGRPER	6	Agrostis perennans	1	FAC-	Nt P-Grass	Upland grass
ALIPLA	3	Alisma plantago-aquatica	-5	OBL	Nt P-Forb	Water plantain
ALLCAC	6	Allium canadense	3	FACU	Nt P-Forb	Wild onion
ALLTRI	9	Allium tricoccum	2	FACU+	Nt P-Forb	Wild leek
ALOCAR	0	Alopecurus carolinianus	-3	FACW	Nt A-Grass	Common foxtail
AMBART	0	Ambrosia artemisiifolia	3	FACU	Nt A-Forb	Common ragweed
AMBTRI	0	Ambrosia trifida	-1	FAC+	Nt A-Forb	Giant ragweed
AMEARB	8	Amelanchier arborea	3	FACU	Nt Tree	Serviceberry
AMOCAN	8	Amorpha canescens	5	UPL	Nt Shrub	Lead plant
AMPBRB	4	Amphicarpaea bracteata	0	FAC	Nt H-Vine	Hog peanut
ANDGER	4	Andropogon gerardii	1	FAC-	Nt P-Grass	Big bluestem grass
ANEVIR	4	Anemone virginiana	5	UPL	Nt P-Forb	Tall anemone
ANETHA	7	Anemonella thalictroides	5	UPL	Nt P-Forb	Rue anemone
ANTNEG	2	Antennaria neglecta	5	UPL	Nt P-Forb	Cat's feet
ANTPLA	2	Antennaria plantaginifolia	5	UPL	Nt P-Forb	Pussy toes
APIAME	4	Apios americana	-3	FACW	Nt H-Vine	Ground nut
APOAND	3	Apocynum androsaemifolium	5	UPL	Nt P-Forb	Spreading dogbane
APOCAN	1	Apocynum cannabinum	0	FAC	Nt P-Forb	Indian hemp
APOSIB	1	Apocynum sibiricum	-1	FAC+	Nt P-Forb	Indian hemp
APOMED	1	Apocynum X medium	5	UPL	Nt P-Forb	Hybrid dogbane
AQUCAN	6	Aquilegia canadensis	1	FAC-	Nt P-Forb	Columbine
ARACAN	7	Arabis canadensis	5	UPL	Nt B-Forb	Sickle pod
ARAHIR	8	Arabis hirsuta	5	UPL	Nt B-Forb	Hairy rock cress
ARIDRA	6	Arisaema dracontium	-3	FACW	Nt P-Forb	Green dragon
ARITRI	4	Arisaema triphyllum	-2	FACW-	Nt P-Forb	Jack-in-the-pulpit
ASACAN	8	Asarum canadense	5	UPL	Nt P-Forb	Wild ginger
ASCHIR	5	Asclepias hirtella	5	UPL	Nt P-Forb	Tall green milkweed
ASCINC	4	Asclepias incarnata	-5	OBL	Nt P-Forb	Swamp milkweed
ASCPUR	7	Asclepias purpurascens	3	FACU	Nt P-Forb	Purple milkweed
ASCSUL	7	Asclepias sullivantii	5	UPL	Nt P-Forb	Prairie milkweed
ASCSYR	0	Asclepias syriaca	5	UPL	Nt P-Forb	Common milkweed
ASCVER	0	Asclepias verticillata	5	UPL	Nt P-Forb	Whorled milkweed
ASPPLA	4	Asplenium platyneuron	3	FACU	Nt Fern	Ebony spleenwort
ASTAZU	7	Aster azureus	5	UPL	Nt P-Forb	Sky-blue aster
ASTDRU	4	Aster drummondii	3	FACU	Nt P-Forb	Drummond's aster
ASTERI	3	Aster ericoides	4	FACU-	Nt P-Forb	Heath aster
ASTLAE	7	Aster laevis	5	UPL	Nt P-Forb	Smooth blue aster
ASTLAN	4	Aster lanceolatus	-5	OBL	Nt P-Forb	Panicled aster
ASTNOV	3	Aster novae-angliae	-3	FACW	Nt P-Forb	New England aster
ASTONT	3	Aster ontarionis	0	FAC	Nt P-Forb	Ontario aster
ASTPAR	4	Aster parviceps	5	UPL	Nt P-Forb	Small-headed aster
ASTPIL	0	Aster pilosus	4	FACU-	Nt P-Forb	Hairy aster
ASTPUN	5	Aster puniceus	-5	OBL	Nt P-Forb	Swamp aster
ASTCAN	4	Astragalus canadensis	-1	FAC+	Nt P-Forb	Canadian milk vetch
ATHFIA	7	Athyrium filix-femina var. angustum	0	FAC	Nt Fern	Northern lady fern
AURGRA	9	Aureolaria grandiflora var. pulchra	5	UPL	Nt P-Forb	Yellow false foxglove
BAPBRG	7	Baptisia bracteata var. glabrescens	5	UPL	Nt P-Forb	Cream wild indigo
BAPLAC	6	Baptisia lactea	3	FACU	Nt P-Forb	White wild indigo
BARVUL	0	BARBAREA VULGARIS	0	FAC	Ad B-Forb	Yellow rocket
BETNIG	6	Betula nigra	-3	FACW	Nt Tree	River birch
BIDFRO	3	Bidens frondosa	-3	FACW	Nt A-Forb	Beggar ticks
BIDPOL	3	Bidens polylepis	-3	FACW	Nt A-Forb	Bur marigold
BOTDIO	6	Botrychium dissectum var. obliquum	0	FAC	Nt Fern	Cut-leaved grape fern
BOTVIR	6	Botrychium virginianum	3	FACU	Nt Fern	Rattlesnake fern
BRAERE	8	Brachyelytrum erectum	5	UPL	Nt P-Grass	Long-awned wood grass
BRAKAB	0	Brassica kaber	5	UPL	Nt A-Forb	Charlock
BROPUB	9	Bromus pubescens	2	FACU+	Nt P-Grass	Woodland brome
CACATR	5	Cacalia atriplicifolia	5	UPL	Nt P-Forb	Indian plaintain
CALCAN	5	Calamagrostis canadensis	-5	OBL	Nt P-Grass	Blue joint grass
CALSEP	0	Calystegia sepium	0	FAC	Nt P-Forb	Hedge bindweed
CAMSCI	9	Camassia scilloides	-1	FAC+	Nt P-Forb	Wild hyacinth
CAMAME	4	Campanula americana	0	FAC	Nt A-Forb	Tall bellflower
CAPBUR	0	CAPSELLA BURSA-PASTORIS	1	FAC-	Ad A-Forb	Shepherd's purse
CARPAR	4	Cardamine parviflora var. arenicola	0	FAC	Nt A-Forb	Small-flowered bitter cress
CXAGGR	5	Carex aggregata	5	UPL	Nt P-Sedge	Smooth clustered sedge
CXANNX	6	Carex annectens var. xanthocarpa	-3	FACW	Nt P-Sedge	Large yellow fox sedge
CXBICK	10	Carex bicknellii	1	FAC-	Nt P-Sedge	Bicknell's sedge
CXBLAN	2	Carex blanda	0	FAC	Nt P-Sedge	Common wood sedge
CXBUSH	3	Carex bushii	-3	FACW	Nt P-Sedge	Long-scaled green sedge
CXCEPP	5	Carex cephalophora	3	FACU	Nt P-Sedge	Short-headed bracted sedge
CXCRIS	5	Carex cristatella	-4	FACW+	Nt P-Sedge	Crested oval sedge
CXDAVI	4	Carex davisii	-1	FAC+	Nt P-Sedge	Awned graceful sedge
CXFEST	8	Carex festucacea	0	FAC	Nt P-Sedge	Fescue oval sedge
CXGRVG	1	Carex gravida	5	UPL	Nt P-Sedge	Long-awned bracted sedge
CXGRIS	4	Carex grisea	5	UPL	Nt P-Sedge	Gray sedge
CXHAYD	5	Carex haydenii	-5	OBL	Nt P-Sedge	Long-scaled tussock sedge
CXHIRS	4	Carex hirsutella	4	FACU-	Nt P-Sedge	Hairy green sedge
CXHIRT	6	Carex hirtifolia	5	UPL	Nt P-Sedge	Hairy wood sedge
CXJAME	6	Carex jamesii	5	UPL	Nt P-Sedge	Grass sedge
CXLEAV	3	Carex leavenworthii	5	UPL	Nt P-Sedge	Dwarf bracted sedge
CXMEAD	9	Carex meadii	0	FAC	Nt P-Sedge	Mead's stiff sedge

CXMOLE	2	Carex molesta	0	FAC	Nt	P-Sedge	Field oval sedge
CXMUHM	5	Carex muhlenbergii	5	UPL	Nt	P-Sedge	Sand bracted sedge
CXNORM	5	Carex normalis	-3	FACW	Nt	P-Sedge	Spreading oval sedge
CXOLIC	6	Carex oligocarpa	5	UPL	Nt	P-Sedge	Few-fruited gray sedge
CXPELL	4	Carex pellita	-5	OBL	Nt	P-Sedge	Broad-leaved woolly sedge
CXPENP	6	Carex pensylvanica	-4	FACW+	Nt	P-Sedge	Pennsylvania oak sedge
CXRADI	6	Carex radiata	5	UPL	Nt	P-Sedge	Straight-styled wood sedge
CXROSE	7	Carex rosea	5	UPL	Nt	P-Sedge	Curly-styled wood sedge
CXSPAR	6	Carex sparganioides	0	FAC	Nt	P-Sedge	Loose-headed bracted sedge
CXSTRC	6	Carex stricta	-5	OBL	Nt	P-Sedge	Common tussock sedge
CXSUBE	8	Carex suberecta	-5	OBL	Nt	P-Sedge	Wedge-fruited oval sedge
CXTENE	8	Carex tenera	-1	FAC+	Nt	P-Sedge	Narrow-leaved oval sedge
CXTRIB	3	Carex tribuloides	-4	FACW+	Nt	P-Sedge	Awl-fruited oval sedge
CXVULP	3	Carex vulpinoidea	-5	OBL	Nt	P-Sedge	Brown fox sedge
CARCOR	5	Carya cordiformis	0	FAC	Nt	Tree	Bitternut hickory
CAROVT	5	Carya ovata	3	FACU	Nt	Tree	Shagbark hickory
CEAAME	8	Ceanothus americanus var. pitcheri	5	UPL	Nt	Shrub	New Jersey tea
CELSCA	1	Celastrus scandens	3	FACU	Nt	W-Vine	Bittersweet
CELOCC	2	Celtis occidentalis	1	FAC-	Nt	Tree	Hackberry
CERVUL	0	CERASTIUM VULGATUM	3	FACU	Ad	P-Forb	Mouse-ear chickweed
CHAPRC	2	Chaerophyllum procumbens	-1	FAC+	Nt	A-Forb	Chervil
CHESTA	6	Chenopodium standleyanum	5	UPL	Nt	A-Forb	Woodland goosefoot
CICMAC	7	Cicuta maculata	-5	OBL	Nt	B-Forb	Water hemlock
CINARU	4	Cinna arundinacea	-3	FACW	Nt	P-Grass	Wood reed
CIRLUT	5	Circaea lutetiana var. canadensis	3	FACU	Nt	P-Forb	Enchanter's nightshade
CIRALT	4	Cirsium altissimum	5	UPL	Nt	P-Forb	Tall thistle
CIRARV	0	CIRSIUM ARVENSE	3	FACU	Ad	P-Forb	Field thistle
CIRDIS	1	Cirsium discolor	5	UPL	Nt	B-Forb	Pasture thistle
CLAVIR	4	Claytonia virginica	3	FACU	Nt	P-Forb	Spring beauty
COMUMB	6	Comandra umbellata	3	FACU	Nt	P-Forb	Bastard toadflax
CONCAN	0	Conyza canadensis	1	FAC-	Nt	A-Forb	Horseweed
CORPAL	7	Coreopsis palmata	5	UPL	Nt	P-Forb	Prairie coreopsis
CORTRP	4	Coreopsis tripteris	0	FAC	Nt	P-Forb	Tall tickseed
CORDRU	4	Cornus drummondii	0	FAC	Nt	Shrub	Rough-leaved dogwood
CORRAC	1	Cornus racemosa	-2	FACW-	Nt	Shrub	Gray dogwood
CORAME	3	Corylus americana	0	FAC	Nt	Shrub	American hazelnut
CRACRU	3	Crataegus crus-galli	0	FAC	Nt	Tree	Cockspur hawthorn
CRASUC	5	Crataegus succulenta	5	UPL	Nt	Tree	Fleshy hawthorn
CRYCAN	4	Cryptotaenia canadensis	0	FAC	Nt	P-Forb	Honewort
CUSGRO	4	Cuscuta gronovii	-3	FACW	Nt	A-Forb	Common dodder
CYPSTR	2	Cyperus strigosus	-3	FACW	Nt	P-Sedge	Long-scaled nut sedge
CYPCAS	10	Cypripedium calceolus var. pubescens	-1	FAC+	Nt	P-Forb	Yellow lady's slipper orchid
CYSPRO	6	Cystopteris protrusa	4	FACU-	Nt	Fern	Creeping fragile fern
DACGLO	0	DACTYLIS GLOMERATA	3	FACU	Ad	P-Grass	Orchard grass
DALCAN	10	Dalea candida	5	UPL	Nt	P-Forb	White prairie clover
DALPUR	8	Dalea purpurea	5	UPL	Nt	P-Forb	Purple prairie clover
DANSPI	5	Danthonia spicata	5	UPL	Nt	P-Grass	Poverty oat grass
DELTRI	7	Delphinium tricorne	5	UPL	Nt	P-Forb	Dwarf larkspur
DENLAC	7	Dentaria laciniata	5	UPL	Nt	P-Forb	Toothwort
DESCAD	6	Desmodium canadense	1	FAC-	Nt	P-Forb	Showy tick trefoil
DESGLU	5	Desmodium glutinosum	5	UPL	Nt	P-Forb	Pointed tick trefoil
DESPAN	8	Desmodium paniculatum	3	FACU	Nt	P-Forb	Panicled tick trefoil
DIAARM	0	DIANTHUS ARMERIA	5	UPL	Ad	A-Forb	Deptford pink
DICCUC	7	Dicentra cucullaria	5	UPL	Nt	P-Forb	Dutchman's breeches
DIGSAN	0	DIGITARIA SANGUINALIS	3	FACU	Ad	A-Grass	Common crab grass
DIOVIL	5	Dioscorea villosa	1	FAC-	Nt	H-Vine	Wild yam
ECHPAL	7	Echinacea pallida	5	UPL	Nt	P-Forb	Pale coneflower
ECHPUR	9	Echinacea purpurea	5	UPL	Nt	P-Forb	Purple coneflower
ECHCRU	0	ECHINOCHLOA CRUSGALLI	-3	FACW	Ad	A-Grass	Barnyard grass
ELEERY	4	Eleocharis erythropoda	-5	OBL	Nt	P-Sedge	Red-rooted spike rush
ELEOBT	3	Eleocharis obtusa	-5	OBL	Nt	A-Sedge	Blunt spike rush
ELETEN	8	Eleocharis tenuis	-3	FACW	Nt	P-Sedge	Slender spike rush
ELLNYC	1	Ellisia nyctelea	-1	FAC+	Nt	A-Forb	Aunt Lucy
ELYCAN	5	Elymus canadensis	1	FAC-	Nt	P-Grass	Canada wild rye
ELYRIP	5	Elymus riparius	-3	FACW	Nt	P-Grass	Riverbank wild rye
ELYVIL	5	Elymus villosus	3	FACU	Nt	P-Grass	Slender wild rye
ELYVIR	3	Elymus virginicus	-2	FACW-	Nt	P-Grass	Virginia wild rye
EPICOL	3	Epilobium coloratum	-5	OBL	Nt	P-Forb	Cinnamon willow herb
EQUARV	0	Equisetum arvense	0	FAC	Nt	Fern	Common horsetail
EQUFER	1	Equisetum X ferrissii	-3	FACW	Nt	Fern	Hybrid scouring rush
ERAPEC	0	Eragrostis pectinacea	0	FAC	Nt	A-Grass	Small love grass
ERASPE	2	Eragrostis spectabilis	5	UPL	Nt	P-Grass	Purple love grass
ERIANN	0	Erigeron annuus	1	FAC-	Nt	B-Forb	Annual fleabane
ERISTR	2	Erigeron strigosus	1	FAC-	Nt	P-Forb	Daisy fleabane
ERYYUC	8	Eryngium yuccifolium	-1	FAC+	Nt	P-Forb	Rattlesnake master
ERYALB	6	Erythronium albidum	5	UPL	Nt	P-Forb	White trout lily
EUPPUR	6	Eupatorium purpureum	0	FAC	Nt	P-Forb	Purple Joe Pye weed
EUPRUG	2	Eupatorium rugosum	3	FACU	Nt	P-Forb	White snakeroot
EUPSER	2	Eupatorium serotinum	-1	FAC+	Nt	P-Forb	Late boneset
EUPCOR	3	Euphorbia corollata	5	UPL	Nt	P-Forb	Flowering spurge
EUTGRG	4	Euthamia graminifolia	-2	FACW-	Nt	P-Forb	Grass-leaved goldenrod
FESOBT	7	Festuca obtusa	2	FACU+	Nt	P-Grass	Nodding fescue
FRAVIR	3	Fragaria virginiana	1	FAC-	Nt	P-Forb	Wild strawberry
FRAAMC	6	Fraxinus americana	3	FACU	Nt	Tree	White ash
FRAPEP	3	Fraxinus pennsylvanica	-3	FACW	Nt	Tree	Red ash
FRAPEL	1	Fraxinus pennsylvanica var. lanceolata	-3	FACW	Nt	Tree	Green ash
GALCIR	6	Galium circaezans	4	FACU-	Nt	P-Forb	Wild licorice

GALCON	7	Galium concinnum	3	FACU	Nt	P-Forb	Shining bedstraw
GALOBT	7	Galium obtusum	-4	FACW+	Nt	P-Forb	Wild madder
GALTRO	7	Galium triflorum	2	FACU+	Nt	P-Forb	Sweet-scented bedstraw
GAUBIE	3	Gaura biennis	4	FACU-	Nt	B-Forb	Bienniel gaura
GENALB	4	Gentiana alba	3	FACU	Nt	P-Forb	Yellowish gentian
GENAND	8	Gentiana andrewsii	-3	FACW	Nt	P-Forb	Bottle gentian
GERMAC	6	Geranium maculatum	3	FACU	Nt	P-Forb	Wild geranium
GEUCAN	2	Geum canadense	0	FAC	Nt	P-Forb	White avens
GEULAC	4	Geum laciniatum	-3	FACW	Nt	P-Forb	Rough avens
GEUVER	4	Geum vernum	1	FAC-	Nt	P-Forb	Spring avens
GLETRI	0	Gleditsia triacanthos	0	FAC	Nt	Tree	Honey locust
GLYSTR	5	Glyceria striata	-5	OBL	Nt	P-Grass	Fowl manna grass
GNAOBT	1	Gnaphalium obtusifolium	5	UPL	Nt	B-Forb	Old field balsam
HACVIR	0	Hackelia virginiana	1	FAC-	Nt	P-Forb	Stickseed
HEDPUL	4	Hedeoma pulegioides	5	UPL	Nt	A-Forb	American pennyroyal
HELAUT	4	Helenium autumnale	-4	FACW+	Nt	P-Forb	Sneezeweed
HELBIC	7	Helianthemum bicknellii	5	UPL	Nt	P-Forb	Rockrose
HELCAN	7	Helianthemum canadense	5	UPL	Nt	P-Forb	Common rockrose
HELDIV	5	Helianthus divaricatus	5	UPL	Nt	P-Forb	Woodland sunflower
HELSTR	5	Helianthus strumosus	5	UPL	Nt	P-Forb	Pale-leaved sunflower
HELHEL	4	Heliopsis helianthoides	5	UPL	Nt	P-Forb	False sunflower
HEURIC	8	Heuchera richardsonii	1	FAC-	Nt	P-Forb	Prairie alum root
HIELON	4	Hieracium longipilum	5	UPL	Nt	P-Forb	Hawkweed
HIESCA	6	Hieracium scabrum	5	UPL	Nt	P-Forb	Rough hawkweed
HUMLUP	3	Humulus lupulus	3	FACU	Nt	H-Vine	Common hops
HYDVIR	3	Hydrophyllum virginianum	-2	FACW-	Nt	P-Forb	Virginia waterleaf
HYPMUT	7	Hypericum mutilum	-3	FACW	Nt	P-Forb	Dwarf St. John's wort
HYPPUN	5	Hypericum punctatum	-1	FAC+	Nt	P-Forb	Spotted St. John's wort
HYPHIR	7	Hypoxis hirsuta	0	FAC	Nt	P-Forb	Yellow star grass
HYSPAT	5	Hystrix patula	5	UPL	Nt	P-Grass	Bottlebrush grass
IMPCAP	3	Impatiens capensis	-3	FACW	Nt	A-Forb	Spotted touch-me-not
IMPPAL	5	Impatiens pallida	-3	FACW	Nt	A-Forb	Pale touch-me-not
JUGNIG	4	Juglans nigra	3	FACU	Nt	Tree	Black walnut
JUNINT	2	Juncus interior	-1	FAC+	Nt	P-Forb	Inland rush
JUNTEN	0	Juncus tenuis	0	FAC	Nt	P-Forb	Path rush
JUNVIR	1	Juniperus virginiana	3	FACU	Nt	Tree	Red cedar
KRIBIF	7	Krigia biflora	3	FACU	Nt	P-Forb	False dandelion
KUMSTI	0	KUMMEROWIA STIPULACEA	3	FACU	Ad	A-Forb	Korean clover
KUMSTR	0	KUMMEROWIA STRIATA	3	FACU	Ad	A-Forb	Japanese clover
LACCAN	1	Lactuca canadensis	2	FACU+	Nt	B-Forb	Wild lettuce
LACFLO	4	Lactuca floridana	1	FAC-	Nt	B-Forb	Blue lettuce
LAMAMP	0	LAMIUM AMPLEXICAULE	5	UPL	Ad	A-Forb	Henbit
LAPCAN	3	Laportea canadensis	-3	FACW	Nt	P-Forb	Wood nettle
LEEORY	2	Leersia oryzoides	-5	OBL	Nt	P-Grass	Rice cut grass
LEEVIR	6	Leersia virginica	-3	FACW	Nt	P-Grass	White grass
LEPDEN	0	Lepidium densiflorum	0	FAC	Nt	A-Forb	Pepper cress
LEPCOG	5	Leptoloma cognatum	5	UPL	Nt	P-Grass	Fall witch grass
LESCAP	3	Lespedeza capitata	3	FACU	Nt	P-Forb	Round-headed bush clover
LESVIO	6	Lespedeza violacea	5	UPL	Nt	P-Forb	Violet bush clover
LESVIR	5	Lespedeza virginica	5	UPL	Nt	P-Forb	Slender bush clover
LEUVUL	0	LEUCANTHEMUM VULGARE	5	UPL	Ad	P-Forb	Ox-eye daisy
LIAASP	8	Liatris aspera	5	UPL	Nt	P-Forb	Rough blazing star
LIACYL	10	Liatris cylindracea	5	UPL	Nt	P-Forb	Cylindrical blazing star
LIASQU	8	Liatris squarrosa	5	UPL	Nt	P-Forb	Squarrose blazing star
LIPLIL	4	Liparis liliifolia	4	FACU-	Nt	P-Forb	Purple twayblade
LITCAN	7	Lithospermum canescens	5	UPL	Nt	P-Forb	Hoary puccoon
LOBINF	2	Lobelia inflata	4	FACU-	Nt	A-Forb	Indian tobacco
LOBSIP	3	Lobelia siphilitica	-4	FACW+	Nt	P-Forb	Great blue lobelia
LOBSPI	6	Lobelia spicata	0	FAC	Nt	P-Forb	Spiked lobelia
LOTCOR	0	LOTUS CORNICULATUS	1	FAC-	Ad	P-Forb	Bird's foot trefoil
LUDALT	4	Ludwigia alternifolia	-5	OBL	Nt	P-Forb	Seedbox
LYCAME	4	Lycopus americanus	-5	OBL	Nt	P-Forb	Common water horehound
LYCVIR	7	Lycopus virginicus	-5	OBL	Nt	P-Forb	Bugle weed
LYSCIL	4	Lysimachia ciliata	-3	FACW	Nt	P-Forb	Fringed loosestrife
LYTALA	3	Lythrum alatum	-5	OBL	Nt	P-Forb	Winged loosestrife
MERVIR	4	Mertensia virginica	-3	FACW	Nt	P-Forb	Virginia bluebells
MIMRIN	3	Mimulus ringens	-5	OBL	Nt	P-Forb	Monkey flower
MOELAT	10	Moehringia lateriflora	3	FACU	Nt	P-Forb	Wood sandwort
MONFIS	2	Monarda fistulosa	3	FACU	Nt	P-Forb	Wild bergamot
MORALB	0	MORUS ALBA	0	FAC	Ad	Tree	White mulberry
MUHFRO	3	Muhlenbergia frondosa	-3	FACW	Nt	P-Grass	Common satin grass
MUHSCH	1	Muhlenbergia schreberi	0	FAC	Nt	P-Grass	Nimblewill
MUHTEN	7	Muhlenbergia tenuiflora	5	UPL	Nt	P-Grass	Slender satin grass
NAJGUA	5	Najas guadalupensis	-5	OBL	Nt	A-Forb	Southern naiad
OENBIE	0	Oenothera biennis	3	FACU	Nt	B-Forb	Common evening primrose
ONOSEN	6	Onoclea sensibilis	-3	FACW	Nt	Fern	Sensitive fern
OSMCLI	3	Osmorhiza claytonii	4	FACU-	Nt	P-Forb	Hairy sweet cicely
OSMLON	5	Osmorhiza longistylis	4	FACU-	Nt	P-Forb	Smooth sweet cicely
OSTVIR	5	Ostrya virginiana	4	FACU-	Nt	Tree	Hop hornbeam
OXADIL	0	Oxalis dillenii	5	UPL	Nt	P-Forb	Common wood sorrel
OXASTR	0	Oxalis stricta	3	FACU	Nt	P-Forb	Tall wood sorrel
OXAVIO	7	Oxalis violacea	5	UPL	Nt	P-Forb	Violet wood sorrel
PANCLA	4	Panicum clandestinum	-3	FACW	Nt	P-Grass	Deer-tongue grass
PANIMP	3	Panicum implicatum	1	FAC-	Nt	P-Grass	Old field panic grass
PANLAT	8	Panicum latifolium	3	FACU	Nt	P-Grass	Broad-leaved panic grass
PANOLS	5	Panicum oligosanthes var. scribnerianum	3	FACU	Nt	P-Grass	Scribner's panic grass
PANPER	5	Panicum perlongum	5	UPL	Nt	P-Grass	Long-stalked panic grass

PARPEN	3	Parietaria pensylvanica	3	FACU	Nt A-Forb	Pellitory
PARINT	9	Parthenium integrifolium	5	UPL	Nt P-Forb	Wild quinine
PARQUI	2	Parthenocissus quinquefolia	1	FAC-	Nt W-Vine	Virginia creeper
PASSEM	4	Paspalum setaceum var. muhlenbergii	0	FAC	Nt P-Grass	Hairy lens grass
PEDCAN	7	Pedicularis canadensis	2	FACU+	Nt P-Forb	Lousewort
PENDIG	4	Penstemon digitalis	1	FAC-	Nt P-Forb	Foxglove beard tongue
PENPAL	4	Penstemon pallidus	5	UPL	Nt P-Forb	Pale beard tongue
PHAARU	0	PHALARIS ARUNDINACEA	-4	FACW+	Ad P-Grass	Reed canary grass
PHLPRA	0	PHLEUM PRATENSE	3	FACU	Ad P-Grass	Timothy
PHLDIV	5	Phlox divaricata	3	FACU	Nt P-Forb	Woodland phlox
PHLPIL	7	Phlox pilosa	1	FAC-	Nt P-Forb	Prairie phlox
PHRLEP	4	Phryma leptostachya	5	UPL	Nt P-Forb	Lopseed
PHYVIG	4	Physalis virginiana	5	UPL	Nt P-Forb	Ground cherry
PILPUM	3	Pilea pumila	-3	FACW	Nt A-Forb	Common clearweed
PLAARI	0	Plantago aristata	5	UPL	Nt A-Forb	Bracted plantain
PLAMAJ	0	PLANTAGO MAJOR	-1	FAC+	Ad P-Forb	Common plantain
PLARUG	0	Plantago rugelii	0	FAC	Nt A-Forb	Red-stalked plantain
PLAVIR	0	Plantago virginica	4	FACU-	Nt A-Forb	Dwarf plantain
POACOM	0	POA COMPRESSA	2	FACU+	Ad P-Grass	Canadian blue grass
POAPRA	0	POA PRATENSIS	1	FAC-	Ad P-Grass	Kentucky blue grass
POAWOL	10	Poa wolfii	5	UPL	Nt P-Grass	Wolf's blue grass
PODPEL	4	Podophyllum peltatum	3	FACU	Nt P-Forb	May apple
POLREP	6	Polemonium reptans	0	FAC	Nt P-Forb	Jacob's ladder
POLSAN	6	Polygala sanguinea	3	FACU	Nt A-Forb	Field milkwort
POLVER	7	Polygala verticillata	5	UPL	Nt A-Forb	Whorled milkwort
POLBIF	4	Polygonatum biflorum	3	FACU	Nt P-Forb	Solomon's seal
POLPER	0	POLYGONUM PERSICARIA	-3	FACW	Ad A-Forb	Lady's thumb
POLPUN	4	Polygonum punctatum	-5	OBL	Nt A-Forb	Water smartweed
POLSAG	4	Polygonum sagittatum	-5	OBL	Nt A-Forb	Tearthumb
POLSCN	2	Polygonum scandens	0	FAC	Nt H-Vine	Climbing false buckwheat
POLTEN	7	Polygonum tenue	5	UPL	Nt A-Forb	Slender knotweed
POLVIG	5	Polygonum virginianum	0	FAC	Nt P-Forb	Jumpseed
POPDEL	1	Populus deltoides	-1	FAC+	Nt Tree	Cottonwood
POTNOR	2	Potentilla norvegica	0	FAC	Nt A-Forb	Norway cinquefoil
POTREC	0	POTENTILLA RECTA	5	UPL	Ad P-Forb	Sulphur cinquefoil
POTSIM	3	Potentilla simplex	4	FACU-	Nt P-Forb	Common cinquefoil
PREALB	7	Prenanthes alba	3	FACU	Nt P-Forb	White lettuce
PRUVUL	0	Prunella vulgaris var. lanceolata	0	FAC	Nt P-Forb	Self heal
PRUAMA	2	Prunus americana	5	UPL	Nt Tree	Smooth wild plum
PRUSER	3	Prunus serotina	3	FACU	Nt Tree	Wild black cherry
PYCPIL	5	Pycnanthemum pilosum	5	UPL	Nt P-Forb	Hairy mountain mint
PYCTEN	6	Pycnanthemum tenuifolium	0	FAC	Nt P-Forb	Slender mountain mint
PYCVIR	4	Pycnanthemum virginianum	-4	FACW+	Nt P-Forb	Common mountain mint
QUEALB	6	Quercus alba	3	FACU	Nt Tree	White oak
QUEIMB	3	Quercus imbricaria	1	FAC-	Nt Tree	Shingle oak
QUEMAC	4	Quercus macrocarpa	1	FAC-	Nt Tree	Bur oak
QUEMUH	7	Quercus muhlenbergii	5	UPL	Nt Tree	Chinquapin oak
QUERUB	6	Quercus rubra	3	FACU	Nt Tree	Northern red oak
QUEVEL	4	Quercus velutina	5	UPL	Nt Tree	Black oak
QUEBEB	5	Quercus X bebbiana	5	UPL	Nt Tree	Bebb's oak
QUEHAW	4	Quercus X hawkinsiae	5	UPL	Nt Tree	Hawkins' oak
RANABO	0	Ranunculus abortivus	-4	FACW+	Nt A-Forb	Small-flowered crowfoot
RANSES	6	Ranunculus septentrionalis	-4	FACW+	Nt P-Forb	Swamp buttercup
RATPIN	4	Ratibida pinnata	5	UPL	Nt P-Forb	Gray-headed coneflower
RHALAN	6	Rhamnus lanceolata	-5	OBL	Nt Shrub	Lance-leaved buckthorn
RHUARM	6	Rhus aromatica	5	UPL	Nt Shrub	Fragrant sumac
RHUGLA	0	Rhus glabra	5	UPL	Nt Shrub	Smooth sumac
RIBMIS	3	Ribes missouriense	5	UPL	Nt Shrub	Wild gooseberry
RORSES	4	Rorippa sessiliflora	-5	OBL	Nt A-Forb	Sessile-flowered cress
ROSARS	4	Rosa arkansana var. suffulta	5	UPL	Nt Shrub	Sunshine rose
ROSCAR	4	Rosa carolina	4	FACU-	Nt Shrub	Pasture rose
ROSMUL	0	ROSA MULTIFLORA	3	FACU	Ad Shrub	Multiflora rose
RUBALL	2	Rubus allegheniensis	2	FACU+	Nt Shrub	Common blackberry
RUBALU	3	Rubus alumus	2	FACU+	Nt Shrub	Common blackberry
RUBCUR	5	Rubus curtipes	5	UPL	Nt Shrub	Short-stalked dewberry
RUBFRO	4	Rubus frondosus	3	FACU	Nt Shrub	Blackberry
RUBMER	5	Rubus meracus	4	FACU-	Nt Shrub	Dewberry
RUBOCC	1	Rubus occidentalis	5	UPL	Nt Shrub	Black raspberry
RUBPEN	4	Rubus pensilvanicus	3	FACU	Nt Shrub	Yankee blackberry
RUBREA	4	Rubus recurvans	3	FACU	Nt Shrub	Recurved blackberry
RUBSET	9	Rubus setosus	-2	FACW-	Nt Shrub	Bristly blackberry
RUBSTE	5	Rubus steelei	5	UPL	Nt Shrub	Steele's blackberry
RUDHIR	2	Rudbeckia hirta	3	FACU	Nt P-Forb	Black-eyed Susan
RUDLAC	4	Rudbeckia laciniata	-4	FACW+	Nt P-Forb	Wild golden glow
RUDSUB	4	Rudbeckia subtomentosa	-3	FACW	Nt P-Forb	Sweet black-eyed Susan
RUDTRI	5	Rudbeckia triloba	1	FAC-	Nt A-Forb	Brown-eyed Susan
RUEHUM	3	Ruellia humilis	4	FACU-	Nt P-Forb	Wild petunia
RUMCRI	0	RUMEX CRISPUS	-1	FAC+	Ad P-Forb	Curly dock
RUMPAT	0	RUMEX PATIENTIA	5	UPL	Ad P-Forb	Patience dock
SALERI	3	Salix eriocephala	-4	FACW+	Nt Shrub	Heart-leaved willow
SALEXI	0	Salix exigua ssp. Interior	-5	OBL	Nt Shrub	Sandbar willow
SALNIG	3	Salix nigra	-5	OBL	Nt Tree	Black willow
SAMCAN	1	Sambucus canadensis	4	FACU-	Nt Shrub	Elderberry
SANCAN	7	Sanguinaria canadensis	4	FACU-	Nt P-Forb	Bloodroot
SANCAS	6	Sanicula canadensis	2	FACU+	Nt B-Forb	Black snakeroot
SANGRE	5	Sanicula gregaria	-1	FAC+	Nt P-Forb	Common snakeroot
SANMAR	5	Sanicula marilandica	5	UPL	Nt P-Forb	Black snakeroot

SCHSCO	5	Schizachyrium scoparium	4	FACU-	Nt P-Grass	Little bluestem
SCIATR	1	Scirpus atrovirens	-5	OBL	Nt P-Sedge	Dark green rush
SCIFLU	5	Scirpus fluviatilis	-5	OBL	Nt P-Sedge	River bulrush
SCLTRI	5	Scleria triglomerata	0	FAC	Nt P-Sedge	Tall nut rush
SCRLAN	4	Scrophularia lanceolata	2	FACU+	Nt P-Forb	Early figwort
SCRMAR	4	Scrophularia marilandica	4	FACU-	Nt P-Forb	Late figwort
SCULEO	7	Scutellaria leonardii	3	FACU	Nt P-Forb	Small skullcap
SENPLA	3	Senecio plattensis	4	FACU-	Nt P-Forb	Prairie ragwort
SETFAB	0	SETARIA FABERII	2	FACU+	Ad A-Grass	Giant foxtail
SETGLA	0	SETARIA GLAUCA	0	FAC	Ad A-Grass	Yellow foxtail
SILANT	1	Silene antirrhina	5	UPL	Nt A-Forb	Sleepy catchfly
SILSTE	4	Silene stellata	5	UPL	Nt P-Forb	Starry campion
SILINT	4	Silphium integrifolium	5	UPL	Nt P-Forb	Rosin weed
SILLAC	7	Silphium laciniatum	4	FACU-	Nt P-Forb	Compass plant
SILPER	1	Silphium perfoliatum	-2	FACW-	Nt P-Forb	Cup plant
SISANG	6	Sisyrinchium angustifolium	-2	FACW-	Nt P-Forb	Stout blue-eyed grass
SISCAM	4	Sisyrinchium campestre	5	UPL	Nt P-Forb	Prairie blue-eyed grass
SMIRAC	4	Smilacina racemosa	3	FACU	Nt P-Forb	False Solomon's seal
SMISTE	5	Smilacina stellata	1	FAC-	Nt P-Forb	Starry false Solomon's seal
SMIECI	6	Smilax ecirrhata	5	UPL	Nt P-Forb	Upright carrion flower
SMIHIS	4	Smilax hispida	0	FAC	Nt W-Vine	Greenbrier
SMILAS	5	Smilax lasioneura	0	FAC	Nt H-Vine	Common carrion flower
SOLAME	0	Solanum americanum	4	FACU-	Nt A-Forb	Black nightshade
SOLCAR	0	Solanum carolinense	4	FACU-	Nt P-Forb	Horse nettle
SOLALT	0	Solidago altissima	3	FACU	Nt P-Forb	Tall goldenrod
SOLCAN	0	Solidago canadensis	3	FACU	Nt P-Forb	Tall goldenrod
SOLGIG	3	Solidago gigantea	-3	FACW	Nt P-Forb	Smooth goldenrod
SOLMIS	5	Solidago missouriensis	5	UPL	Nt P-Forb	Missouri goldenrod
SOLNEM	4	Solidago nemoralis	5	UPL	Nt P-Forb	Field goldenrod
SOLSPE	7	Solidago speciosa	5	UPL	Nt P-Forb	Showy goldenrod
SOLULM	6	Solidago ulmifolia	5	UPL	Nt P-Forb	Elm-leaved goldenrod
SORNUT	4	Sorghastrum nutans	2	FACU+	Nt P-Grass	Indian grass
SPAPEC	4	Spartina pectinata	-4	FACW+	Nt P-Grass	Prairie cord grass
SPHOBM	4	Sphenopholis obtusata var. major	0	FAC	Nt P-Grass	Slender wedge grass
SPILAC	4	Spiranthes lacera	-1	FAC+	Nt P-Forb	Slender ladies' tresses
SPOVAG	1	Sporobolus vaginiflorus	5	UPL	Nt A-Grass	Sheathed rush grass
STAASP	6	Stachys aspera	-4	FACW+	Nt P-Forb	Rough hedge nettle
STAPAL	4	Stachys palustris	-5	OBL	Nt P-Forb	Woundwort
STEMED	0	STELLARIA MEDIA	3	FACU	Ad A-Forb	Common chickweed
SYMORB	0	Symphoricarpos orbiculatus	3	FACU	Nt Shrub	Coralberry
TAEINT	9	Taenidia integerrima	5	UPL	Nt P-Forb	Yellow pimpernel
TAROFF	0	TARAXACUM OFFICINALE	3	FACU	Ad P-Forb	Common dandelion
TEUCAN	4	Teucrium canadense	-2	FACW-	Nt P-Forb	Germander
THADAD	4	Thalictrum dasycarpum	-2	FACW-	Nt P-Forb	Purple meadow rue
THADIO	8	Thalictrum dioicum	2	FACU+	Nt P-Forb	Early meadow rue
THAREV	5	Thalictrum revolutum	0	FAC	Nt P-Forb	Waxy meadow rue
TILAME	5	Tilia americana	3	FACU	Nt Tree	Basswood
TOXRAD	0	Toxicodendron radicans	-1	FAC+	Nt W-Vine	Poison ivy
TRAOHI	4	Tradescantia ohiensis	2	FACU+	Nt P-Forb	Common spiderwort
TRIFLA	0	Tridens flavus	5	UPL	Nt P-Grass	Purple top
TRIHYB	0	TRIFOLIUM HYBRIDUM	1	FAC-	Ad P-Forb	Alsike clover
TRIPRA	0	TRIFOLIUM PRATENSE	2	FACU+	Ad P-Forb	Red clover
TRIREP	0	TRIFOLIUM REPENS	2	FACU+	Ad P-Forb	White clover
TRIPEA	3	Triodanis perfoliata	0	FAC	Nt A-Forb	Venus' looking glass
TRIAUT	4	Triosteum aurantiacum	5	UPL	Nt P-Forb	Early horse gentian
TRIPEM	4	Triosteum perfoliatum	5	UPL	Nt P-Forb	Late horse gentian
ULMAME	2	Ulmus americana	-2	FACW-	Nt Tree	American elm
ULMRUB	2	Ulmus rubra	0	FAC	Nt Tree	Slippery elm
UVUGRA	7	Uvularia grandiflora	5	UPL	Nt P-Forb	Bellwort
VERWOO	8	Veratrum woodii	5	UPL	Nt P-Forb	False hellebore
VERTHA	0	VERBASCUM THAPSUS	5	UPL	Ad B-Forb	Common mullein
VERHAS	3	Verbena hastata	-4	FACW+	Nt P-Forb	Blue vervain
VERSTR	1	Verbena stricta	5	UPL	Nt P-Forb	Hoary vervain
VERURT	2	Verbena urticifolia	-1	FAC+	Nt P-Forb	White vervain
VERALT	4	Verbesina alternifolia	-3	FACW	Nt P-Forb	Wingstem
VERBAL	2	Vernonia baldwinii	5	UPL	Nt P-Forb	Baldwin's ironweed
VERGIG	4	Vernonia gigantea	0	FAC	Nt P-Forb	Tall ironweed
VERPEG	0	Veronica peregrina	-4	FACW+	Nt A-Forb	Purslane speedwell
VERVIM	5	Veronicastrum virginicum	0	FAC	Nt P-Forb	Culver's root
VIOPUP	5	Viola pubescens	4	FACU-	Nt P-Forb	Downy yellow violet
VIOSOR	1	Viola sororia	1	FAC-	Nt P-Forb	Hairy blue violet
VITRIP	1	Vitis riparia	-2	FACW-	Nt W-Vine	Riverbank grape
ZANAME	3	Zanthoxylum americanum	5	UPL	Nt Shrub	Prickly ash
ZIZAUR	6	Zizia aurea	-1	FAC+	Nt P-Forb	Golden alexanders

Appendix B: Vascular Flora of Sampling Plots

		Plot #1	Plot #2	Plot #3	Plot #4	Plot #5	Plot #6	Plot #7	Plot #8
	Native Species	86	82	90	79	111	99	97	86
	Mean C	4.3	4.5	4.2	4.3	4.2	3.9	4.1	4.2
C	FQI	40	40	40	38	45	39	40	39
4	Acalypha gracillens	1	2	3					
6	Acalypha rhomboidea			3	4	5		7	8
0	Acalypha virginia							7	
0	Acer negundo							7	
0	Achillea millefolium lanulosa	1				5			
7	Adiantum pedatum								8
4	Aesculus glabra			3	4				
10	Agalinis gattingeri					5			
3	Agrimonia gryposepala					5			
3	Agrimonia parviflora						6		
4	Agrimonia pubescens	1	2	3	4	5	6		
0	AGROSTIS GIGANTEA					5			
6	Agrostis perennans		2						
6	Allium canadense	1	2	3	4				
0	Ambrosia artemisiifolia	1				5		7	
0	Ambrosia trifida						6		
8	Amelanchier arborea		2						8
8	Amorpha canescens	1						7	
4	Amphicarpaea bracteata	1	2	3	4	5	6	7	8
4	Andropogon gerardii	1				5			
4	Anemone virginiana	1			4	5	6		
7	Anemonella thalictroides		2	3	4	5	6	7	8
2	Antennaria neglecta					5			
2	Antennaria plantaginifolia	1	2			5		7	
3	Apocynum androsaemifolium	1	2		4			7	
1	Apocynum cannabinum	1							
6	Arisaema dracontium						6		
4	Arisaema triphyllum				4		6		
8	Asarum canadense					5			
7	Asclepias purpurascens	1						7	
0	Asclepias verticillata	1							

7	Aster azureus	1	2	3		5			
4	Aster drummondii	1	2	3	4	5	6	7	8
0	Aster pilosus					5			
3	Bidens frondosa						6		
6	Botrychium dissectum obliquum						6		
6	Botrychium virginianum		2		4		6		
9	Bromus pubescens	1	2	3	4			7	8
5	Cacalia atriplicifolia				4		6		
4	Campanula americana							7	
5	Carex aggregata						6		
10	Carex bicknellii					5			
2	Carex blanda		2	3	4		6	7	8
5	Carex cephalophora	1	2	3	4	5	6	7	8
4	Carex davisii			3			6		
4	Carex grisea				4		6		
4	Carex hirsutella	1	2	3		5		7	8
6	Carex hirtifolia			2	4	5	6		8
6	Carex jamesii	1	2	3	4	5	6	7	8
9	Carex meadii					5			
5	Carex normalis		2	3	4	5	6	7	8
6	Carex oligocarpa			3	4		6		
6	Carex pensylvanica	1	2	3	4	5	6	7	8
6	Carex radiata	1	2	3	4	5	6	7	8
7	Carex rosea		2		4			7	8
8	Carex tenera	1		3		5			8
5	Carya cordiformis	1	2	3	4	5	6	7	8
5	Carya ovata	1	2	3		5	6	7	8
1	Celastrus scandens	1	2					7	8
2	Celtis occidentalis		2	3	4		6	7	8
4	Cinna arundinacea			3					
5	Circaea lutetiana canadensis		2	3	4	5	6	7	8
4	Cirsium altissmum							7	
1	Cirsium discolor					5			
4	Claytonia virginica	1		3	4				
6	Comandra umbellata					5			
7	Coreopsis palmata	1						7	
4	Coreopsis tripteris			3		5			

4	Cornus drummondii	1	2	3		5		7	
1	Cornus racemosa	1					6		8
3	Corylus americana	1		3		5	6	7	8
4	Cryptotaenia canadensis			3	4		6		
6	Cystopteris protrusa			3	4			7	8
	DACTYLIS GLOMERATA			3				7	
5	Danthonia spicata	1	2						
7	Dentaria laciniata			3		5	6		
6	Desmodium canadense	1				5		7	
5	Desmodium glutinosum	1	2	3	4	5	6	7	8
8	Desmodium paniculatum	1		3				7	
5	Dioscorea villosa						6		
5	Elymus canadensis					5			
5	Elymus villosus					5	6	7	8
3	Elymus virginicus		2	3	4			7	
0	Erigeron annuus	1					6		
2	Erigeron strigosus	1				5		7	8
6	Erythronium albidum	1					6		
2	Eupatorium rugosum	1	2	3	4	5	6	7	8
2	Eupatorium serotinum								8
7	Festuca obtusa	1	2	3	4	5	6	7	8
3	Fragaria virginiana				4	5	6		
6	Fraxinus americana					5	6	7	
1	Fraxinus pennsylvanica lanceolata	1	2	3	4	5	6		
6	Galium circaezans	1	2	3	4	5	6	7	8
7	Galium concinnum	1	2	3	4	5	6	7	8
7	Galium triflorum		2		4	5	6	7	8
6	Geranium maculatum		2		4	5		7	8
2	Geum canadense		2	3	4			7	8
4	Geum vernum		2	3	4	5	6		
0	Gleditsia triacanthos	1							8
1	Gnaphalium obtusifolium					5			
0	Hackelia virginiana						6	7	8
4	Hedeoma pulegiodes	1							
7	Helianthemum canadense	1				5			
5	Helianthus strumosus	1	2	3	4	5	6	7	8
8	Heuchera richardsonii	1							

4	Hieracium longipilum	1	2						
3	Hydrophyllum virginianum		2	3	4	5			
5	Hypericum punctatum					5	6		
7	Hypoxis hirsuta	1				5			
5	Hystrix patula	1	2	3		5		7	8
4	Juglans nigra						6		8
2	Juncus interior			3					
0	Juncus tenuis					5			8
1	Juniperus virginiana					5	6	7	
	KUMMEROWIA STRIATA					5			
1	Lactuca canadensis	1				5			
4	Lactuca floridana			3				7	
6	Leersia virginica		2	3	4		6		
6	Lespedeza violacea	1	2						
5	Lespedeza virginica	1							
8	Liatris aspera					5			
10	Liatris cylindracea					5			
4	Liparis lilifolia		2	3					
2	Lobelia inflata								8
2	Monarda fistulosa					5			
	MORUS ALBA		2						
1	Muhlenbergia schreberi		2						
3	Osmorhiza claytonii		2		4		6	7	8
5	Osmorhiza longistylis							7	8
5	Ostrya virginiana	1	2	3	4	5	6	7	8
0	Oxalis dillenii			3	4		6	7	
0	Oxalis stricta					5	6	7	
7	Oxalis violacea	1							
3	Panicum implicatum	1	2	3		5	6	7	8
8	Panicum latifolium	1	2	3					8
3	Parietaria pensylvanica							7	
9	Parthenocissus quinquefolia	1	2	3	4	5	6	7	8
4	Penstemon pallidus	1	2	3		5		7	
5	Phlox divaricata	1	2	3	4	5	6	7	8
4	Phryma leptostachya	1	2	3	4	5	6	7	8
4	Physalis virginiana	1							
	PLANTAGO MAJOR					5			

0	Plantago rugelii			3			6		8
	POA COMPRESSA	1	2	3		5	6	7	8
	POA PRATENSIS	1		3	4	5			
10	Poa wolfii		2					7	8
4	Podophyllum peltatum		2	3	4	5	6	7	8
6	Polemonium reptans					5	6		
4	Polygonatum biflorum	1	2	3	4	5	6	7	8
5	Polygonum virginianum			3	4		6		8
3	Potentilla simplex		2	3		5	6		
7	Prenanthes alba			3	4		6		8
0	Prunella vulgaris lanceolata					5			8
2	Prunus americana		2			5	6		
3	Prunus serotina	1	2	3	4	5	6	7	8
5	Pycnanthemum pilosum			3					
6	Pycnanthemum tenuifolium	1				5		7	
6	Quercus alba	1	2	3	4	5	6	7	8
5	Quercus x bebbiana				4				
3	Quercus imbricaria	1	2	3		5	6	7	8
4	Quercus macrocarpa						6		
6	Quercus rubra	1	2	3	4		6	7	8
4	Quercus velutina	1	2	3		5	6	7	8
0	Ranunculus abortivus	1	2		4		6	7	
0	Rhus glabra			3					8
3	Ribes missouriense	1	2	3	4	5	6	7	8
4	Rosa carolina	1	2	3	4	5		7	8
	ROSA MULTIFLORA	1	2	3	4		6	7	8
2	Rubus allegheniensis					5	6		
5	Rubus curtipes	1	2			5	6	7	8
4	Rubus frondosus			3		5			
5	Rubus meracus						6		8
1	Rubus occidentalis			3		5		7	8
4	Rubus pensylvanicus							7	
2	Rudbeckia hirta					5			
3	Ruellia humilis					5			
7	Sanguinaria canadensis					5			
6	Sanicula canadensis				4		6	7	
5	Sanicula gregaria	1	2	3	4	5	6	7	8

5	Sanicula marilandica		2			5		7	
5	Schizachyrium scoparium	1				5		7	
5	Scleria triglomerata	1							
4	Scrophularia lanceolata			3				7	
7	Scutellaria leonardii	1							
4	Silene stellata		2		4	5	6	7	
4	Sisyrinchium campestre	1							
4	Smilacina racemosa		2	3	4				8
5	Smilacina stellata								8
6	Smilax ecirrhata				4				8
4	Smilax hispida		2		4		6	7	8
0	Solanum americanum			3					
0	Solidago altissima			3	4	5	6	7	8
3	Solidago gigantea				4		6	7	
4	Solidago nemoralis					5			
7	Solidago speciosa	1				5		7	8
6	Solidago ulmifolia	1	2	3	4	5		7	8
0	Symphoricarpos orbiculatus	1	2	3	4	5	6	7	8
9	Taenidia integerrima					5			
	TARAXACUM OFFICINALE						6		
4	Teucrium canadense					5		7	
4	Thalictrum dasycarpum							7	8
8	Thalictrum dioicum						6		8
5	Tilia americana						6		
0	Toxicodendron radicans	1	2		4	5	6	7	8
4	Tradescantia ohiensis	1							
0	Tridens flavus					5			
3	Triodanis perfoliata						6		
4	Triosteum aurantiacum	1		3		5	6		
4	Triosteum perfoliatum	1		3	4	5	6	7	
2	Ulmus americana			3	4			7	8
2	Ulmus rubra			3	4	5	6	7	8
7	Uvularia grandiflora		2						8
4	Vernonia gigantea		2			5	6		
5	Veronicastrum virginicum		2	3	4		6		
5	Viola pubescens			3	4				
1	Viola sororia			3	4	5	6	7	8

1	Vitis riparia	1		3			6		8
3	Zanthoxylum americanum		2	3		5	6	7	
6	Zizia aurea		2						

APPENDIX C: ANTS OF TIMBERHILL
56 Species: May 2007

Dolichoderinae
Forelius pruinosus
Tapinoma sessile

Formicinae
Acanthomyops claviger
Brachymyrmex depilis
Camponotus chromaiodes
Camponotus americanus
Camponotus nearcticus
Camponotus pennsylvanicus
Camponotus subbarbatus
Formica dakotensis
Formica difficilis
Formica dolosa
Formica exsectoides
Formica incerta
Formica neogagates
Formica obscuriventris
Formica pallidefulva
Formica pergandei
Formica prociliata
Formica querquetulana
Formica subsericea
Lasius alienus
Lasius flavus
Lasius neoniger
Lasius umbratus
Paratrechina parvula
Polyergus lucidus (montivagus)
Prenolepis imparis

Myrmicinae
Aphaenogaster mariae
Aphaenogaster N16
Aphaenogaster N22a
Aphaenogaster tennesseensis
Crematogaser lineolata
Monomorium minimum
Myrmecina americana
Myrmica evanida
Myrmica fracticornis
Myrmica hamulata trullicornis
Myrmica pinetorum
Myrmica punctiventris
Myrmica sculptilis
Myrmica smithana
Pheidole pilifera
Protomognathus americanus
Pyramica dietrichi
Pyramica pilinasis
Solenopsis molesta
Stenamma brevicorne
Stenamma schmitti
Temnothorax ambiguus
Temnothorax curvispinosus
Temnothorax pergandei
Temnothorax schaumii
Tetramorium caespitum

Ponerinae
Hyponera opacior
Ponera pennsylvanica