A MARQUETTE COUNTY WISCONSIN SAVANNA REEXAMINED

Philip B. Whitford and Kathryn D. Whitford
Emeritus University of Wisconsin Milwaukee
Biological Sciences Department

Kathryn D. Whitford
University of Wisconsin Milwaukee
English Department

(Both Deceased)

Posthumously revised and submitted by

Philip C. Whitford
Biology Department
Capital University, One College and Main
Columbus, OH 43209
pwhitfor@capital.edu

ABSTRACT

An oak savanna surveyed in 1968 was resurveyed in 1989. In the earlier study, we concluded that the site had remained as savanna in the absence of fire due to interacting climatic, edaphic and biotic factors. Since 1968 the site has had some losses and replacement of canopy trees, but has not become a denser closed forest. Many of the oldest trees of 1968 were lost to oak wilt or to storm damage resulting in a drop of one third in the average dbh and about two thirds of BA/ha. Replacement of the oaks is mainly by black cherry clustered on the sites of the dead oaks. Oak seedlings are more evenly distributed and still comprise 70% of seedlings, but generally lack vigor and have high mortality. It appears that this stand will remain a savanna; the grassy open areas will probably remain open with some oak seedlings as well as cherry growing to canopy height as replacements of canopy oaks.

KEY WORDS: Oak wilt, Oak savanna, Dry Wisconsin Prairie

INTRODUCTION

This work was written based on 35 years of research done by my late parents on a small area of savanna adjacent to the sand county farm they bought in 1955. The paper was originally submitted to The American Midland Naturalist for publication in 1991 and returned with suggestions for minor revisions. My father died in June of that year before returning the paper. Had you ever seen his desk in Lapham Hall, you would understand why the paper remained missing until my mother found it and gave it to me to “rework” shortly before her death in 2005.

My parents were raised in northern Illinois and met at Northern Illinois University in 1938. Both got their Bachelor degrees there and returned to school at UW-Madison after the war for advanced degrees. Though her degrees were in the field of English, my mother worked alongside my father on field work from 1939 until his death, helping collect data for his masters’ and dissertation research (the latter under Curtis at UW-Madison) on species associations of prairie remnants in Wisconsin and Illinois. Both were experts in species identifi-
Our old sand farm and its long term management and use for research were (and still are) inspired by my parent’s brief association with Aldo Leopold, his family and farm, made famous in “A Sand County Almanac” (Leopold 1949). That legacy was passed down to me and my sister along with the farm.

Oak savannas, also called “oak openings,” were common in southern and central Wisconsin at the time of European settlement, mainly in the broad ecotone between true prairie grasslands and true forest of moister northern and eastern regions. Generally, these savannas were cleared early for agriculture or were grazed by domestic cattle, so that nearly all were denuded or greatly changed before 1900. Thus Curtis (1959) stated, “Beyond question an oak savanna with intact ground-layer is the rarest community in Wisconsin today,” and in an earlier work (Curtis 1956) he discussed in detail the processes by which man had changed vegetation in the region. Savanna sites which were not plowed or grazed commonly become closed forests, a fact often cited in support of the theory that the oak savanna was a subclimax community maintained only by frequent fires set by native Indians (Cottam 1949, Curtis 1959, Sauer 1950).

This study deals with one stand located in Marquette County, WI (Lat. 43°53′ N., Long. 80°20′ w.; Section 6, T16N, R10E) on a site recorded in the U.S. General Land Office Survey in 1851 as “openings, timber black and white oak. No undergrowth.” In 1968, having observed this particular site frequently for some years, we noted that there was no sign of fire (fire scars, etc.) having occurred for at least 50 years, but also that there had been no obvious change in tree canopy, seedling or sapling density, or understory. The understory was dominated by herbaceous species, mostly of prairie or “barrens” affinity. Therefore, we initiated a detailed survey to document its stability and to look for possible controlling factors.

The site is approximately three ha, located on nearly level glacial outwash with loamy sand soil, identified by Peck and Lee (1961) as Oshtema-Gotham series. Climate is temperate continental with mean annual rainfall of 79 cm, mean July temperature of 21 C and mean January temperature of about –10 C. The site lies near the southern margin of the “transition zone” between the prairie-oak forest region and the northern conifer-hardwood region, as defined and mapped by Curtis (1959). The climate is highly variable in the annual rainfall, snow cover, and frost-free days; both drought and frost often occur during the average growing season of about 25 May to 5 September, while severe wind storms, hail, lightning, or freezing rain may damage trees almost any year.

The earlier study (Whitford and Whitford 1971) indicated canopy trees of three essentially even-aged size classes: a few large survivors of the original pre-settlement savanna; about two-thirds with origins dating to roughly the first decade of white settlement (circa 1835–1845), and less than one-fourth of more recent origin. Density and BA/ha were well under half those typical of mesic closed forests in Wisconsin, but 75–90% of values given for xeric forests in southern Wisconsin by Cottam (1949) and Curtis (1959). Canopy cover of about 40% and heights averaging 45 ft (13.7 m) as well as low density put this stand in savanna or “woodland” category rather than forest (Dyksterhuis 1957). Thus, in
spite of an apparent increase in tree density related to early settlement, the canopy had, in 1968, remained relatively open and increase in density had been very slow or none in the past century. The stand had reached another level of stability rather than succeeding to a typical closed forest as postulated by Curtis (1959) and others. The size class structure of the stand, very low in 10–25 cm dbh classes and almost lacking in saplings, was distinctly different from that of typical forest sites.

Since the 1968 survey, sporadic casual observations of this site indicated further changes not anticipated by the earlier study, mainly due to severe losses of canopy trees from oak wilt (*Ceratocystis fagacearum*) with replacement mainly by black cherry (*Prunus serotina*). Yet, it remains similar in aspect to the savanna described in 1971, so we resurveyed the site in 1989 to document the changes and reassess its relative stability.

**METHODS**

As in the 1968 survey, we analyzed canopy trees (>10 cm dbh) by the point-centered quarter method (Curtis 1959) at 30 points (120 trees), seedlings and saplings in 40 random quadrats, each 2 × 2 m, and ground layer species in 40 quadrats of 1-m square. Height of 10 random individual oak canopy trees was measured with an Abney hand level and canopy cover was estimated using a handheld sighting grid (the same observer estimating in both 1968 and 1989 surveys). Because of the observed mortality, in the 1989 survey we also noted standing dead trees or stumps judged to have been cut in the past 20 years if they were closer than the nearest live tree in each compass quarter, i. e. where the tree’s death resulted in greater point-to-tree distance.

Terminology and measures used are the same as those in the original 1971 paper so that data reported are directly comparable between studies. Basic measures used are common to forestry and early ecological assessment studies and each is briefly explained below:

- **DBH** Diameter at breast height. This is a standard measure of tree size used in forestry. Breast height is standardized as 4.5 feet above the ground.

- **BA/ha** Basal area/hectare. Calculated as the sum of cross sectional area of all tree trunks at one foot above ground level (usually for a given species) within a one hectare area. Used with the dbh information, it provides a means to clearly describe stand density, age, and relative species abundance.

- **I.V.** Importance Value. This again is a single number that is meant to provide a reader with appropriate background an ability to glean a mental image of the area described in terms of species present, their relative numbers and sizes. This single number is calculated for each major species in the study area as the sum of three values: relative density, relative frequency, and relative dominance. Each of those numbers is expressed as a percent value based on the total for that species for all sites sampled. Thus I.V. must always be a number between 0 and 300 since that represents the minimum and maximum values possible when adding from three groups totaling 100% each. Sampling was by quadrat method where cardinal compass directions are used to form four quadrats.
around a randomly chosen sample point. Distance to the nearest tree in each quadrat is measured and its species name and dbh is recorded. The species of the tree with the greatest measured canopy area in any of the four quadrats is also recorded. Thus, relative density for a species is the fractional percentage of total sample plots where that species was considered the species with the greatest stem density for the four quadrats sampled. Relative frequency for a species is an expression of the number of sample sites where an individual of that species was the tree closest to the plot center, expressed as a percentage of the total number of sites sampled. Thus, if 34 of 100 plots had a red oak tree as the nearest tree of the four trees used to define the plot, that species would have a relative frequency of 34.0. Relative dominance is an expression of the number of sample sites (of the total) where a given species was designated as the dominant canopy species within the four quadrants. Thus, percent of total plots where Hill’s oak was the dominant canopy species is its relative dominance.

RESULTS

The most obvious change in canopy trees is the decline of both Hill’s and red oaks (*Quercus ellipsoidalis* [*Q. coccinea*] and *Q. borealis* [*Q. rubra*]) and some hybrids (Table 1). This resulted from oak wilt, which severely affected the stand starting in the early 1970’s. Replacement is mainly by black cherry, which now shows 31.6% relative density. One red pine (*Pinus resinosa*) was present in 1968

**TABLE 1.** Summary of tree data from quarter method samples. Table values shown below are approximate due to omission of one red pine, and one white pine, from point-centered quarter plot data used for constructing the tables for 1968 and 1989, respectively. Values shown from quarter plots are reproduced directly from the original manuscript. R. Dens. = relative density, R. Freq. = relative frequency, R. Dom. = relative dominance, I.V. = importance value.

<table>
<thead>
<tr>
<th>Species</th>
<th>Sample of 1968</th>
<th>Sample of 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill’s oak*</td>
<td>66.7 60.5 61.4 188.6</td>
<td>49.2 39.0 54.4 142.0</td>
</tr>
<tr>
<td>Red oak</td>
<td>31.6 35.5 38.0 105.1</td>
<td>12.5 19.0 22.7 54.2</td>
</tr>
<tr>
<td>White oak</td>
<td>1.7 4.1 0.6 6.4</td>
<td>3.3 6.0 5.8 15.1</td>
</tr>
<tr>
<td>Black Cherry</td>
<td>— — — —</td>
<td>31.6 32.0 11.9 75.5</td>
</tr>
<tr>
<td>Red pine</td>
<td>— — — —</td>
<td>2.5 3.0 3.7 9.2</td>
</tr>
</tbody>
</table>

| Density:       | Trees/Acre 91.9 Trees/ha 227.1 | Trees/Acre 67.7 Trees/ha 167.3 |
| Basal area:    | BA/Acre 95.2 ft$^2$ BA/ha 21.87 m$^2$ | BA/Acre 29.5 ft$^2$ BA/ha 6.77 m$^2$ |
| Average BA/tree: | 148 in$^2$ 956.9 cm$^2$ | 62.8 in$^2$ 405.2 cm$^2$ |
| Average dbh:   | 13.7 in 35.1 cm | 8.95 in 22.7 cm |

*Hill’s oaks are mainly *Q. ellipsoidalis* but may include hybrids.
but was not included in the sample; in 1989 two red pines and one small white pine (*P. strobus*) were tallied.

Average BA is now less than one-half that of 1968 and average dbh has now dropped by one-third. Density (trees/ha) declined by more than one fourth (Table 1). Density of seedlings and saplings was 0.97/m², of which over three fourths were <1/2 m tall; this compares to 0.89/m² in 1968, an increase of <10%. Oaks comprised 70% of the seedlings sampled and black cherry 27%. Many of the larger oak seedlings showed partial die-back, as noted in 1968, and some were completely dead.

Herb data showed the three species of highest frequency in 1968 (*Carex pensylvanica*, *Euphorbia corollata* and *Amorpha canescens*) are still highest and in the same order, while most of the other species common in the first survey are still present, most in the same magnitude of frequency as before.

**DISCUSSION**

Oak wilt infections developed at a few sites in this stand by the early 1970’s. These have continued to spread slowly, though we have no data on dates or numbers of trees dying each year. Most dead trees were removed within a few years after death for salvage as firewood. In the 1989 survey our tally of dead trees and stumps within the sample area showed that 21 points of the 30 sampled had a total of 34 dead trees and stumps, which gives a good indication of the extent of loss. At least one tree was killed by lightning during that time and others may have been injured by wind or ice storms or lightning, which would provide entry for the spores of the oak wilt. The data on diminished tree density and basal area noted above reflect the severe loss of the older oaks during this period.

Oak wilt is apparently an endemic fungal disease in this region (Curtis 1959). It is normally fatal to red or Hill’s oaks, which together made up over 99% of BA
for the study site in 1968, and both species show severe declines in both density and dominance by 1989. White oak (Q. alba) has some resistance to the wilt organism and has doubled in importance value (6.4 to 15.1) between the first and second sampling.

Replacement of the oaks is mainly by black cherry, which in 1968 was noted as one tree in the stand but not tallied in the sample. This species is common on surrounding lands as scattered trees along fences, roadsides and any open untiled sites. Presently black cherry has 31.6% relative density, although these are small young trees and make up only 11.9% of relative dominance. Since most of the oaks lost were canopy trees of >25 cm dbh, there is a severe decrease of about one-third in average dbh, while average BA is now <1/2 that of 1968. This decrease in average size, combined with the loss in trees/ha (227 to 167), results in a drop of about two-thirds in BA/ha. Surprisingly, the average of estimated canopy values has dropped by less than one-fourth i.e. from 40% to 31.2%. This evidently reflects the low canopy value relative to BA noted in the stand in 1968 (see Whitford and Whitford 1971), which showed much loss of branches due to varied storm damage over the years. The greater vigor and rate of growth of the younger remaining trees now maintains a relatively greater canopy.

The importance of black cherry as a replacement species is not surprising; it is common in the area around this stand and produces abundant fruits which are readily and widely dispersed by birds. The seeds apparently can survive for years dormant in the soil and germinate quickly when increased light and warmer soil follow loss of canopy. Its shade tolerance is rated as intolerant to intermediate; young seedlings are more tolerant and can survive in partial shade for some years until released (Curtis 1959, Auclair and Cottam 1971). Both seedlings and saplings grow vigorously given enough light, so that saplings may reach 10 cm dbh and 7 m in height within 15 years. For these reasons Auclair and Cottam (1971) stated that “black cherry occupies a key position in the oak forest of southern Wisconsin.”

It should be noted that the cherry invaders tend to be in rather dense clumps on sites where oaks had died within the past 20 years. Very few cherry seedlings or saplings were found in the larger, older openings where herbaceous species were dense. This may reflect uneven distribution of the seed bank, with most of the seed deposited by birds under former perch trees; it may also reflect less root competition with herbs where canopy of the now-dead oaks had inhibited ground-layer species. Oak seedlings were more evenly distributed and comprised 70% of all seedlings tallied, although most were small (<1/4 m tall).

It appears that very few tree seedlings in the open grassy areas of the savanna survive to become saplings and finally canopy trees. As noted above, and in results in the earlier paper, many larger seedlings showed partial die-back, some were completely dead, and few appear to survive beyond about .5 m in height. Our conclusion in 1971 suggested a very high mortality of seedlings. We believe the edaphic condition of droughty, nutrient-poor outwash sand retards growth and reduces vigor, which is compounded by competition and possibly allelopathic effects of dense sedge/grass/forb competition in the openings. Further, the micro-climate in this low, nearly level site is basically a broad “frost pocket”
where cold air settles in on clear still nights. We have often observed frost damage in these low sites in early June and once as late as July 5.

The frost damage blackens half-developed to nearly mature leaves of the seedlings while the older higher canopy trees are not damaged, nor are those on higher ground. Seedlings already barely surviving from drought or edaphic and biotic factors may be killed by one or more such late frost events. While deer are abundant in the area and do tend to browse tree seedlings, they do not seem to be a major factor here, as most of the dead branches show intact buds at the tips.

Our conclusion of high mortality of seedlings seems to be true. It would be nearly impossible to pinpoint a single causal factor, but the net result is the tendency of savanna openings in such sites in central Wisconsin to remain open.

It appears that this stand, despite changes recently initiated by oak wilt, will remain a savanna in the foreseeable future, with an increase in the proportion of cherry in BA and I.V. totals and with the cherry mostly grouped in sites which had been under oak canopy in 1968.

The larger openings will probably stay open and grassy and the larger oaks will probably continue to decline slowly in the numbers with some oak saplings as well as cherry eventually growing into the canopy at the edges. Fire is not needed to prevent closure of the forest under this combination of factors and with oak wilt apparently periodically removing trees and assuring that only widely spaced oaks without overlapping roots (which permit the disease to move from tree to tree and achieve 100% kill in dense growth situations) survive to form the dominant canopy trees of a largely self-perpetuating sand country savanna opening.

Epilogue – 2007

Drought conditions of 2004 and 2005, coupled with summer power line clearing efforts that limbed nearby oaks leaving them susceptible to oak wilt spore contamination, have resulted in a third outbreak of oak wilt in the study site and several adjacent areas. From the 1989 data collection to the beginning of the most recent oak wilt infestation the study site retained the relatively open canopy, grassy understory, and limited sapling survival described in my parents manuscript. As such, it still has the characteristic appearance of the dry sand-based savanna I recall from my youth and from the 50 years I have walked it regularly since we first bought the farm. What stands out most in hindsight and fifty years watching the effects of oak wilt is the difference in mortality between dense stands of young oaks that have sprung up in abandoned fields and fence lines on our property and that of neighbors, and that of the savanna oaks. Oak wilt regularly approaches a virtual 100% spread and kill in those dense stands of disturbed sites where overlapping root masses can carry the fungus tree to tree. Yet, in the open savanna, like that my parents researched, the canopy trees are widely spaced with intervening dense grass, sedge and forb communities. Their work implied that this dense herbaceous understory limited sapling size and survival (and thus sapling root spread). If that is true, as it appears, then the dense herbaceous cover essentially assured that roots of canopy trees would not overlap with those of other oaks that might spread the fungus to and/or between them. In my experience and observations it has only been the recently damaged
canopy trees that develop oak wilt and die in the savanna, while I’ve watched all of the 50–60 year old oaks of our third mile long west fenceline die enmass in the space of less than 4 years. What accounts for the difference? On that once over-pastured, disturbed, fence line plot average distance between mature oak trees was less than 30 feet—assuring continuous root to root transmission of the disease.

LITERATURE CITED


U.S. General Land Office Survey. (1851). Unpubl. mss. Field notes of the original public land survey, by various surveyors, on file at Commission of Public Lands, Madison, WI.