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A floristic survey of Fontenelle Forest and Neale Woods nature centers.

Gary Garabrandt

A HISTORY OF LAND USE IN THE OAK-HICKORY WOODLAND OF FONTENELLE FOREST

A Thesis

Presented to the

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and the

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In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

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THESIS ACCEPTANCE

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INTRODUCTION

When contemplating a stand of timber a forest ecologist knows from experience that during its life history the stand has been shaped and influenced by a bewildering array of interacting phenomena. A few of these interacting forces might include climatic fluctuations, soil development, fire, windstorms, land use, and insect and disease epidemics (Spurr, 1964).

An exciting and challenging project the forest ecologist can undertake is to select a stand of timber, isolate one or more of these influencing forces, and attempt to demonstrate how those forces have affected the stand's life history. Land use is one of those forces. Although a few unlogged remnants of old-growth timber still exist, the composition of most of our native American forests has been altered to some degree by human occupancy and land use disturbance.

The forest ecologist or biological historian who documents the land use history of any given stand of timber will uncover evidence of such things as logging, complete land clearing, domestic grazing, deliberate burning or combinations of all these on the same plot of ground. The attempt to unravel a history of land use in a forested stand is especially challenging if the study area is fairly large and is a patchwork of successional communities ranging from recently abandoned fields to remnants of old-growth forest.

At the outset of the investigation, the biological historian

knows nothing of where these successional communities are located, how many exist, how large an area each covers, or what sort of land use disturbances have influenced their development. The challenge is to locate the communities, map their boundaries, and determine the nature and intensity of the disturbance that created them in the first place.

In this paper I will develop a land-use history for 130.3 hectares (322 acres) in the north half of a roughly 233.4 hectare (577 acre) region of oak-hickory woodland in the upland portion of a wooded reserve known as Fontenelle Forest. This reserve is located along the west side of the Missouri River in Sarpy county, Nebraska, just a mile south of Omaha.

In Nebraska, extensive alteration of the native flora began in the mid 1850's when settlers were officially allowed to enter the newly formed Nebraska Territory. Many of these newcomers went out onto the treeless prairies, took up the plow, built homes from the prairie sod and made their living from the bounteous "Great American Desert". But a number of settlers went no further into Nebraska than the wooded bluffs along the Missouri River. There they took up axes, built sawmills, and for a time thrived by supplying lumber to nearby communities or fuelwood to the constant stream of steamboats plying the Missouri River. Later, with their timber supply nearly depleted, a few turned to small scale farming, terrain permitting, or dairy farming on the logged-over slopes.

In Fontenelle Forest this pattern of land use was slowly phased-out beginning in 1913. That year a small group of citizens incorporated, calling themselves the Fontenelle Forest Association, and purchased a portion of the wooded bluffs between Omaha and Bellevue. Their goal

was the creation of a natural woodland park or reserve.

The venture was successful, and by 1925, most of the present 233.4 hectares in the upland had been included in the reserve. However, several tracts have been included since that time, and in a field recently added to the reserve, farming continued until 1962. Whenever a newly acquired property was added to the reserve, disturbance ceased, and the Association usually allowed the land to recover naturally without the aid of artificial planting or other form of management. Since the Forest was put together piece-meal over a period of time, and because the pre-Fontenelle Forest landscape was divided into many different properties, the land use history of the area is fairly complex.

One of the interesting peculiarities about the Forest's upland is that while in one part disturbance may have continued until 1962, in other parts disturbance actually ceased decades before the land was placed under protection in 1913. For example, the pioneer who owned a large estate in the north half of the Forest used his land very selectively, removing only the trees that he wanted. By the mid 1870's he quit logging, allowing most of his land to remain idle. In this area the forest has had a century to recover without any subsequent human disturbance. In the passage of time this landowner and others who once owned land in the bluffs of Fontenelle Forest have been forgotten. Their personal histories were never recorded and no one left a record of their activities as land users. Because these people have been forgotten, and because the woods in some parts of the Forest appear at first glance to be old-growth, undisturbed timber, it is easy to assume that natural forces alone have shaped the plant community that exists there today.

When I began working at the Fontenelle Forest Nature Center in 1970, naturalists employed there at the time had formulated a theory regarding the development and life history of the forest plant community. This theory rested solely on the basis of natural phenomena. Fire, or in some cases lack of fire, was regarded as the principle shaper of the forest ecosystem and the influence of human disturbance was not considered. The details of this fire theory and its application to Fontenelle Forest will be covered in detail later. For the time being it is sufficient to state that while fire is an important force in the life history of a stand of timber, in Fontenelle Forest, it is not the only force that has shaped the present plant community.

The research for this manuscript was inspired in part by my desire to learn something about the lives of the forest pioneers, and also because the human-influenced successional communities must be identified before we can properly interpret the life history of the timber stand in the Forest's upland bluffs.[1]

[1]A large amount of information was gathered during the course of this study and it is impractical to include all of it in this paper. The results and discussion section of this paper will only cover land use in the north half of the Forest's upland, which is interesting ecologically for it contains the most mature stands of timber. Within this 130.3 hectare region are remnants of undisturbed old-growth timber, and areas that were logged selectively or heavily only once during a short time period and then allowed to recover. Copies of the information on land use in the remainder of the Forest's upland are available from the Fontenelle Forest Nature Center, and the Biology Department of the University of Nebraska at Omaha. This material covers areas that sustained heavy logging over a period of several decades, cultivated areas, an area in the vicinity of a trading post and Indian agency which operated from approximately 1823 until 1840, and areas where the flora is dominated by species introduced by planting.

PHYSICAL FEATURES OF FONTENELLE FOREST

Location

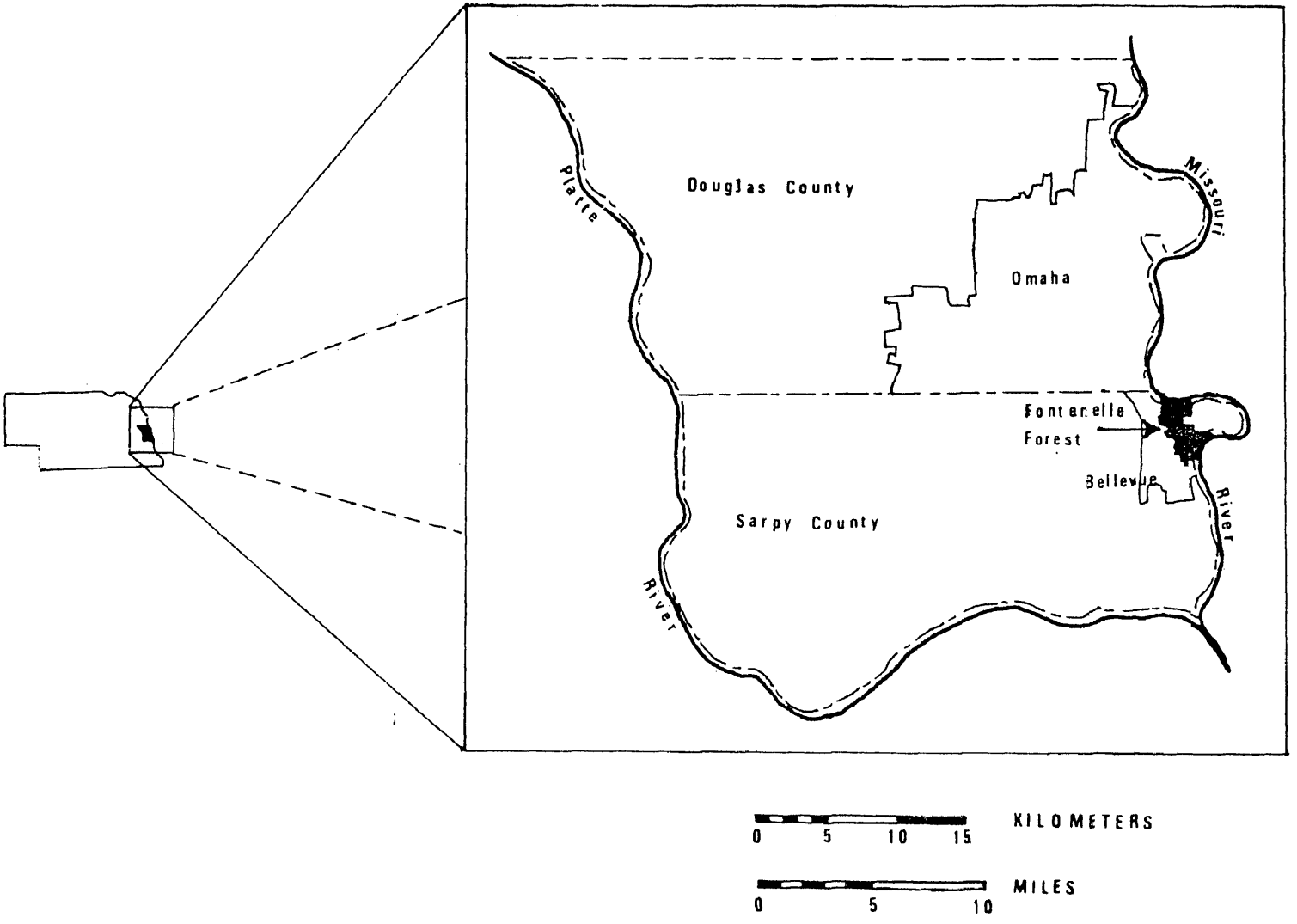
Fontenelle Forest is located on the west side of the Missouri River in the northeastern corner of Sarpy county, Nebraska. This reserve, containing over 495.6 hectares (1,200 acres) of deciduous woodland, extends nearly 4.827 kilometers (three miles) in length, and 1.609 kilometers (one mile) at its widest point. It occupies parts of sections 13, 14, 24 and 25 in township 14 north, range 13 east, and parts of sections 18, 19 and 30 in township 14 north, range 14 east. Roughly half of the Forest's total area lies in the floodplain of the Missouri River, and the remainder, in the loess bluffs bordering the floodplain (Map 1).

Geology

The geology of the Omaha-Council Bluffs area has been thoroughly described by Miller (1964). The underlying bedrock in the Forest area consists of alternating layers of limestone and shale of the Kansas City and Lansing Groups of the Missouri Series of Late Pennsylvanian age. Of the more recent Lansing Group there are outcroppings of the South Bend Limestone Member of the Stanton Limestone exposed in places at the base of the Forest's bluffs. In early pioneer days these outcroppings supported several small-scale limestone quarry and kiln operations. One of these quarries was located near the Forest's southern border.

The Kansan Till of Pleistocene age uncomformably overlies the bedrock. This till consists of a mixture of small boulders, rocks, pebbles and sand. Overlying the till is a fluvial sand and gravel deposit of late Kansan age called the Grand Island Formation. In the Forest the Kansan

Map 1. Nebraska and location of Fontenelle Forest in northeast Sarpy county.

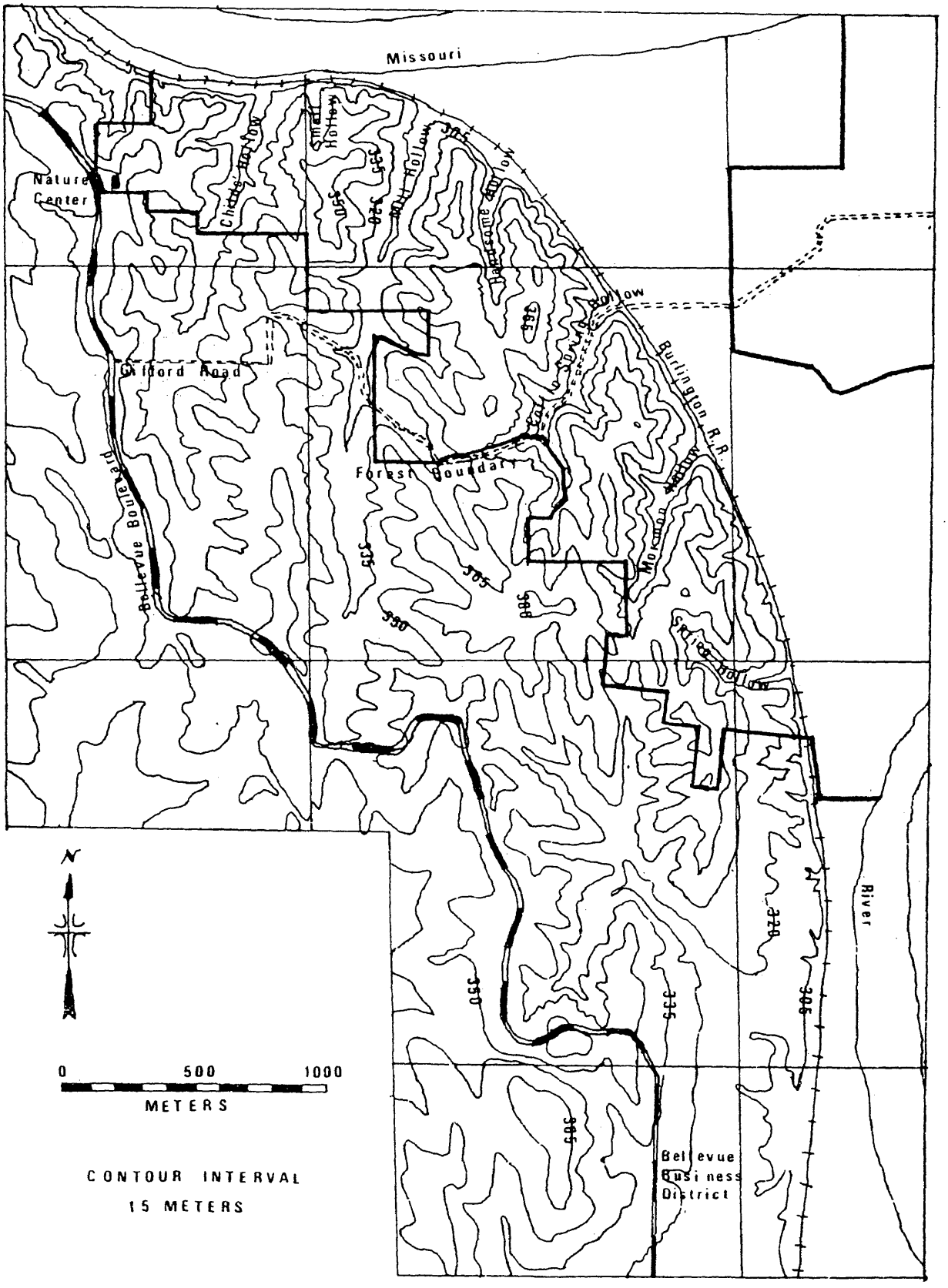


Till and Grand Island Formation are exposed continuously for about a mile along the base of the bluffs north from Gifford Road (see Map 2 for place names). These layers, which are from 15 to 2 meters thick, contain numerous pure, cold water springs.

Overlying these strata are massive deposits of eolian silt, called loess, which constitute the major geologic feature of the entire Omaha-Council Bluffs region. The oldest deposit of the clayey silt is the Loveland Loess, believed transported here by winds during the latter part of the Illinoian Glaciation. On the upper surface of the loess is a thin layer of soil formed during the Sangamon Interglaciation. Two lesser deposits, the Peorian Loess and Bignell Loess, were deposited during the early and land part of the Wisconsin Glaciation respectively. Loess accumulation is as much as 67.5 meters (220 feet) thick in the Fontenelle Forest area.

Physiography

Erosion of the loess by intermittent streams flowing from the upland toward the river, and by headward erosion from the floodplain, has dissected the Forest upland into several deep, steep sided, roughly parallel ravines, with elongated, narrow ridges between. Within the larger ravines, smaller lateral ridges and ravines have developed. These enter the main ravines at roughly right angles. The lateral ravines have extremely steep sides, and some are nearly vertical. The steep slopes are fairly stable as long as the vegetation cover remains unbroken. However, severe erosion occurs rapidly when this protective cover is removed. Overly-steep trails and children sliding down steep banks present a constant maintenance problem in the Forest.



Map 2. Topography and place names of Fontenelle Forest upland and surrounding area.

Just south of the Forest's boundary the upland topography changes. The slope from the river valley to the first upland ridge becomes gradually less steep, and finally blends into a near level terrace of Wisconsin age on which the business district of Bellevue is built. The terrace surface is about 21.3 meters (70 feet) above the floodplain.

The area of dissected bluff land in northeast Sarpy county is estimated roughly as 647.5 hectares (1,600 acres). Bellevue Boulevard, which runs along the west side of this area, more or less follows a series of ridgelines which separate the dissected bluffs from the more undulating land to the west. Drainage west of the boulevard is west or southwest to Mud Creek and the Papillion Creek. Except for entrenched drainageways, the land surface west of the Boulevard is high, with undulating hills. The transition to the rugged terrain east of the Boulevard is abrupt (Map 2).

Soils

Two types of soils occur in the Fontenelle Forest area (Bartlett, 1975). The most extensive are the Monona and Ida Silt Loams found on 30 to 60 percent slopes which are too steep for cultivation. Here runoff is rapid and water erosion of the soil is a main hazard. A less extensive soil of the Forest is the Monona Silt Loam found on 3 to 7 percent slopes. This soil is tillable, and suitable for corn, alfalfa and soybeans. Runoff is medium on these slopes, but rills and gullies will form in cultivated areas.

Climate

The climate of Sarpy county, Nebraska is continental. Summers are warm, winters cold and rainfall is moderate. Annual precipitation averages 28.4 inches (Table 1). About three-fourths of this falls between April

Table 1

Temperature and precipitation data

(adapted from Bartlett, 1975).

Month	Temperature		Precipitation
	Average daily Maximum	Average daily Minimum	Average total
	°F.	°F.	Inches
January	31	13	0.7
February	36	17	0.9
March	47	28	1.4
April	62	41	2.6
May	73	53	3.8
June	82	62	4.6
July	88	67	3.7
August	85	65	3.4
September	77	56	3.1
October	66	44	2.1
November	49	30	1.2
December	36	19	0.9
Year	61	41	28.4

and September as a result of southerly winds that bring moist air up from the Gulf of Mexico. Winter precipitation is usually in the form of snow which averages 32 inches annually (Bartlett, 1975).

Natural Vegetation

Fontenelle Forest is part of a narrow strip of eastern deciduous forest which has developed in eastern Nebraska along the Missouri River and the lower portions of its tributaries. Aikman (1926) first described the structure of the plant communities in this band of woodland. Aikman divided the upland forest communities into three main associations. These are, in order of increasing mesophytism; the bur oak-bitternut hickory (Quercus macrocarpa-Carya cordiformis) association; the black oak-shagbark hickory (Quercus velutina-Carya ovata) association; and the red oak-American linden (Quercus borealis-Tilia americana) association.

According to Aikman, the red oak-American linden association is found on north slopes and protected ravines. Black oak and shagbark hickory dominate on well drained slopes where conditions are slightly more xerophytic. Bur oak and bitternut hickory occupy the most xerophytic slopes and tops of ridges.

METHODOLOGY AND PRELIMINARY RESULTS

Usually, when a researcher decides to investigate a problem in plant ecology, there are standard patterns to follow. After defining the problem the investigator selects a number of study sites using a systematic or random method, then investigates each site using a sampling method that seems most appropriate. But in a study such as this, where the researcher

is attempting to reconstruct a total picture of past land use in a given geographic area, the investigative procedure is not so clear.

In a land use study one does not select study sites in the traditional sense. The sites are already there, their size and locations determined decades or centuries ago by persons who did something to alter the original native vegetation. Each site, or land use area, is a successional plant community, its flora more or less distinct in age and appearance from adjacent land use areas. The distinctions are sometimes obvious, sometimes subtle depending on severity of disturbance and time elapsed since disturbance.

Occasionally a land use area is easily located. The successional plant community in an abandoned field, for instance, is easily distinguishable from the more mature forest surrounding the field.

While old fields are an interesting part of the Forest's land use history, the real challenge in this study was the Forest's northern half. Here I wanted to know whether areas that were assumed to be untouched, except by fire, indeed had a history of human disturbance, and also, whether actual remnants of undisturbed timber, if they existed, could be distinguished from places that had been only slightly disturbed.

In order to cope with the varied aspects of the study, my investigative procedure had to be flexible. Three somewhat independent investigative efforts proved valuable: historical, biological, and dendrochronological.

The value of investigating land use from several different perspectives is that if one line of research fails to yield adequate information then another method can be substituted. More important, several lines of research can be used simultaneously, and information gained from any one

method complements information from the others, adding strength and credibility to the overall findings. The method are as follows:

Historical Research

1. Notes From the Land Office Survey of 1855-1856

In 1855 and 1856, U. S. Government survey teams established the locations of townships, ranges and sections of Sarpy county. The hand-written, compiled notes from these surveys, entitled Field Notes of Original Survey of Sarpy County 1855-1856, are available at the county surveyor's office in Papillion, Nebraska.

I used these notes to locate the prairie-forest border, squatter claims, roads and structures. The Fontenelle Forest region was surveyed in June, 1856, by a team headed by Deputy Surveyor John Paynter. When surveying from west to east, Paynter noted the exact chainage where the vegetation cover changed from prairie to forest. This transition was often abrupt, and occurred when the high, rolling upland on the west met the rugged, broken topography of the river bluffs (Map 2). Paynter also mentioned encountering roads and other man-made structures in this area.

2. Title Abstracts

Title abstracts, although usually voluminous, filled with legal jargon, and difficult to follow, are frequently helpful in land use research. An abstract to a particular tract of land, or tax lot, gives the names of the various owners, locates the property's boundaries, and sometimes gives clues about land use.

Once I had established a property line on paper I could usually find it in the forest in the form of a long buried fence, blaze line, or

property stakes. Since tax lots are often separate land use areas, knowing their size and locations on paper saved countless hours of searching for them in the field.

3. Personal Interviews

By contacting individuals who had been regular visitors to the Forest for many years, I acquired a small collection of old photographs taken in the Forest as long as fifty or sixty years ago. These photos, by revealing the condition of the land years ago, dramatize the change that has occurred since.

Mr. Edward Sterba, President of the Sarpy County Historical Society, proved a valuable source of local history. He was not only knowledgeable about the area, having grown-up near the Forest, but provided valuable old maps and photographs of the Forest area.

The most valuable source of historical information was Mr. Charles Everard Childs, grandson of pioneer landowner and sawmill operator, Charles Childs, whose activities as a land user will receive close scrutiny in this paper. C. E. Childs provided deeds, tax receipts, family history, and even photographs taken by himself as a boy on his grandfather's land at the turn of the century. Correspondence between Mr. Childs and me resulted in a brief published history of the Childs family (Garabrandt, 1976), and culminated in my visit to Mr. Childs' estate in Vermont a few months before he died in December, 1976, at age 84.

4. Physical Evidence of Settlers' Activities

Features such as old logging roads, fences, and the remains of structures are usually not found on maps or in the abstracts and can only be located by careful field observation. Using a metal detector, I traced

the courses of buried wire fences, and verified the location of the original Childs' homestead and sawmill site.

Biological Research

1. Forest Ecology

Searching for evidence of land use in a forest involves exploration for features or changes in the plant community which have no apparent natural explanation. Since differing microhabitats throughout a forest are also responsible for changes in the plant community (Spurr, 1964), it is useful to know enough about the ecology of an area to be able to distinguish between the two. For example, when walking a transect up a slope from the mesic lower slope to the xeric upper slope, one expects to see a change in the plant associations due to decreasing soil moisture. However, one must keep in mind that a former landowner may also have noted these association changes and used them to his advantage, cutting certain species from one association while leaving the other associations untouched. Thus, as one proceeds up the slope one encounters differences between the associations caused by land use that are superimposed on the natural differences caused by changing soil moisture. By being familiar with the ecology of the associations one can usually see through the natural changes and detect the superimposed changes caused by land use.

During the course of this study I became aware of apparent discrepancies in several published reports concerning the ecology and distribution of deciduous tree species in Nebraska. For example, maps published by Aikman (1926) show the black oak-shagbark hickory association extending north of Fontenelle Forest into Douglas county. Other authorities have also reported black oak in Fontenelle Forest (Pool, 1951, Omaha Botany

Club, 1959). However, I am convinced after years of searching, that the species is not found in the Forest. Black oak does enter Sarpy county, however, and grows on the bluffs of the Platte up to a point about ten miles west from the river's mouth. Near the terminus of the species' range, I have found it growing only near exposed outcroppings of sandstone and limestone bedrock. Since Fontenelle Forest is slightly beyond the range of black oak, shagbark hickory forms an association with bur oak on well drained slopes.

Aikman's designation of a bur oak-bitternut hickory association also seems inaccurate. Bur oak grows on hilltops and drier slopes but bitternut is not so confined. In Fontenelle Forest and other wooded areas bitternut sometimes grows with bur oak as Aikman described but more often is found in stands on mesophytic lower slopes and valley bottoms in association with other species. Bitternut distribution may be influenced by something other than soil moisture. More information on this is included toward the end of the Methodology and Preliminary Results section.

2. Plot Sampling

When I began this study, I intended to provide a land use history and do enough vegetation sampling in each land use area to describe adequately its vegetational composition. This would provide specific quantitative data on how the plant community in each site had been altered by disturbance.

However, as the field work progressed, it became evident that the total land use history was very complex, and the number of areas with distinct land use histories more mumerous than I had anticipated. I soon concluded that documenting the pattern of land use for the area would be

possible, but that quantifying the actual effects of various types of land use on the area's flora would not. Although vegetation frequently reflects land use, I decided I could not study both, and abandoned the vegetation sampling. But before abandoning the sampling, I investigated fifty-nine rectangular plots measuring 10 x 20 meters, of which thirty pertain to this paper. Having chosen plots which appeared to be most representative of any given land use area, the data I obtained, although statistically unreliable, will still be useful in describing the present appearance of the land use areas in a general sense. I will refer to these plots for information on slope aspect, degree of slope, heights of vegetative strata, and the presence or absence of certain species.

Dendrochronological Methodology

The growth record of a tree can be obtained by examining prepared cross sections, pie-shaped sections, or more often, from increment cores. Increment cores are long, pencil-like cylinders of wood extracted from one or more radii of a tree, using a hollow auger device called an increment borer. Once a core is carefully dried, sanded and polished, the annual rings can be examined, revealing a tree's chronological history.

Using either a 30.5 cm or a 40.7 cm increment borer, I sampled trees throughout the study area. When taking an increment sample from a tree, I recorded the species, diameter at breast height (dbh), and the radius(i) direction from which the core(s) were taken. After the core was removed, I plugged the holes with short pieces of .5 cm wooden dowel to prevent entry by fungi or insects.

I also took notes on the general appearance of the sampled tree, its crown and branch development, its distance and direction from other trees sampled, and its size in relation to other trees in the stand.

When sampling sprouts, I recorded the number of stems but usually measured and cored only one.

Sampled trees were marked by nailing a numbered brass tag near the base. Other trees sampled within the thirty plots (usually understory trees), were not marked individually, but the plots were marked with aluminum tags nailed to the base of each plot's largest tree.

Dendrochronologists working at the Laboratory of Tree-Ring Research in Tucson, Arizona, have standardized the methods of increment core preparation and ring counting. These methods are described in detail by Stokes and Smiley (1968) and Fritz (1976).

I allowed the cores at least three days drying time before gluing them to a 45 cm long, square wooden stick, or mounting tray, which had a groove cut into it to receive the core. When gluing the cores to the tray I positioned them so that the vessels of the annual rings were clearly visible. The cores were held in place by wrapping them tightly with twine until the glue hardened. I then sanded them with medium and fine grades of sandpaper, finally rubbing them with fine steel wool. The latter procedure polishes and removes sawdust from the vessels, making the annual rings easier to see.

Counting from the bark end and working toward the pith, I determined the year in which each annual ring was formed. Decade, half century and century rings were marked with one, two or three pin pricks, respectively. I counted rings by eye or used a low power dissecting scope.

Where a core is broken or has a piece missing from the bark end, the year each ring was formed can still be determined by cross-dating. Cross-dating, one of the basic techniques of dendrochronology (Estes, 1970, p. 299)

> "is the recognition of certain patterns or sequences of wide and narrow rings that occur consistently in specimens taken from different radii of the same tree, or from different trees at the same site, or even from trees at several sites some distance apart."

The Increment cores yielded three categories of information:

1. using the borer to determine the location of even-aged stands that were once logged, and the presence of old-growth stands of timber.

2. using the borer to date logging disturbance by searching for trees showing release (growth acceleration) in response to thinning of the forest around them.

3. dating logging by taking increment core samples from stump sprouts.

In Fontenelle Forest there are secondary stands that were logged so long ago that the trees have reached maturity and it is difficult to distinguish these stands from old-growth stands on the basis of tree diameter. Therefore, in the first procedure several of the largest trees in a stand were sampled and their ages determined. This revealed whether the stand was even-aged or if it was old-growth. An even-aged stand is a form of secondary succession where the individuals entered at approximately the same time, because suddenly much space was available (Braun, 1964). Thorough logging, where only saplings and seedlings are left uncut, results in an even-aged stand. An all-age or old-growth stand is generally a primary or virgin stand, where individual trees have germinated at various times, space permitting (Braun, 1964).

The second procedure involves sampling for trees showing release. When a tree is growing under an overtopping canopy stratum, it is suppressed and its annual increment of wood is small. But if loggers remove the large canopy trees reducing competition for previously suppressed saplings, these saplings experience a sudden and sometimes dramatic increase in their annual increment growth, a phenomenon known as release (Braun, 1964). When a stand is thinned, remaining trees release the following growing season (Minckler, 1957), therefore release not only indicates once present logging, but dates the logging event as well.

A tree can also release when fire destroys competing trees around it, or when a windstorm knocks over some of the overstory trees (Spurr, 1964). However fire and wind have little respect for property boundaries, hence the value of studying title abstracts and knowing the locations of property lines. When trees on opposite sides of an old fence line release at different times, one can usually rule out fire or wind as the cause.

The drawback in sampling for trees exhibiting release is that when first entering a stand of unknown history, it is difficult to decide which trees to sample. Although the choice is somewhat subjective, it is safest to assume that the stand was once logged and then sample several representative maximum diameter trees. If the stand was indeed logged and the sampled trees were present in the stand as young suppressed individuals when logging took place, then they generally exhibit release. I found that in a logged, even-aged stand, the trees exhibiting release are the oldest trees in the stand as well, so the stand's age can be determined and the year of logging ascertained from the same trees. If

the stand was only lightly logged, or is undisturbed old-growth, this procedure will not uncover release, but it will reveal the stand's age.

From different land use areas I selected several increment samples showing release and measured the rings with a dendrochronograph. Charts showing the growth rate of these trees, before and after release, are included in the discussion and results section.

I discovered that the most reliable method of determining the exact year a stand of timber was logged was the third procedure, taking increment samples from stump sprouts. Roth and Hepting (1943) studied sprouting in oak species and determined that a stump usually produces six to eight sprouts the first growing season following cutting. These sprouts originate from dormant buds near the ground around the root collar. Within five years one to three sprouts die. In Fontenelle Forest I encountered sprouted specimens of bur oak, red oak, green ash, black walnut, shagbark hickory, and occasionally American linden, with from two to four surviving stems.

When dating logging from stump sprouts, it is important that the borer pass through or near the pith in order that the annual ring formed during the first growing season after logging is included on the increment core. I often took several samples from different radii on the sprout before obtaining one that included the annual rings near the pith region. Unfortunately sprouts are often hollow because of rot spreading from the parent stump. This is especially true in sprouts of red oak and green ash.

It was necessary to sample only a few of the sprouts in any given

land use area, but I counted all sprouts present and mapped their locations. It seems logical to think that a heavily logged area would contain a large number of sprouts, but this is not always the case. Stumps of large old trees seldom produce sprouts, so even if loggers remove all the old trees from a previously undisturbed stand, probably few of the stumps will sprout. The reason old trees seldom sprout is that the dormant buds around the root collar are connected to the primary xylem. They elongate as the tree increases in diameter and eventually die. Roth and Hepting (1943) found in white oak, (Quercus alba), that while 78 percent of stumps 30 to 40 cm sprouted, only 12 percent of those 41 to 55 cm sprouted, and only 2 percent of those over 55 cm in diameter produced sprouts. These larger stumps were about 100 years old.

In some areas I found that stump sprouts were almost too numerous to map, while in other areas they were scarce. By noting the abundance or scarcity of sprouts in any given area I could make inferences about the area's appearance before it was logged, and also about the selectivity of the persons doing the cutting.

While doing the increment core sampling, I found that bur oak, because of its resistance to rot, is more reliable in yielding good cores than other species. This was true both in sprouts and single trunks.

When studying land use, it is difficult to ignore fire disturbance. It was necessary that I become familiar with the Forest's fire history to distinguish fire disturbance from land use. Occasionally I found references to fires in the Fontenelle Forest records, or I talked to persons who had knowledge of past fires. If there were no written or

verbal records of a burn it was still possible to find evidence of fire damage in the burned area itself.

When a ground fire burns through a hardwood forest, the accumulated litter near the trunks of large trees may burn hot enough to burn through the bark and kill the living cells of the cambium and phloem, thereby producing a wound or fire scar at the base of the tree (Jemison, 1944). Although the charred scar surface is permanent, undamaged living cells at either edge of the scar continue forming overlapping annual rings until eventually the burned surface is covered over.

Dendrochronologists working with coniferous species (Fritz, 1976) have dated fires by sawing a wedge from the callous margin (new wood covering the scar) deep enough to include a portion of the charred surface and the first annual ring of the margin that formed after the fire. I found that in fast growing deciduous species the callous margin may be 5 or 6 cm thick within a few decades following the fire. This made it impractical and perhaps damaging to the tree to remove such a deep wedge. However, I was sometimes able to approximate fire dates by taking several increment samples from the callous margin at intervals outward from the center of the scar. Usually the fire date was estimated to within a few years. Because this method of fire dating is time consuming, I did not resort to it often, for there is an easier, more accurate means of dating a fire.

When a ground fire burns through a deciduous woodland it may destroy the above ground portions of shrubs, seedlings, and even saplings less than 10 cm dbh whose bark is not thick enough to survive the fire. These top-killed trees and shrubs sprout vigorously, though some species produce

more sprouts per killed stem than others (Swan, 1970). By taking increment core samples from fire induced sprouts, I was able to date fires in the same manner that I dated logging from stump sprouts. These fire sprouts were marked and mapped, and the cores prepared using the same procedures described above.

Fortunately there are several ways of knowing whether the sprouts in any given area are a result of logging or fire. Fire crosses property boundaries, producing same age sprouts on either side of a property line. On the other hand the ages of logging sprouts are different from one property to another. Furthermore, there is often a difference in appearance between stump sprouts and fire sprouts. Figure I illusrates a typical bur oak stump sprout, and a young ash fire sprout. Notice that the stems of the fire sprout are grown together, while the stems of the stump sprout are separated. This is because the accumulation of tannic acids in the heartwood of bur oak makes this wood extremely rot resistant (Peattie, 1950). The stump may resist rotting for forty or fifty years, and the sprouts are kept apart, growing in a ring around it. I verified this on an illegally cut bur oak in the northwest section of the Forest. The sprouts dated to 1931, and the heartwood of the 45 cm stump was still solid. When a bur oak stump finally rots away the sprouts coalesce slowly, if at all, and often a cavity or basin remains between the sprouts, sometimes holding water after a rain.

When a fire destroys a sapling, there is little or no remaining stump, and the rapidly growing sprouts coalesce. Sprouts resulting from fires during the dry 1930's, such as the ash in Figure I, are now clumped trees with trunks growing together to a height of 0.5 meters.

Fig. 1 A bur oak stump sprout (left) and a green ash fire sprout

As in verifying land use disturbance, verifying that a fire occurred in a particular area at a certain time is only part of the problem; describing the effect of that fire on the flora is the other part. This effect goes far beyond the initial impact of dead and damaged vegetation. When fire destroys the above ground portions of saplings and shrubs, there is an increase in light intensity at ground level. In addition, fire causes changes in soil temperature and moisture content, in soil nutrients, and even in soil texture (Kozlowski and Ahlgren, 1974). Because of these changes, some species that were present in a stand before a fire increase in frequency following the fire. Other species that were not already in the stand may invade the burned area providing there is a nearby seed source (Kozlowski and Ahlgren, 1974).

My intent in this study was only to identify and date the obvious burn sites in the Forest and to distinguish these fire damaged areas from land use disturbance. With one exception I paid little attention to the effect that fire has on the frequency and distribution of plant species.

I have already mentioned that the distribution and frequency of bitter nut hickory may be influenced by something other than a preference for dry soil (xerophytism), as Aikman (1926) suggested. In Fontenelle Forest, bitternut is totally absent in some areas and very frequent in others. The tree does not appear to be site specific. I found groves of bitternut on slopes of varying aspect, and on the sides of ravines as well as hilltops. While examining the post-fire response of several hardwood forest communities in New York State, Swan (1970) found that bitternut hickory invaded at least one burned area where it had previously been absent. It is possible that bitternut is a fire follower, invading various sites after a burn,

provided there is a seed source nearby. There also may be a relationship between bitternut distribution and land use. I will point out in later sections that areas of bitternut are usually those that have been burned following heavy human disturbance.

RESULTS AND DISCUSSION

Introductory Remarks

This section will cover in detail a history of land use, and to a limited extent, a fire history in the northern portion of the Forest's upland. This region contains remnants of undisturbed timber, areas that were logged selectively or heavily only once during a short time period and then allowed to recover, and an area that was pastured following logging (see footnote page 4).

The discussion of each land use area is divided into six subheadings. Rather than repeatedly listing these subheadings under each land use area in the Table of Contents, I will explain the format here. The subheadings include: Area Boundaries, Ownership History, Physical Evidence of Human Occupation, Land Use History, Fire History and The Area Today. In the first and second subheadings I will describe the area's exact location and list the names of its owners from the time of settlement until the land was included in the Fontenelle Forest reserve. Under the third subheading I will point out man-made features such as roads, fences and structures. Under Land Use History and Fire History I will discuss the results of increment core sampling in the area. The last subheading will be a general description of the area's present appearance emphasizing the effects of land use and fire.

Property Formerly Owned by Charles E. Smith, Known as Tax Lots 7a2 and 11

The Smith property (Map 3)[2] is presented first because it is one of the easiest areas in the Forest to diagnose. The discussion of this area will serve to demonstrate how I applied the various methods to gain a pattern of land use. Information on the Smith property will later be used as a reference for comparing the remnant of old-growth timber that adjoins the north boundary of lot 7a2 on the Childs' property.

Area Boundaries: Tax lot 7a2 contains 17.1 hectares (42 acres). It is bounded on the north by a fence line marking the old Smith-Childs border, on the west and northwest by the current Grabowski property, on the south by a fence line marking lot 8a, and on the east by a fence roughly marking the boundaries of lots 9, 10 and 11. The northwest, northeast, and southeast corners of lot 7a2 are still marked by iron stakes (see Map 4, located in envelope inside back cover).

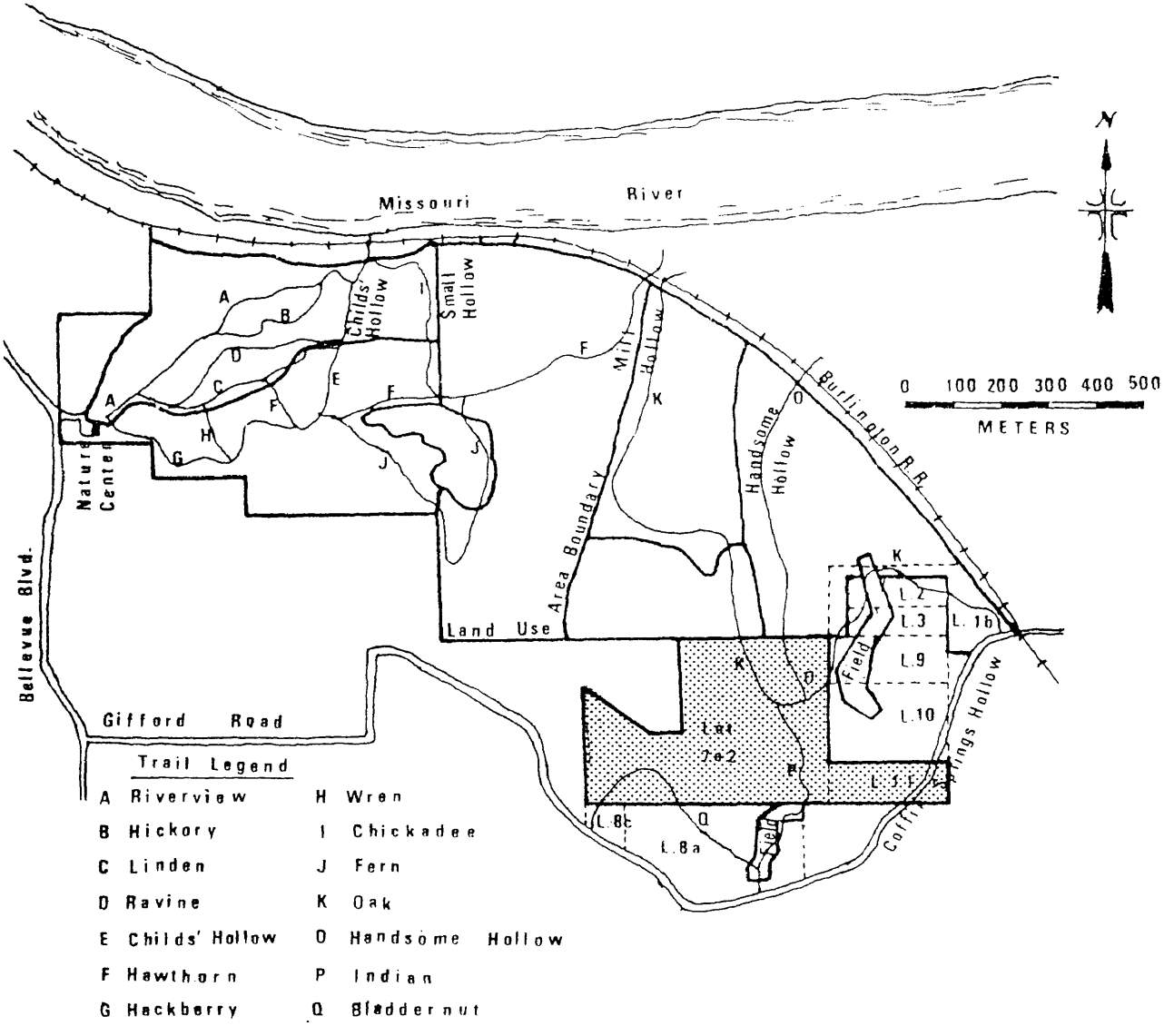
Tax lot 11 contains 2.4 hectares (6 acres), and is connected to the southeast corner of lot 7a2. Camp Gifford Road passes through the east end of the lot. (The fences referred to are not readily visible, having fallen into disrepair decades ago, and can only be traced by searching for buried scraps with a metal detector, or by locating trees with bits of embedded wire protruding from them.)

[2]Maps 3 through 14 show the locations of several properties that are adjacent to, but not included in the study area. These properties are included on the maps because they are occasionally mentioned in the text.

Map 3

Location of tax lots 7a2 and 11

(shaded)



Ownership History: Charles E. Smith, for whom I have no biographical information, held title to lots 7a2 and 11 by 1861 (Abstract to Title, Tax Lots 7a2 and 11). In December, 1874, he had title to lot 11 transferred to his wife, but the land still remained in the family. After the elder Smiths died, their heirs incorporated in 1911, calling themselves the Hillcrest Land Company. In October, 1919, this company sold lot 7a2 to Sarah H. Joslyn, a trustee of the newly-formed Fontenelle Forest Association. She in turn donated the land to the Association in July, 1923.

In June, 1916, Hillcrest Land Company sold lot 11 to a Dr. Louis Swoboda, who in turn sold it in May, 1920 to Association trustee Dr. Harold Gifford, Sr., who then donated it to the Forest in November, 1925.

Physical Evidence of Human Occupation: There are no structures on the properties. The Smiths lived on nearby land outside Fontenelle Forest.

There are two old roads in lot 7a2 (Map 4). Indian Trail and Oak Trail are part of an old ridgetop road which carried people between northern Bellevue and Childs' mill. In June, 1856, surveyor John Paynter mentioned this road while surveying the line between section 13 and 24. The other road was used more recently. A farmer named Grabowski, whose son still owns the property west of lot 7a2, used this road to travel to and from the field he was farming on the ridgetop just east of lot 7a2. He abandoned the field in the early 1930's.

The old fence line cutting across lot 11 was used in conjunction with Grabowski's field on the ridgetop just north of lot 11. Presumably Grabowski turned animals out to graze in and around the field during the

winter months when his crops were out. Grazing pressure is evident in lot 10, but signs of grazing are not apparent in lot 11.

Land Use History, lot 7a2: The six stump sprouts listed in Table II, were chosen from twenty bur oak and red oak sprouts located on the property (see Map 5, located in envelope inside back cover). They are all about the same diameter and are typical of the remaining fourteen not sampled. These sprouts date from the late 1860's to the mid 1870's. The odd date of bur oak sprout 234, dating from 1860P, may indicate earlier cutting or may be a naturally forked tree, though these are rare in bur oak. There are no stump sprouts of younger age. (P behind the date means that the borer passed through the pith. See Appendix A for explanation of all symbols behind tree dates).

There is a close correlation between the ages of stump sprouts and the years that some trees released (Tables III and IV). Of eleven trees sampled that were saplings in the stand in the late 1860's and early 1870's, seven showed release following disturbance over an eleven year period from 1866 to 1877. In most of these, release resulted in a doubling or tripling of the growth rate. This growth increase is readily apparent on the core samples (Figs. 2 and 3).

A red oak in plot 35, located just north of lot 7a2's south boundary, (Table IV), released slightly beginning in 1904. This lasted until 1907, after which annual growth returned to the pre-1904 rate.

The explanation for this involves a dispute about land use. In August, 1904, Charles Smith filed petition against his neighbor to the south, Samuel Nelson, alleging that Nelson had placed a fence illegally

Table II

Core samples from stump sprouts and fire sprouts on the Smith property, lot 7a2.[3]

Field #	Species[4]	DBH in cm	Age
	Stump sprouts		
234	Bur oak	50	1860P
448	"	47	1871P
156	"	42	1872(1869)
233	"	30	1877+
206	"	47	1877(1873)
447	Red oak	47	1880++H
	Fire sprouts		
108	Green ash	19	1919P
79	Green ash	22	1933P

[3]See Appendix A for explanation of column headings and symbols.

[4]See Appendix B for a list of scientific names.

Table III

Core samples from single trunk bur oaks on the Smith property, lot 7a2.

Field #	Species	DBH in cm	Age	Release Date
366	Bur oak	67	1837P	
210	"	64	1840+	1869
209	"	60	1844+	1869
359	"	34	1845+	1870
P.35	"	53	1852(1848)	1866
368	"	62	1860+	
364	"	51	1863+	1875
211	"	68	1864++	1869
P.36	"	23	1867(1863)	
367	"	53	1870++	1877
373	"	41	1872+	
P.36	"	37	1882+	
P.35	"	14	1920P	

Table IV

Core samples from single trunk species other than bur oak on the Smith property, lot 7a?.

Field #	Species	DBH in cm	Age	Release Date
358	Shagbark hickory	37	1857P	
P.35	Red oak	50	1872++H	1904
372	Red oak	52	1873++H	1919
P.38	Red oak	53	1874+	
P.38	American elm	62	1875+	
365	Red oak	63	1875(1872)	
363	Red oak	70	1882+	
371	Black walnut	60	1882+	
369	Shagbark hickory	36	1885++	
370	Red oak	68	1886++H	
P.39	Red oak	43	1895+	
P.37	Red oak	44	1904++	1919
362	Green ash	83	1909++H	
P.35	Green ash	24	1922(1920)	
P.37	Green ash	53	1937+	
P.35	Bitternut hickory	23	1941+	

Fig. 2

Core samples taken from bur oaks

209 and 364 on lot 7a2

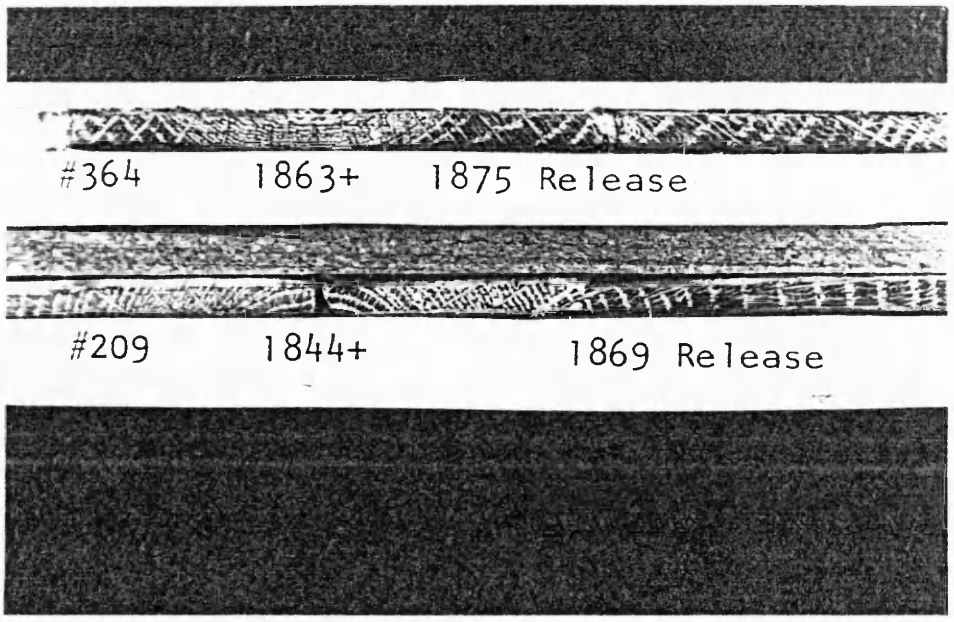
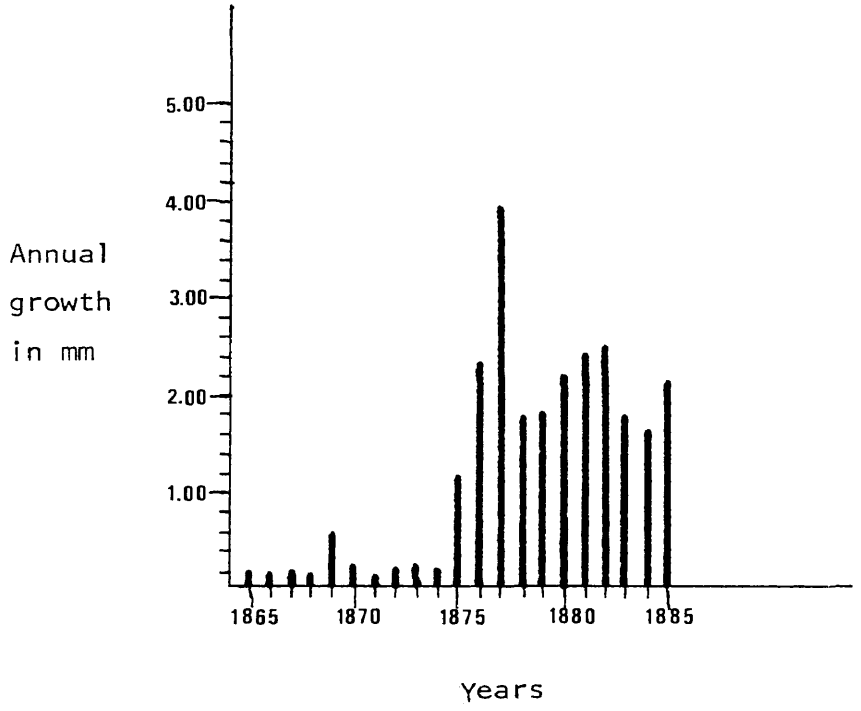


Fig. 3

Growth rate chart of bur oak Number 364

(Release begins in 1875)



some 20.1 meters (66 feet) north of the property boundaries of lots 7a2 and 11. This narrow strip, totalling 1.6 hectares (4.72 acres), is indicated by a dotted line on Map 5. Smith also charged that Nelson had "wrongfully and without the consent of the plaintiff cut and removed therefrom large quantities of timber and wood, which he has sold and otherwise converted to his own use." Smith asked for $200.00 in damages and removal of the fence. Nelson denied the allegation, but in December, 1905, a judge ruled that Smith receive $100.00 damages and recovery of the 1.6 hectares (Abstracts to Title, lots 7a2 and 11). The red oak that released slightly in 1904, located at the north edge of the contested strip, bears witness to Nelson's mistake.

None of the sampled trees that were saplings in the stand during the 1870's were larger than 10 cm dbh at the time of logging. Presumably they were too small for Smith's purposes and were spared. These culled saplings were no older than 40 and as young as 10 years at the time of logging. It is very unlikely that there are any trees left on the property that germinated before the 1830's. This is in contrast to the Childs' property, where even in the most heavily cut over areas, loggers left some of the large pre-1800 vintage trees standing. It appears that during a short period, Smith, or someone working for him, did a thorough job of removing all the commercially valuable timber from the property, leaving only saplings that were too small to use even for fence posts or firewood.

After the initial period of disturbance, which ended in the late 1870's, there was no further timber cutting on the property, with the exception of renewed cutting by a neighbor in a narrow strip along the

lot's southern boundary in the early 1900's.

Land Use History, lot 11: Since lot 11 was owned by the Smith family, I am assuming that it received the same treatment as lot 7a2. Judging from the property's similar appearance to lot 7a2 there is no reason to assume otherwise.

There are only four stump sprouts on lot 11. I sampled a 2 stem bur oak sprout that measured 48 cm dbh. The tree was hollow, but I counted 85 annual rings on the partial core before discarding it. The tree probably dates back to the 1870's, as do the sprouts on lot 7a2.

Fire History, lot 7a2: Fire scarred trees are scattered throughout the property, but none were sampled. An ash fire sprout, Number 108, growing near Bladdernut Trail, dated from 1919P, indicating that a fire occurred in the fall of 1918 or spring of 1919 (see Map 6, located in envelope inside back cover). Two trees listed in Table IV released in 1919. One, a red oak, Number 372, was 12 cm dbh at the time, and the other, also a red oak in plot 37, was 4 cm dbh. Both these saplings may have released after fire destroyed competing vegetation around them. Why the fire did not destroy the small red oak in plot 37 as well is difficult to explain.[5]

[5]Without collaborating the age of the ash fire sprout with a similar date from the callous margin of a fire-scarred tree, how can one be sure that it was fire, and not another episode of timber cutting that produced the ash sprout and caused the two red oaks to release? This is easily resolved when one is in the Forest and has an opportunity to compare lot 7a2 with some of the areas that actually were logged as recently as 1919. The mature canopy trees in lot 7a2 are quite large in diameter, and they are at least a century old or more (Table III). On the other hand, the canopy trees in areas that were logged in the early 1900's, such as Samuel Nelson's property, lot 8a, adjacent to lot 7a2, are smaller in diameter and the stand is younger. The disturbance in lot 7a2, which occurred prior to the growing season of 1919, producing the ash sprout and causing two red oaks to release, affected only the shrub-sapling strata; the canopy trees remain untouched.

Although land use and fire information for the southern portion of the Forest's upland is not included in this paper (see footnote, p.4). it is worth mentioning that in addition to the 1918 or 1919 fire in lot 7a2, I also encountered evidence of a widespread fire that occurred at the same time on properties south of Camp Gifford Road. Although the road would normally act as a barrier to ground fires, wind blown sparks and dry conditions could easily have enabled the fire to spread from one side of the road to the other. That exceptionally dry conditions prevailed then is evidenced by the relatively narrow ring produced by most trees in 1918.

In addition to the 1918/19 fire, there is evidence of another ground fire that burned through the area in the early 1930's. An ash fire sprout, Number 79, just north of the 7a2 south boundary, in the strip contested by Smith and Nelson, is one of several apparent fire sprouts in that area. It dates from 1933P.

Fire History, lot 11: Red oak and shagbark hickory trees on the west facing slope of lot 11 are severely fire damaged. Some are nearly hollowed out from rot spreading from the open wound. Increment samples from the callous margin of one shagbark and a small wedge cut from the callous margin of another revealed that rot had spread into the margin, making it impossible to date the fire. However, a ring count from the incomplete samples indicated that a fire probably occurred sometime during the 1930's. This may be the same fire that produced ash sprout Number 79, which is roughly 100 meters west of the burned slope in lot 11.

The Smith Property Today: Without quantitative data it is possible to describe the property's appearance only in general terms. The flora could be called a "one hundred year successional community", and the overstory an "even-aged stand" comprised of trees that are fairly uniform in diameter. I know of no source that defines an even-aged stand in terms of a specific age spread between canopy trees. The term is used rather loosely. Here it means that most of the canopy trees began growing within a few decades of one another, before, during or after the brief, but thorough episode of logging disturbance. There are no 200-year-old remnants of the pre-settlement forest remaining here as there are on the Childs' property to the north.

The distribution of bitternut hickory on lots 7a2 and 11 may reveal something about the tree's apparent preference for burned areas. Throughout both of these lots there are only scattered bitternut seedlings and saplings up to 4 cm dbh; however, in the vicinity of plot 35, within the 20.1 meter strip contested by Smith and Nelson in 1904, bitternut hickory is a dominant. Here the bitternut population ranges from seedlings up to canopy-size trees 25 cm dbh. A 23 cm dbh bitternut in plot 35 dates from 1941+. (+ indicates that tree is an estimated 5 to 10 years older than date given. See Appendix A). Notice that this bitternut population surrounds three sides of the old field nearby in lot 8a (Map 6). Another large bitternut, Number 107, 24 cm dbh, located east of the field in lot 8a, dates from 1935P. It appears that fire damage in the early 1930's in the disturbed ecotone near the field and in the twice logged strip north of the field created conditions favorable to bitternut invasion. That the species is confined to a narrow belt near the field indicates that fire alone did not prompt the

invasion. Prior human disturbance was also a factor.

Property Formerly Owned by Charles Childs

1. Biographical Sketch of Charles Childs

The estate of Charles Childs' was extensive, covering roughly 110.8 hectares (274 acres) of upland forest, as well as floodplain and prairie land. Unlike Smith, whose pattern of timber removal was consistent over his entire property, Childs logged heavily on some slopes, selectively or not at all on others, and left behind a confusing pattern of land use.

Charles Childs (1815-1903), (Fig. 4), moved from Springfield, Massachusetts, to Bellevue, Nebraska Territory, in the autumn of 1856 when he was forty years old. His decision to leave the east came after his wife's death, and the failure of his carriage business. He settled in Bellevue at the advice of his brother-in-law, Walter Lowrie, who had been to Bellevue several times.

Shortly after arriving in Bellevue, Childs purchased a sawmill from Almann Lockwood and James S. Allen, who had a 129.5 hectare (320 acre) squatter's claim in the wooded hills north of town (Sayre, 1911). A road running along the base of the bluffs between Allen's mill and Bellevue was mentioned by surveyor John Paynter, in June, 1856. Childs did not build the mill himself as I stated previously (Garabrandt, 1976).

Childs was not alone in his venture, but was in equal partnership with three other men. Walter Lowrie, and a friend, William Rankin, provided financial backing, but remained in the east. A fourth partner, Matthew McCaslin, brother of Childs' second wife, came to Bellevue at the same time as Childs and took an active interest in the sawmill operation.

Fig. 4

Charles Childs and his grandson Charles E. Childs

(Photo taken in 1893)

During 1857, the partners, possibly taking advantage of loopholes in the Homestead and Bounty Acts, bought, sold, and mortgaged land to and from one another and outside parties, until finally, they had amassed 158.2 hectares (391 acres) of wooded land in the hills and flood-plain.

In the logging and milling operation, Childs and McCaslin probably supervised a crew of at least fourteen or fifteen men. In the Forest the labor was divided into the tasks of felling the trees, cutting off branches and peeling bark, bucking the logs into desired lengths, and skidding the logs to the mill behind teams of oxen or horses. The crew at the mill site (Fig. 5), usually consisted of an engineer who fueled the boiler and repaired machinery, a couple of sawyers, and a few more men who stacked the lumber for drying (Garabrandt, 1976).

Childs' mill furnished lumber for buildings in Omaha and Bellevue, and some lumber was even loaded on board the river steamers and taken to towns up the Missouri.

By running a belt from the power source to horizontal grinding stones, a sawmill could double as a gristmill. Childs derived a portion of his income by grinding flour and cornmeal for local farmers on one day each week. He also stacked cords of fuel-wood near the river bank, and the steamboat captains landed their craft there to load up his wood.

In April, 1862, McCaslin moved to Colorado, selling out his one-fourth interest in the operation to Lowrie and Rankin for $2,000.00. In December that same year, Childs purchased, in his own name, two tracts of land from a neighbor, Daniel Clitton. Some of this land is now included in Fontenelle Forest, but the rest was in section 22, about a mile west of the Forest. his other land was all prairie, except for some acreage Clifton tilled.

A steam operated sawmill

(This mill operated in Richardson county, Nebraska. The photo was taken in 1879. Courtesy Nebraska State Historical Society)

For several years following his arrival, Childs and his second wife, Catherine, lived in a small cabin near the sawmill. The mill was located near the river at the mouth of a deep ravine, now known as Mill Hollow (Map 4). Their first child, Caroline, was born there. After buying Clifton's farm, Childs and his family moved there from their cabin in Mill Hollow.

From then on Childs ran both a farm and a logging operation. I stated previously (1976) that he cut back on the sawmill operation after moving to the farm, but after completing my increment core sampling on his land I found that he logged steadily up until 1876. The mill is said to have burned, though the date is unknown.

Walter Lowrie died in December, 1868, and Childs then bought both Lowrie and Rankin's share of the partnership for $8,000.00.

In 1873, Childs moved from the farm to a large home in Omaha at 1806 Leavenworth Street. Though living in Omaha he traveled daily to Bellevue to supervise his farm and sawmill operation.

Childs also had a second child, named Lowrie, who was born at the farm in 1863. In 1882, Lowrie went off to school at Princeton, but dropped out after two years for lack of funds. From 1884 until 1889, he earned money by supervising a dairy farm on his father's property. The farm was located on the present site of the Fontenelle Forest Nature Center. The dairy cattle were pastured on nearby land that had been cleared of trees by the logging crews years earlier. In 1889, Lowrie returned to Princeton, and the dairy was taken over by another party.

In his later years Childs encountered financial difficulties, and by the mid-1890's had mortgaged all of his real estate. The mortgages

were taken over by a man named Everard D. Ferguson, of Troy, New York, who was Lowrie Childs' father-in-law. Lowrie, who was living in Pittsburgh with his wife Hortense, and a baby son Evarard, moved back to Bellevue temporarily in 1894, to assist his father with financial matters. They lived in a house located a few hundred meters south of the dairy farm. This house, called "Maxwellton", was built entirely of hardwoods cut from Childs' property.

Childs was never able to repay the mortgages, and after he died in January, 1903, Ferguson assumed ownership of his estate. In September, 1906, Ferguson also died, willing Childs' former estate to his own heirs. The Ferguson heirs were anxious to sell the property they had inherited, but were unable for several years because of litigation initiated by some of Childs' relatives against Fergusons' will. The willingness of the Fergusons to sell the property made possible the Fontenelle Forest reserve.

About 1910, a biology professor from the old Bellevue College, Dr. Ansel A. Tyler, proposed that the state allocate money to buy all the hilly land east of Bellevue Boulevard and create a state park or forest reserve. This proposed park included the old Childs' estate and other land. The first meeting of what eventually became the Fontenelle Forest Association, was held at Maxwellton one evening in March, 1910.

Tyler and his following were unable to get a bill through the Nebraska legislature that would have provided funds to purchase land. Undaunted by the unwillingness of the state, the conservationists incorporated in April, 1913, and began to attempt to raise money to buy the land themselves.

When Ferguson's will was finally settled and his heirs able to sell some of the real estate, the newly formed Association had no money to acquire land. An Association member, Dr. Harold Gifford, Sr., purchased the estate lands east of the Boulevard in 1916, giving the Association the option to buy it when money could be raised.

During a fund raising drive in 1919, enough money was collected, and in January, 1920, a portion of Charles Childs' old estate officially became the nucleus of the Fontenelle Forest reserve.

2. Old-Growth Remnant Between Mill Hollow and Oak Trail

Area Boundaries: This is the largest undisturbed area in the Forest, comprising roughly 7.2 hectares (18 acres). It is bounded on the north by a steep ravine, on the west by Mill Hollow stream, on the south by the Grabowski property and tax lot 7a2, and on the east by the brink of the ravine sloping to Handsome Hollow (Maps 4 and 7).

Ownership History: Most of this undisturbed remnant is on land purchased by Childs & Company from William H. Smith, brother of Charles E. Smith, in October, 1857 (from Abstract of Title, Childs' Estate). It was purchased for the Fontenelle Forest Association by Harold Gifford, Sr. in 1916, as was the remainder of Childs' estate discussed in this paper.

Physical Evidence of Human Occupation: Oak Trail runs along the ridgetop in the east part of the area. Its role as a public wagon road in pioneer days has already been mentioned.

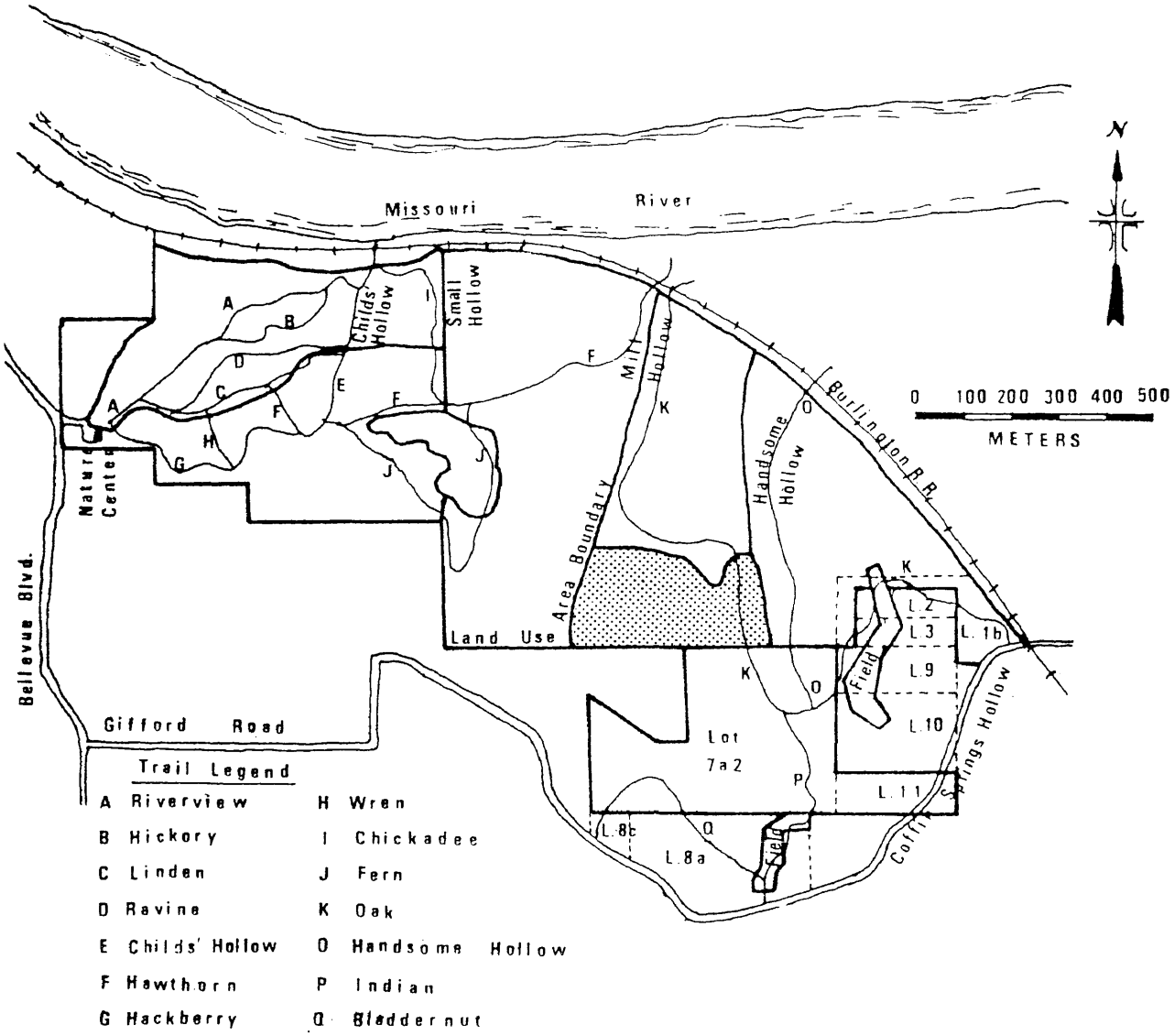
In the southwest corner of this area is an illegal fence running along the ridge at the brink of a steep slope (Map 4). This fence was

Map 7

Location of old-growth remnant between

Mill Hollow and Oak Trail

(shaded)



placed there by the neighbor to the south sometime in the 1930's (Fontenelle Forest Association Records, 1938). Although this small area appears undisturbed by logging, the understory and shrub layer were once cut and burned to open the area for grazing. The understory is still scrubby and young.

Land Use History of Remnant Stand Between Mill Hollow and Oak Trail: In later sections I will demonstrate that even in areas that were only lightly cut over, where Childs was "high-grading", or selecting only the best trees for cutting, the disturbance is always detectable. Within a logged area there are always a few stump sprouts present, and at least a few nearby trees show release. Within this remnant stand there are no stump sprouts, with the exception of a possible red oak stump sprout just inside the area's northeast edge. This tree is hollow, but may date to about 1872, having been cut when the nearby slope of Handsome Hollow was logged.

Of the 32 sampled trees listed in Tables V and VI only one released. This tree, a bur oak, Number 153, (Table V), is growing just inside the area's north boundary and apparently released following logging of the slope north of it in the late 1860's. This oak not only released but lists heavily to the north having evidently taken advantage of the sunlight in the once open post-logging clearing. Several other oaks near 153 also lean to the north. Aside from these explainable exceptions, the absence of stump sprouts or release within this area is evidence that it is undisturbed.

Table V

Core samples from single trunk bur oaks in the remnant stand between Mill Hollow and Oak Trail

Field #	Species	DBH in cm	Age	Release Date
152	bur oak	33	1740(1738)	
356	"	64	1753+	
340	"	66	1756+	
239	"	62	1760+	
240	"	92	1766++	
347	"	75	1780P	
348	"	79	1793++H	
344	"	73	1800++H	
355	"	102	1816++	
153	"	43	1820+	1869
357	"	38	1836P	
341	"	51	1840+	
P.43	"	56	1841(1836)	
84	"	47	1843++	
241	"	40	1846+	
146	"	46	1849+	
238	"	31	1858+	
P.44	"	44	1874++H	

Table VI

Core samples from single trunk species other than bur oak in the remnant stand between Mill Hollow and Oak Trail

Field #	Species	DBH in cm	Age
345	Shagbark hickory	41	1839+
350	Shagbark hickory	46	1842+
342	Shagbark hickory	36	1852(1848)
352	Green ash	67	1860+
349	Shagbark hickory	43	1863+
343	Red oak	85	1870+
P.44	Red oak	32	1874+
P.43	American elm	45	1876+
346	Red oak	58	1878++
351	Green ash	50	1881(1879)
P.44	Shagbark hickory	44	1880++
354	Green ash	26	1935+
353	Shagbark hickory	14	1942(1940)
P.43	Red oak	25	1942(1940)

Fire History of Remnant Stand Between Mill Hollow and Oak Trail: There are large trees bearing fire scars scattered throughout the tract. The red oak and green ash sprouts listed in Table VII are representative of many sprouts in the area that resulted from fire(s) in the late 1930's or early 1940's.

The Oak Trail Remnant Stand Today: The easiest way to locate this undisturbed stand is to enter it from the south along Oak Trail through lot 7a2. Near the north boundary of lot 7a2 a level ridge runs off to the west, and a few meters east of the trail there is a dead elm with a short length of the old boundary fence protruding from it. In summer the dense foliage limits visibility, and the difference between the timber stands on opposite sides of the fence is not apparent. In winter, however, when the leaves have fallen, one's attention is drawn to a group of three massive bur oaks growing west of the trail a few meters north of the old boundary (Fig. 6). Core samples from two of these oaks, 239 and 240, reveals that they are more than 200 years old (Table V).

During a rough count of the bur oak population (excluding the small area inside the illegal fence) I located 79 trees 55 cm dbh and up. The majority of these oaks are probably close to 200 years old or are older. These trees are roughly 25 meters tall, with spreading crowns of stout branches. The main branches begin 9-10 meters above the ground, grow out from the tree, and curve upward. The appearance of these oaks suggests that they have always been attended by a competing understory, preventing them from branching low on the trunk and spreading laterally.

Table VII

Core samples from fire sprouts in the remnant stand between Mill Hollow and Oak Trail

Field #	Species	DBH in cm	Age	No. of Stems
236	Green ash	19	1940P	3
237	Red oak	19	1942P	3

Fig. 6

Bur oaks 239 and 240 in Oak Trail remnant stand

While counting the bur oaks, I located 29 between 30 and 55 cm dbh. These 29, plus the 79 larger trees, comprise the entire bur oak population of the area. Core samples from 9 of these smaller oaks revealed that they were older than anticipated. For example, the smallest bur oak sampled, Number 152, 33 cm dbh, was the oldest, dating from 1740(1738). (Date in parenthesis is the estimated true age. See Appendix A). The youngest bur oak sampled was Number 238, dating from 1858+. (The last tree listed in Table V is much older than the date given because it is hollow.)

A thorough search of the area revealed no bur oak saplings or immature understory trees. One first year bur oak seedling was found in plot 43, and plot 44 contained three. Although germination is occurring, no seedlings are apparently surviving.

The decline in bur oak seedling survival beginning in the late 1850's may have resulted from extensive settlement and plowing of the prairies west of the Forest. By plowing the prairie lands settlers put an end to the wind-swept prairie fires that occasionally burned into the woodland along the Missouri river bluffs. Although the use of fire as an effective tool for obtaining oak regeneration has not been adequately tested (Kozlowski and Ahlgren, 1974), some ecologists feel that survival of oak seedlings is enhanced by fire disturbance. Carvel and Tryon (1961) found in West Virginia that the degree of disturbance in a stand was very closely correlated with an increase in oak reproduction. Stands which had been burned, thinned or grazed, possessed a greater number of surviving oak seedlings than undisturbed stands. They attributed this increase to the amount of light reaching the forest floor following

disturbance, thus enhancing oak reproduction and survival. When prairie fires stopped burning into Fontenelle Forest, the shrub-sapling stratum in this stand probably became denser than it had been previously, and light intensity on the forest floor decreased, contributing to a decline in bur oak seedling survival.

As a result of the drought and fire(s) of the 1930's, a young understory generation invaded the area beginning in about 1940. This understory consists mainly of red oak, linden, shagbark hickory and some bitternut hickory, ranging in size from 10 to 25 cm dbh.

3. Old-Growth Remnant Encompassed by Fern Trail

Area Boundaries: This stand of old-growth timber covers roughly 3.6 hectares (9 acres). Its precise boundaries are difficult to fix because it is surrounded by selectively logged timber which also contains some old bur oak trees. The northern boundary is roughly Hawthorn Trail. The west boundary has a lobed appearance because black walnut and some bur oak were selectively cut from the side ravines on the lower slope, but the timber on the xeric lateral ridges was left untouched. South of this remnant area is previously logged forest containing a number of stump sprouts. The eastern boundary runs along the edge of the ridgetop (Maps 4 and 8).

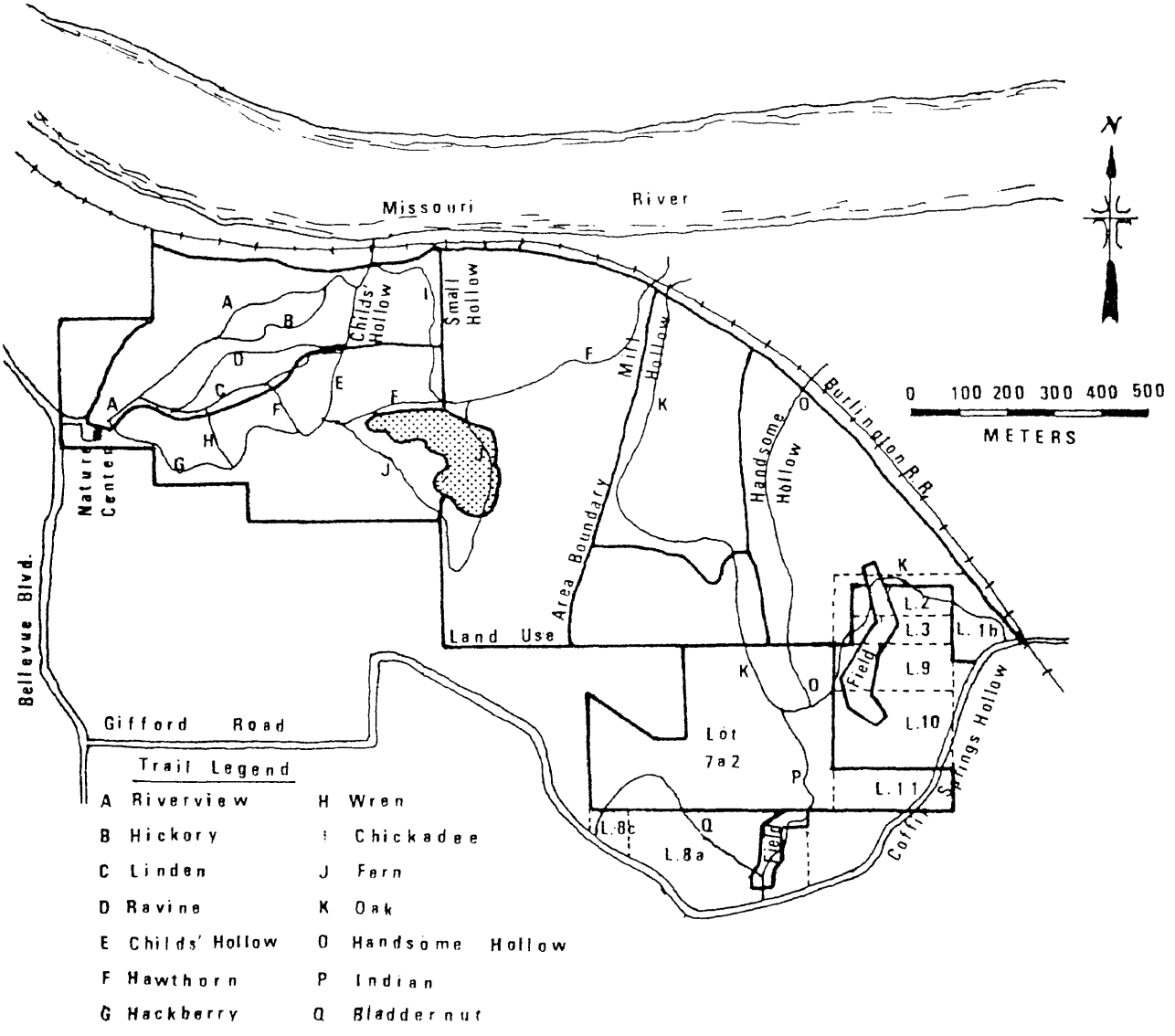
Ownership History: The west half of this area lies in section 14, and the east half in section 13. The eastern portion belonged to Childs & Company by the end of 1857. The western portion is part of a tract purchased by Childs from Daniel Clifton in December, 1862. The bur oak

Map 8

Location of old-growth remnant

encompassed by Fern Trail

(shaded)



and black walnut had already been cut from the lower slope at the time of the purchase.

Physical Evidence of Human Occupation: The only unusual feature is an apparent cowpath barely visible on the western slope. This is probably a continuation of a path that begins near the site of a former barn not far from the sawmill site in Mill Hollow (Map 4). The oxen and horses used as draft animals for Childs' logging operation are probably responsible for this eroded path.

Land Use History of Remnant Stand Encompassed by Fern Trail: This area is surrounded by previously logged forest containing stump sprouts and trees showing release. As there are no stump sprouts or trees showing release within the tract (Table VIII), it is undoubtedly an unlogged remnant.

Fire History: A fire probably occurred around 1930 as evidenced by ash sprout Number 145 (Table IX). The extent of this fire is unknown.

The most damaging fire in recent Forest history began in the northeast portion of this tract in the immediate vicinity of Fern Trail. This fire started on November 13, 1939, at the end of nearly a decade of drought when there were hundreds of drought-killed trees scattered about the woods (Omaha World Herald, Nov. 15, 1939). This fire was believed caused by poachers trying to smoke an opossum out of a dead, hollow tree at night. A west wind fanned the fire through the leaf-covered woods, and kept Boy Scouts, Forest Board members, and volunteers from Omaha Walking Club busy battling the blaze for three days. An estimated 40.4

Table VIII

Core samples from single trunk trees in the remnant stand encompassed by Fern Trail

Field #	Species	DBH in cm	Age
P.29	Bur oak	55	1792+
P.32	"	51	1805++H
401	"	74	1805(1801)
P.30	"	43	1815+
396	"	71	1815+
P.30	"	63	1820+
403	"	47	1820+
226	"	73	1820+
399	"	92	1835++H
191	"	57	1837(1835)
219	"	35	1842(1839)
P.29	"	36	1850+
400	Shagbark hickory	47	1840(1836)
389	Red oak	68	1844(1841)
404	Shagbark hickory	43	1851++
P.29	Shagbark hickory	25	1855+
P.30	Red oak	28	1938(1935)
405	Green ash	34	1940

Table IX

Core sample from a fire sprout in the remnant stand encompassed by Fern Trail

Field #	Species	DBH in cm	Age
145	Green ash	22	1933(1930)

hectares (100 acres) were burned.

According to Forest Board member, Harold Gifford, Jr., (personal communication), who helped fight the blaze, the fire spread east from the Fern Trail region. The wind blew sparks across Mill Hollow stream and the flames burned up the slope east of the hollow to the next ridge. Then the wind carried sparks across Handsome Hollow and a portion of the next slope was burned.

After the fire several Forest Board members mapped the burned area, and took photographs and movies of the damage "so that the life and future growth of the trees and shrubbery in the area may in later years be observed and compared with other parts of the forest." (Fontenelle Forest Association Records, 1940). Unfortunately, none of these materials can be found today.

Map 6 shows the extent of this fire's damage based on dates from fire sprouts and observations of fire-damaged trees.

The Fern Trail Remnant Stand Today: The bur oak population in this stand is a great deal different from the bur oak population in the Oak Trail remnant. While counting bur oaks here I found only 49 trees 55 cm dbh and up and 75 trees between 30 and 55 cm dbh. None of the larger trees approached 200 years in age, and most dated from the early 1800's. Most of the bur oaks in this stand, particularly on the upper slope and ridgetop are short in stature, being 15-18 meters tall. Branching begins only 4 to 6 meters above the ground. On some trees main branches grow out from the trunk and then dip downward, their tips nearly touching the ground (Fig. 7). The growth form of these oaks indicates that the

Fig. 7

Open grown bur oak (left) and green ash in

Fern Trail remnant stand

upper slope and ridge has always been open, the oaks have been free of competing undergrowth and have branched low and spread laterally.

This stand contained 75 bur oaks 30 to 55 cm dbh, while the Oak Trail remnant contained only 29. On a tree per hectare basis these figures can be expressed as 8.3 smaller bur oaks per hectare in the Fern Trail area and only 1.6 per hectare in the Oak Trail remnant. Admittedly, it is risky to generalize a relationship between a tree's age and its diameter. However, extensive sampling of the bur oak population on the Childs' property has led me to believe that there is a distinct generation of bur oaks that germinated in the 1830's and 1840's. These trees are generally between 30-55 cm dbh, with most being 40-55 cm dbh.

That conditions were favorable to bur oak reproduction during that period might be explained on the basis of fire disturbance. A fire in the 1820's or 1830's might well be responsible for increased bur oak germination in the 1830's and 1840's. Since the undergrowth in the Fern Trail remnant was more sparse than in the Oak Trail remnant, as evidenced by the growth form of the old oak trees in the two areas, light conditions on the forest floor were more favorable to bur oak survival in the Fern Trail region.

Although I did not examine the Fern Trail stand for young bur oaks as intensively as the stand on Oak Trail, I believe that bur oak reproduction also declined sharply there after the 1850's. Of three plots sampled, none contained any bur oaks smaller than 36 cm dbh. The 36 cm bur oak, listed in Table VIII, dated from about 1850+. These plots also contained first-year bur oak seedlings but none older.

4. Logged Region From Mill Hollow West to the Small Hollow-Fern Trail Area.

Area Boundaries: This is a large area containing roughly 30.3 hectares (75 acres). Most of it lies in section 13. A 4.0 hectare southern portion is in section 24. It is bounded on the north by the Burlington right-of-way, on the west by section 14 and the Fern Trail remnant, on the south by the Forest boundary, and on the east by Mill Hollow stream and the Oak Trail remnant (Maps 4 and 9).

Ownership History: Childs and Company had control of all of this plot by the end of 1857.

Physical Evidence of Human Occupation: In two places on the east-facing slope near Mill Hollow stream are prominent ruts caused by logging crews skidding logs downslope.

On the north side of Hawthorn Trail, at the point where the trail reaches the bottom of the slope and turns north along Mill Hollow Stream, there is a square area 10 by 10 meters that I believe was once the site of a livestock shed. The shed floor is now covered with 10 cm of fill that has washed down from the slope above. Beneath this loose fill, the shed floor is packed hard. Digging here, I once found some lime or plaster and a large tooth of an ungulate. There is a faint cow path leading from the shed and winding up the slope north of Hawthorn Trail. This path is not visible on the ridgetop, but can be traced again winding down the west slope in the Fern Trail remnant area toward Childs' Hollow (Map 4).

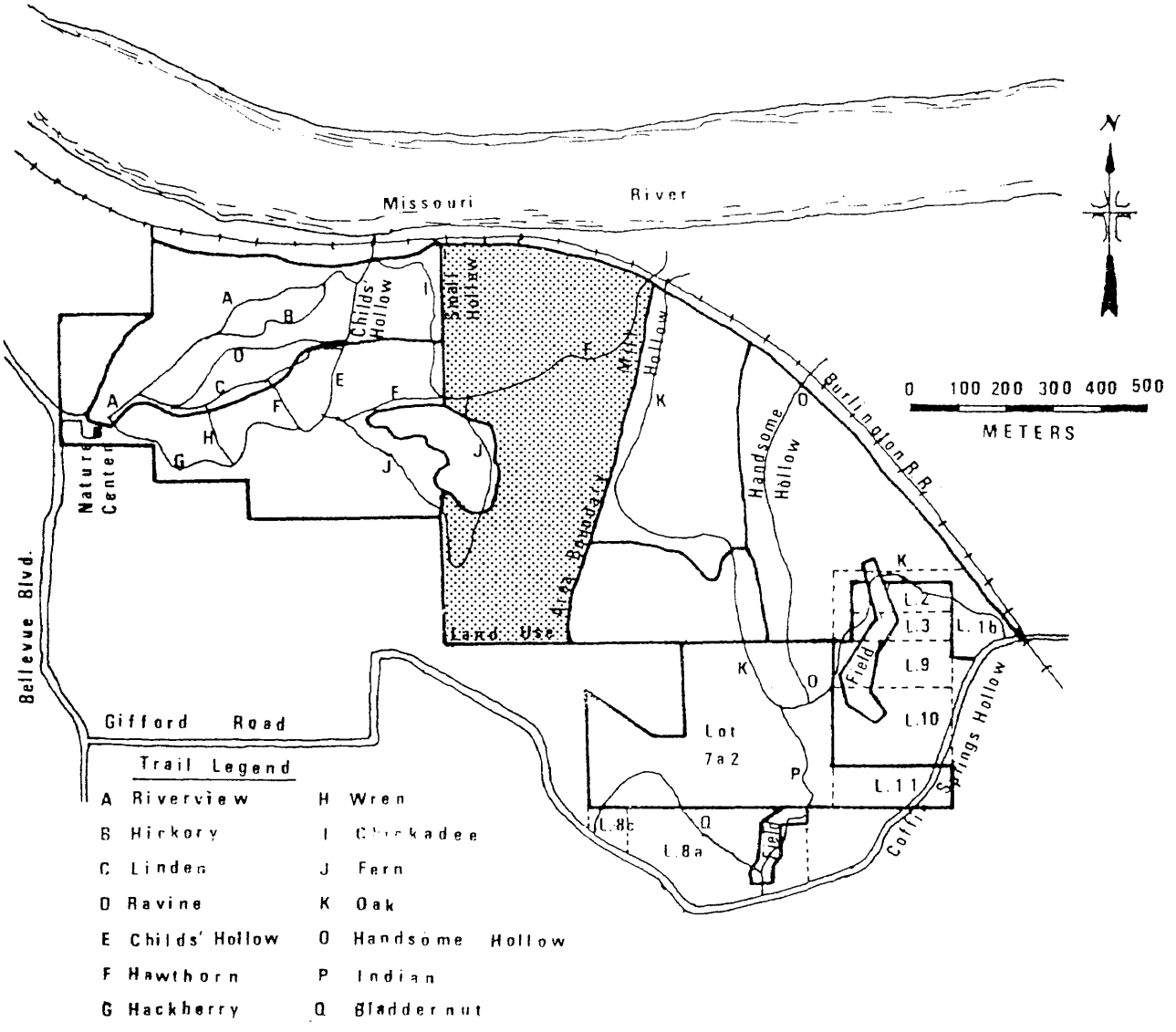
A 40 by 40 meter area on the slope just above the shed was invaded

Map 9

Location of region from Mill Hollow west

to the Small Hollow-Fern Trail area

(shaded)



long ago by American elm. Most of these large trees are now dead from dutch elm disease, giving the small area a disorderly appearance. In Fontenelle Forest American elm invades severely disturbed areas such as old fields, sometimes forming solid stands. Its invasion of the small area on the slope apparently followed severe grazing disturbance. The oxen or horses used for the logging operation were probably stabled in the shed and spent time on the nearby slope. There is no evidence of an enclosure however, and the animals wandered elsewhere as well, resulting in the path.

Land Use History of Region From Mill Hollow West to the Small Hollow-Fern Trail area: The 19 stump sprouts listed in Table X are roughly half of the total sprout population in the area. Dates from these sprouts indicate logging in this region over a 20 year period beginning 1856, and ending in the mid 1870's. Charles Childs did not arrive in Bellevue until the fall of 1856, so the first two sprouts listed probably resulted from logging by his predecessors Almann Lockwood and James S. Allen. Childs and his logging crew seem to have returned to this region periodically, each time selecting the best specimens of several species. Although all but two of the sprouts sampled are bur oak, red oak, green ash, black walnut, shagbark hickory and linden sprouts are also found in this area.

During this episode of logging, release occurred in bur oak trees beginning in 1862 and ending in 1874 (Table XI). No trees released in the 1850's, even though loggers were cutting then. Perhaps in the initial stages of logging the canopy stratum was not yet thinned out enough to promote faster growth in the remaining trees.

Table X

Core samples from stump sprouts from Mill Hollow west to the Small Hollow-Fern Trail area.

Field #	Species	DBH in cm	Agc	Release Date
453	Bur oak	47	1856P	
104	"	46	1856P	1890
199	"	54	1859(1857)	
193	"	33	1859(1857)	
218	"	34	1859(1857)	
455	"	52	1862(1858)	
195	"	47	1863+	
452	"	33	1863+	
446	"	45	1864+	
136	"	48	1865+	
140	"	47	1867(1865)	
192	"	37	1870	1890
231	"	53	1872+	1890
229	Red oak	45	1872(1870)	
445	Bur oak	44	1873+	
198	Bur oak	32	1874(1872)	
144	Bur oak	30	1874++H	
89	Bur oak	38	1877+	
230	Red oak	45	1878+	

Table XI

Core samples from single trunk bur oaks from Mill Hollow west to the Small Hollow-Fern Trail area.

Field #	Species	DBH in cm	Age	Release Date
424	Bur oak	80	1736++	
87	"	72	1790++	1868
381	"	95	1796++	
421	"	86	1810++H	
429	"	81	1810++	
387	"	99	1811++	
402	"	58	1813(1811)	1867
143	"	60	1816(1813)	1862
454	"	52	1820+	1871
428	"	66	1825P	1872
419	"	64	1832+	1869
433	"	56	1834P	1862/1890
P.33	"	44	1835P	
388	"	74	1835P	1872
408	"	77	1836+	1869/1872
430	"	51	1836+	1872
227	"	43	1838(1836)	
141	"	45	1839P	1873
434	"	58	1840+	1874

Table XI cont.

Field #	Species	DBH in cm	Age	Release Date
432	Bur oak	69	1840++	
407	"	68	1840+	
431	"	66	1846(1842)	1890
391	"	45	1847+	1890
423	"	52	1856P	1889
406	"	34	1857+	1889
142	"	46	1866+	
427	"	54	1885+	
409	"	35	1885+	
P.34	"	10	1954P	

The eight bur oaks listed in Tables X and XI, that released in 1889 or 1890, are all confined to a .4 hectare region on the ridgetop along Hawthorn Trail. In some trees release was dramatic, resulting in a tripling of the annual increment growth rate. I found no sprouts in this area corresponding to the 1889/1890 release dates, so it is difficult to determine the probable cause of release. None of the other species sampled that were in the stand during the episode of logging released (Table XII). The growth rates of two bur oaks before and after release are shown in Fig. 8 and Fig. 9.

Scattered throughout this tract are large old bur oaks which Childs chose not to cut. Most of the oaks listed in Table XI that began growing before 1810 were between 25 and 40 cm dbh at the time Childs was logging the area. That he culled these trees in spite of their large size is an indication of his selectivity in cutting only the best specimens. Size alone is not an indicator of quality. The trees that he cut were probably those with the straightest trunks from which he could saw board lumber at his mill.

Fire History From Mill Hollow West to the Small Hollow-Fern Trail Area: Damage from the fire of November, 1939, is still much in evidence here, particularly on the ridges and upper slopes. Here, one may find an occasional fire charred snag still standing. Fire scarred trees and stump sprouts are common. The two bur oak sprouts listed in Table XIII resulted from this fire.

Although this fire was widespread and caused severe damage, I know of only 6 or 7 bur oak sprouts resulting from it. This is because there were few bur oak saplings in this part of the Forest in 1939 that were

Table XII

Core samples from single trunk species other than bur oak from Mill Hollow west to the Small Hollow-Fern Trail area.

Field #	Species	DBH in cm	Age
420	Shagbark hickory	48	1840(1837)
425	American elm	73	1874+
426	Red oak	60	1884++H
121	Bitternut hickory	23	1941P
P.33	Green ash	29	1945P
P.34	Red oak	26	1947+
P.34	American linden	17	1950P
P.33	Bitternut hickory	10	1956P
P.33	American linden	12	1961+

Fig. 8

Growth rate chart of bur oak Number 388

(Release begins in 1872)

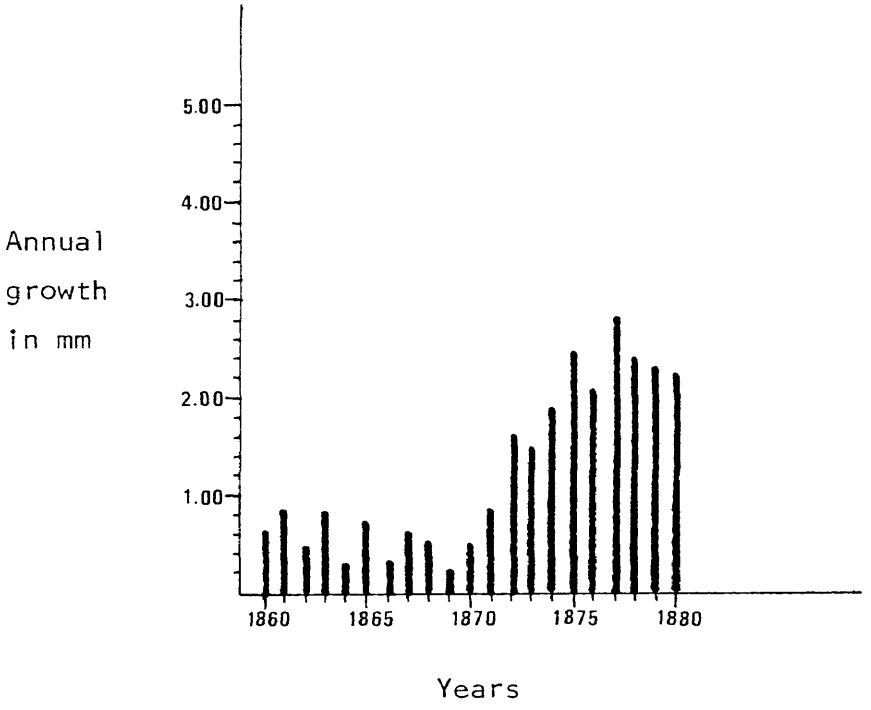


Fig. 9

Growth rate chart of bur oak Number 423

(Release begins in 1889)

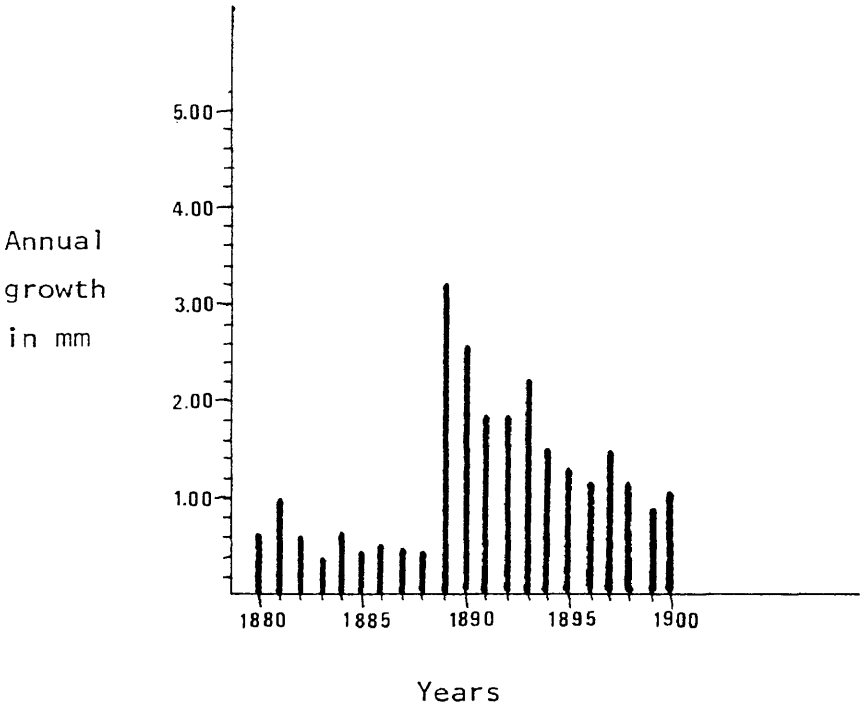


Table XIII

Core samples from fire sprouts from Mill Hollow west to the Small Hollow-Fern Trail area

Field #	Species	DBH in cm	Age
196	Bur oak	16	1941(1940)
451	Bur oak	16	1944(1940)

susceptible to severe fire damage. Most of the 1939 bur oak population consisted of larger trees that were scarred but not burned off.

The Timber Stand From Mill Hollow West to the Small Hollow-Fern Trail Area Today: The bur oak population of 1830-1840's vintage is very conspicuous today throughout these 30.3 hectares, because Childs cut down most of the older oaks. Most of these younger oaks were less than 10 cm dbh in the 1860's and 1870's. During a rough census of the bur oaks in a 6.0 hectare area along the ridgetops and west facing slope of Small Hollow, I counted 102 between 40-55 cm dbh, and only twelve 55 cm dbh and up. Eight of these larger trees are listed in Table XI. Only two are very old trees, the remaining six are 1830-1840 vintage and have attained a large girth because of release at one time or another.

During the bur oak census, I noticed that red oak, 40-55 cm dbh is just as numerous. Ash and black walnut, 40-55 cm dbh, are also common, particularly on the west facing slope of Small Hollow.

Although I did not sample many immature bur oaks, the last four listed in Table XI indicate that bur oak reproduction and survival did not decline after the 1850's, but continued into the 20th century. Stand disturbance, resulting in increased light intensity on the forest floor, probably contributed to continuing oak reproduction.

Along the rdigetops and upper slopes, land use is less important than fire as the principle historic environmental influence of the forest community. For example, all of the understory is post-1939 fire. (See the last six trees in Table XII).

The only place in the Forest where I have found the supposed bur oak-bitternut hickory association as described by Aikman (1925) is on the ridge in the burned area near the intersection of Fern-Hawthorn Trails. According to Aikman, this community consisted of a sparse stand of trees, with bur oak outnumbering bitternut by three to one. The oaks were slightly larger than the hickories. Averaging several 100 by 100 foot quadrats, he found a ratio of 48 oaks and 15 hickories per unit area.

In a similar sized quadrat near the trail intersection I counted 15 bur oaks and 20 bitternut hickories. The oaks were all 40-55 cm dbh, and the hickories 10-23 cm dbh. The largest hickory was Number 121, 23 cm dbh, dating from 1941P. The oaks, of course, are 1830-1840 vintage. It is in this same area that trees released during the episode of Childs' logging and again in response to an unexplained disturbance in 1889/1890. The combination of these two periods of stand disturbance and the fire of 1939, probably created conditions favorable to bitternut invasion following the fire. Although I do not know what these favorable conditions are, I will hypothesize that they are partly physical, and partly chemical. The physical aspect might be extreme stand openness resulting from multiple disturbances, and the chemical aspect might be a change in soil nutrients and acidity resulting from ash residue. The bur oak-bitternut hickory association seen by Aikman on xeric slopes in the 1920's was probably a result of disturbance followed by fire, or simply excessive fire damage to those dry upper slopes.

5. The Logged West-Facing Slope East of Mill Hollow.

Area Boundaries: This region of roughly 11.3 hectares (28 acres) is bounded on the north by the Burlington tracks, on the west by Mill Hollow stream, on the south by the Oak Trail remnant, and on the east by the break in the slope separating the Mill Hollow and Handsome Hollow watersheds (Maps 4 and 10).

Ownership History: The tract was owned by Childs and Company by the end of 1857.

Physical Evidence of Human Occupation: Charles Childs' house and sawmill were located near Oak Trail in the extreme northwest tip of this area. The house remains include a limestone-lined, rectangular pit which served as a cellar. The mill site is just north of the house on level ground about 30 meters south of the railroad tracks (Map 4). John Kluson, who was a caretaker at the Forest in the early 1940's, built a fishing shack on the same site. This shack burned, so today, modern rubbish overlies heavy iron bolts, window glass, bricks and other debris of the mill.

There are two skid roads still in evidence, branching away from Oak Trail. One leads up into the deep ravine at the south end of the region, and the other leads down to Mill Hollow stream. There was probably a crossing there at one time, and trees cut on the west side of the hollow were skidded across the stream, onto Oak Trail to the mill.

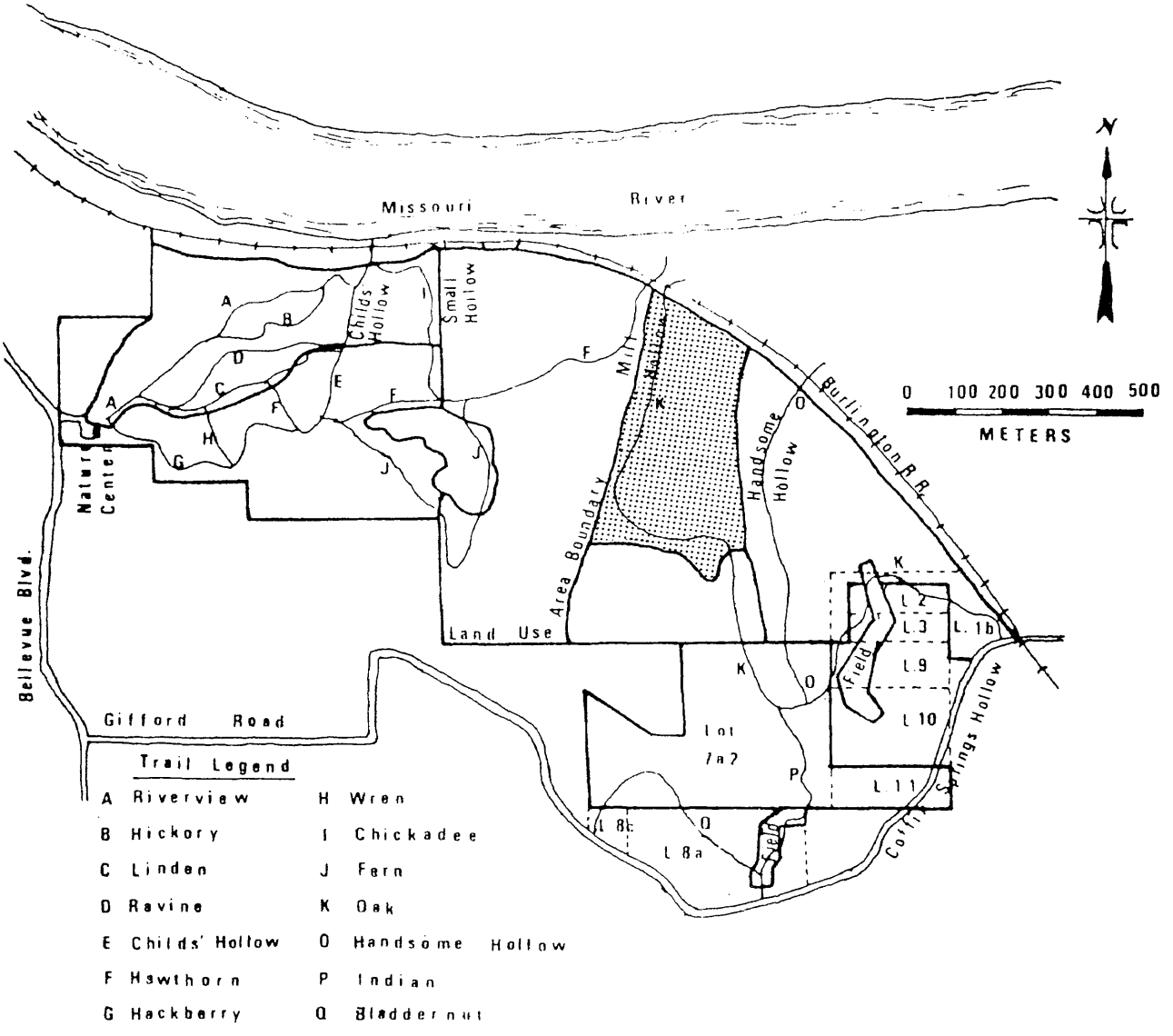
An old fence cuts across the lower slope and then runs south parallel to Oak Trail before disappearing near the southern boundary

Map 10

Location of west facing slope on the

east side of Mill Hollow

(shaded)



of the region. Whatever purpose this fence served is not evident today. There is no difference in the size or species composition of trees on either side of the fence.

Through the 1920's Oak Trail was still sufficiently open to accommodate a vehicle. Edward Sterba (personal communication) attempted this once, and about halfway down the slope in the south part of the region his car bogged down to the axles in a thick deposit of buried sawdust. It may be that Childs had a portable mill that could be pulled about on skids to a logging site and used to cut lumber or fuelwood. Sterba and I went over the site with a metal detector but found nothing.

Land Use History of the West Facing Slope of Mill Hollow: Obtaining information about land use by increment core sampling was difficult in this area. Three fourths of all stump sprouts located in the region were hollow. The sprout population consists only of ten or eleven bur oak sprouts scattered about the slope, and a half dozen each of red oak and linden sprouts on the lower slope. Though I usually did not core linden sprouts, I was forced to do so here because of a lack of suitable sprouts in other species.

The sprouts listed in Table XIV indicate that logging crews were cutting trees from 1860 until about 1870. Number 242 is probably a naturally forked tree. No other sprouts in the Forest correspond to it in age.

The attempt to date disturbance by observing release in remnant trees was unsuccessful. Nineteen trees sampled, (Tables IX and XVI), were present in the stand by 1860, but only one released as a result of logging. This was Number 151, (Table XV), located at the upper end of

Table XIV

Core samples from stump sprouts and fire sprouts on the west facing slope of Mill Hollow

Field #	Species	DBH in cm	Age
	Stump Sprouts		
242	Bur oak	37	1851(1847)
458	Bur oak	47	1861(1860)
P.47	American linden	42	1867+
457	Red oak	50	1867++
456	American linden	50	1869++
232	Bur oak	38	1871++
245	Bur oak	33	1873++
244	Bur oak	51	1875(1871)
	Fire Sprouts		
148	Bur oak	17	1940P
246	Green ash	20	1942(1940)

Table XV

Core samples from single trunk bur oaks on the west facing slope of Mill Hollow

Field #	Species	DBH in cm	Age	Release Date
263	Bur oak	72	1732+	
271	"	65	1750(1747)	
243	"	66	1756+	
335	"	67	1761P	
P.46	"	46	1778+	
150	"	55	1780++	
261	"	61	1796++H	
260	"	54	1834(1830)	
151	"	58	1825(1821)	1869
147	"	48	1850++H	
334	"	37	1850+	
82	"	30	1852P	
266	"	43	1858++	

Table XVI

Core samples from single trunk species other than bur oak on the west facing slope of Mill Hollow

Field #	Species	DBH in cm	Age
262	Shagbark hickory	45	1832(1828)
333	Shagbark hickory	41	1838P
194	Bitternut hickory	45	1841(1838)
339	Shagbark hickory	43	1853P
265	Red oak	63	1853+
268	Green ash	42	1862(1859)
332	American linden	68	1865++
P.47	Green ash	55	1869+
337	Red oak	59	1869(1865)
P.48	Red oak	62	1870++H
P.48	American elm	35	1870(1868)
101	Bitternut hickory	45	1873+
338	Honey locust	73	1882++
270	Hackberry	54	1882+
P.47	Red oak	39	1900++H
336	Red oak	44	1906(1904)
P.45	American elm	18	1921(1918)
267	American linden	34	1946(1942)
P.46	Red oak	27	1950(1946)
P.45	Bitternut hickory	26	1953(1950)

a ravine just north of the Oak Trail remnant. This tree released in 1869 (Fig. 10).

Five of the bur oaks listed in Table XV were mature canopy trees at the time of logging, and would not be expected to show release. The remaining 14 trees in Tables XV and XVI that were in the stand by 1860 were all saplings and understory trees and would be expected to respond to removal of canopy trees. That they did not respond suggests that the pre-logging forest on this slope was relatively open and the canopy layer discontinuous. Saplings and understory trees were getting adequate sunlight and further opening of the canopy stratum by logging had minimal affect on their growth rate.

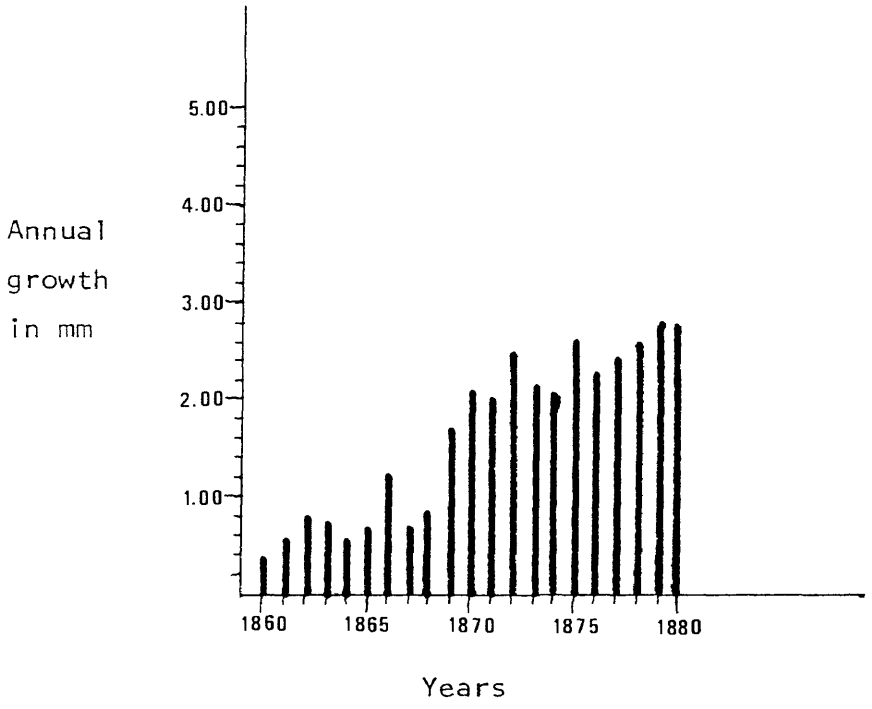
Fire History of the West Facing Slope of Mill Hollow: The fire of November, 1939, burned the middle portion of this region from mid-slope up to the ridgetop and about 40 meters down the other side. Fire damage is not evident in the south and north portions of the area (see Map 6). In the burned area large trees are scarred and sprouts of hop hornbeam (Ostrya virginiana), American elm, red oak and green ash are numerous. The red oak and green ash sprouts listed in Table XIV resulted from this fire.

The West Facing Slope of Mill Hollow Today: In the southern portion of this region near Oak Trail, there is a southwest facing slope covering about 2.8 hectares. Here, there is a dense stand of bur oak and shagbark hickory, all of the trees, such as Number 82 and 339, being from 30 to 50 cm dbh. These trees are all 1830-1850 vintage. The older oaks, except for two or three, have all been cut.

Fig. 10

Growth rate chart of bur oak Number 151

(Release begins in 1869)



On Map 5, is an outlined area on the upper slope and ridge containing roughly 1.6 hectares. Here there is a concentration of very old bur oaks, dating back to the 1700's, and also younger bur oak and shagbark hickory of 1830-1850's vintage. Childs was much more selective in his logging here than on the rest of the slope.

The remaining 6.8 hectares, from tree Number 82 north to the railroad, was heavily logged. The half dozen old bur oaks scattered about this area are conspicuous against the surrounding second growth of red oak, ash, elm and linden.

If the pre-logging forest was relatively open as I have suggested, the situation changed rapidly following logging. The even-aged stand of red oak, ash, linden and elm that invaded the slope in the 1860's and 1870's was much denser, and those trees today are tall, 23-24 meters, with confined crowns, and are free of branches on their lower trunks.

In the vicinity of plot 46, on the upper slope, the dry 1930's and the 1939 fire took a heavy toll on the even-aged, post logging stand. Here a younger, even-aged, post-fire stand of red oak, ash and elm forms a dense stand with a low canopy of 17 meters. These post-1940 trees have confined crowns, and are shedding their lower branches as they grow in height.

In spite of fire damage there has been no invasion of bitternut hickory in the burned area. The bitternut population in this region is confined to the mesic lower slopes along Oak Trail. Some of these bitternuts are the largest and oldest in the Forest. Number 194, 45 cm dbh, dates from 1841(1838). The species is still reproducing. Both

plots 47 and 48 on the lower slopes east of Oak Trail contained young bitternuts in the understory and shrub layers. Why this species did not invade the upper slope after it was opened by burning in 1939 is difficult to explain.

6. Handsome Hollow Region

Area Boundaries: This large tract contains roughly 19.4 hectares (48 acres). It is bounded on the north and east by the Burlington tracks, on the west by the upper reaches of Handsome Hollow's east-facing slope, on the south by the old Smith property (lot 7a2), and also by tax lots 2 and 3 (Maps 4 and 11).

Tax lots 2 and 3, each containing 1.6 hectares, were sold by Childs (lot 3 in 1873 and lot 2 in 1875), to other parties. Up until the time he sold them, Childs used the timber resource on these lots much as he did on the remainder of this parcel.

This 19.4 hectare tract includes the upland portion of an irregular shaped lot known as tax lot 1b. Lots 2 and 3 were originally part of 1b until Childs sold them.

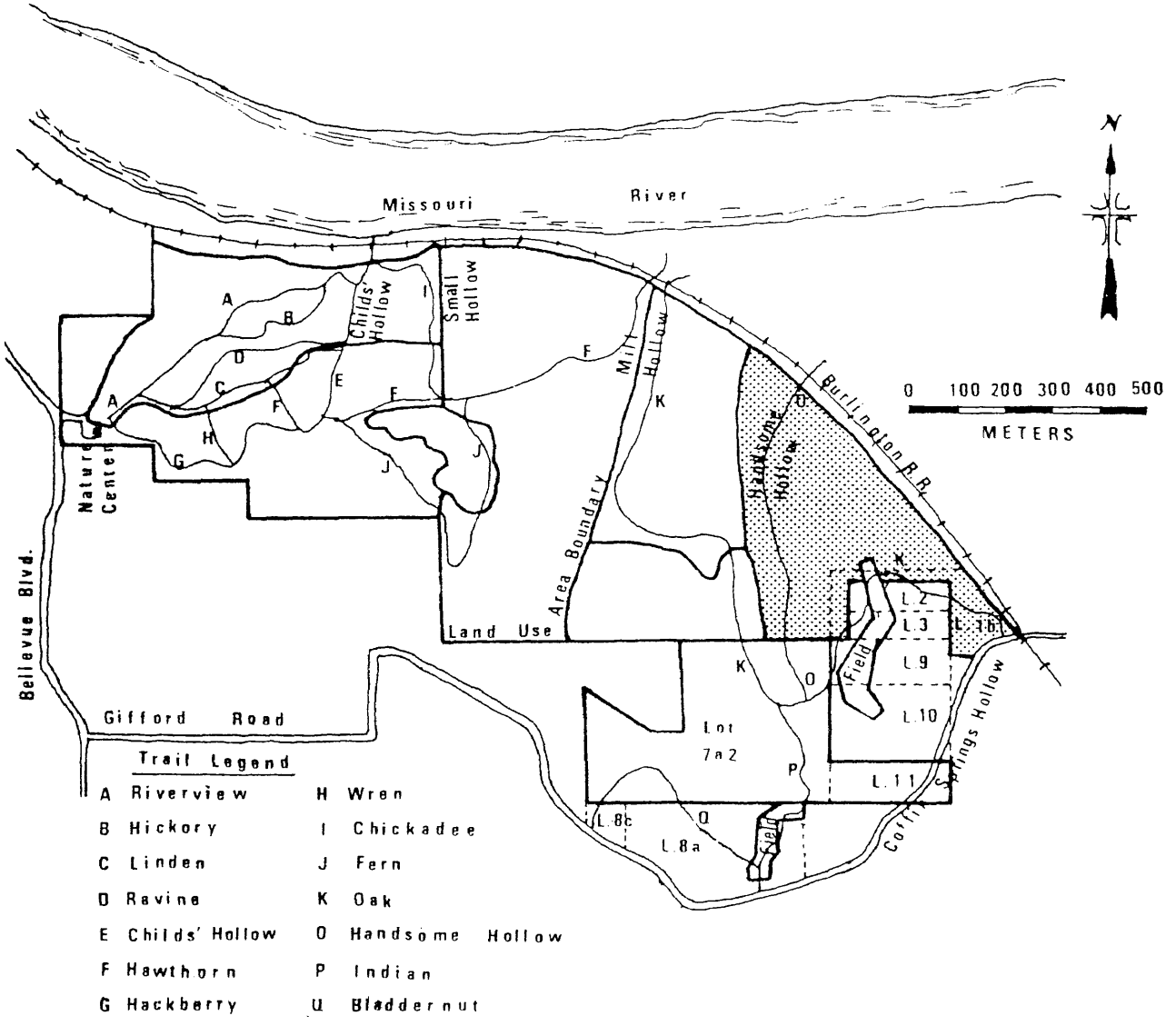
Ownership History: This tract was owned by Childs and Company by the end of 1857.

Physical Evidence of Human Occupation: There is no evidence of roads or structures in this area. In the bottom of Handsome Hollow, there is evidence of recent erosion and gullying that has since stabilized. This erosion probably resulted from scouring of the ravine bottom by logs dragged behind oxen or horses.

Map 11

Location of Handsome Hollow region

(shaded)



On the east side of Handsome Hollow's bottom and slightly up the slope are fragments of an old fence line. This fence meets the fence marking the north boundary of lot 7a2, and then runs the length of the hollow, finally connecting with the fence marking the railroad's right-of-way. The purpose of this fence is not evident, for there are no signs of grazing in the area.

Land Use History of the Handsome Hollow Region: The nine bur oak sprouts sampled were selected from twenty sprouts in the area, (Table XVII), most of them concentrated on the west facing slope. There were also a few unsampled red oak and green ash sprouts found on the lower west facing slope. Eight of the sprouts sampled indicate that logging occurred during a four year period between 1872 and 1876. Number 279, yielded an odd date, 1866P, but is an atypical sprout and may be a naturally forked tree.

Trees that were present at the time of logging released between 1870 and 1874, with most releasing in 1872 (Tables XVIII and XIX). The release response in this area is quite a contrast to the lack of release response on the west facing slope of Mill Hollow, bordering on the west.

Tables XVIII and XIX list 25 trees that were present in the stand in the early 1870's. Of these, only four failed to show some release response. The release response to cutting occurred in trees found throughout the area. Even large oaks a century old in the 1870's showed a slight response. This widespread release suggests, that compared to the west facing slope of Mill Hollow, the pre-logging stand

Table XVII

Core samples from stump sprouts and fire sprouts in the Handsome Hollow region

Field #	Species	DBH in cm	Age
		Stump sprouts	
279	Bur oak	44	1866P
201	"	29	1872P
134	"	40	1873(1872)
115	"	36	1876(1872)
83	"	45	1876P
157	"	41	1877+
235	"	52	1877+
203	"	29	1878+
204	"	45	1883++H
		Fire sprouts	
113	Green ash	30	1932+
N.A.	Green ash	21	1931+

Table XVIII

Core samples from single trunk bur oaks

in the Handsome Hollow region

Field #	Species	DBH in cm	Age	Release Date
250	Bur oak	71	1771++	
253	"	85	1775++	Slight
254	"	76	1779+	growth rate
169	"	77	1793++	increase
166	"	46	1794+	in 1870's
P.41	"	43	1813(1810)	1872
330	"	29	1813P	1872
172	"	52	1815P	
P.12	"	44	1818P	1873
P.42	"	50	1822++H	1872
154	"	53	1824+	1872
257	"	61	1830+	1871
259	"	58	1833+	1872
280	"	58	1834+	1872/1877
155	"	58	1835+	1872
P.13	"	57	1838++H	1872
163	"	61	1847++	1872
171	"	47	1850++H	1872

Table XVIII cont.

Field #	Species	DBH in cm	Age	Release Date
281	Bur oak	61	1850++	1870
164	"	50	1838++H	1871/1875
168	"	51	1866(1862)	1871
P.42	"	20	1871(1867)	

Table XIX

Core samples from single trunk species other than bur oak in the Handsome Hollow region

Field #	Species	DBH in cm	Age	Release Date
P.13	Black walnut	50	1840++H	1872
331	Red oak	54	1860+	1872
252	Shagbark hickory	32	1868(1865)	
P.13	Red oak	44	1876++	
258	Red oak	57	1877++H	
255	Shagbark hickory	34	1877+	
256	Red oak	65	1882++H	
251	Red oak	44	1883++	
170	Red oak	50	1883++	
P.41	Red oak	33	1884+	
P.12	Red oak	54	1903++H	
P.12	American elm	47	1905(1901)	
167	Red oak	44	1925+	1941
P.42	American elm	20	1937(1934)	
P.13	American linden	22	1938(1934)	

in this region was dense and the canopy layer continuous. Two bur oaks listed in Table XVIII released twice. Number 164, released in 1871 and 1875, and Number 280, in 1872 and 1877. Referring to Map 5, notice that these trees are within a few meters of the west boundaries of tax lots 2 and 3. Both these trees released a second time after Childs sold the lots and the new owners began cutting what Childs had left. The growth rate of number 164 is charted in Fig. 11.

Fire History of the Handsome Hollow Region: A fire took place around 1927 or 1928. An ash sprout Number 113, dated from 1932+, and another ash sprout dated from 1931+. These two sprouts are located on the west facing slope in the middle portion of the region. There are numerous other sprouts in their vicinity as well as fire-scarred trees.

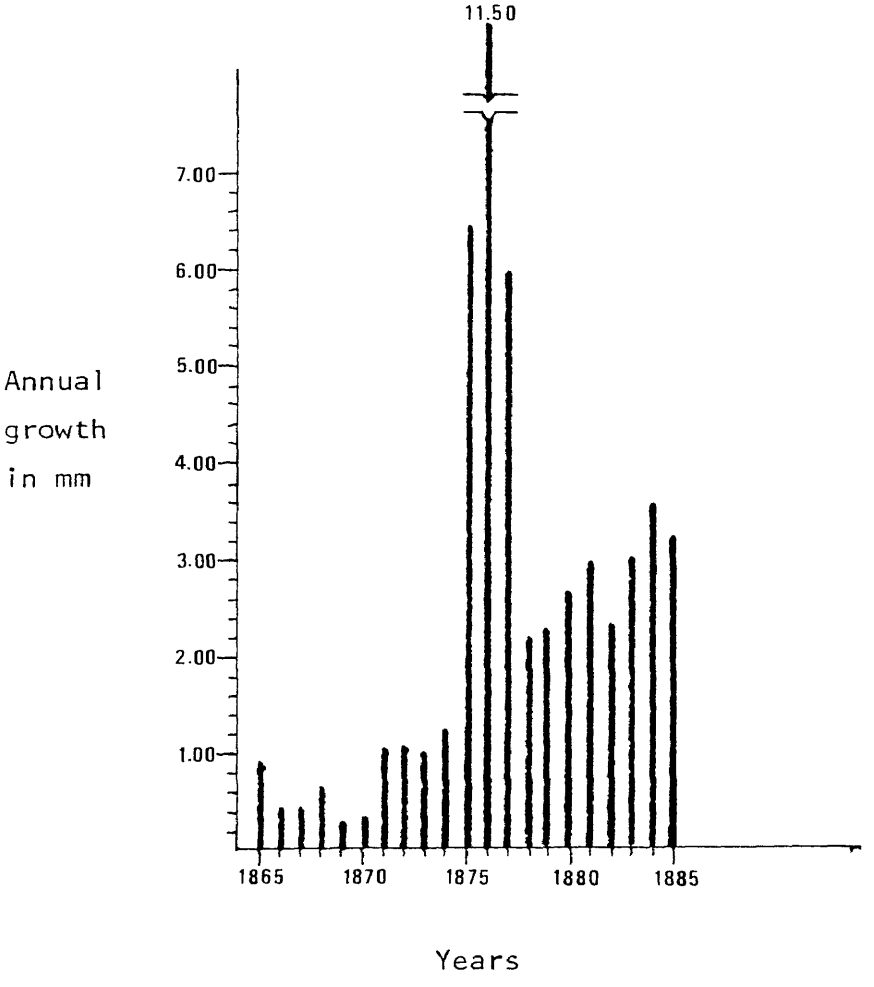
The fire of November, 1939 damaged only the west facing slope of the northern tip of this region. North from bur oak number 166, the stand is almost entirely post-fire, with only a handful of pre-1939 trees surviving.

One of these survivors is a red oak, Number 167. From 1925 until 1940, this tree's annual increment growth rate averaged slightly less than 1 mm per year. In 1941 the tree released. By 1943 the annual growth rate was up to 4 mm per year and has continued at that rate since. This is a verified case in which a tree released following destruction of the stand around it by fire. Since the fire occurred in 1939, release should have happened during the growing season of 1940. The crown of this tree was probably fire-damaged and the one year lag reflected recovery time. According to Jemison (1944) even severe fire

Fig. 11

Growth rate chart of bur oak Number 164

(Release occurs in 1871 and 1875)



scarring of the trunk does not reduce the growth rate of a tree, but damage to the crown does hinder growth.

The Handsome Hollow Region Today: An even-aged, post-logging stand of red oak dominates the east facing slope of the hollow and the steep slope bordering the floodplain. Most of the mature red oaks are between 45 and 55 cm dbh. Cores from three large, representative red oaks on the east facing slopes suggest that the stand developed in the 1870's following logging. On east facing slopes, bur oak if found only on the upper one third of the slope. Cores from five bur oaks on the upper east slopes, indicate release in 1871/72. These were Numbers 154, 155, 259, 168 and 169 (Table XVIII). I have the impression that Childs very thoroughly logged the timber on the east facing slopes and probably the lower west facing slope of the hollow as well. Childs supplied board lumber to people in the nearby communities, and he found his best lumber trees in the valley bottoms and on slopes with a north or east aspect. Trees growing in these localities must compete for sunlight, and as a result, do not spread or fork, but grow tall, shedding their lower branches as they grow vertically. The canopy height in these localities is generally 24 to 26 meters. Trees in the bottom of Handsome Hollow reach heights of 30 meters. These tall, unbranched trees yield long, straight boards.

On the ridgetop and upper east and west facing slopes, Childs was much more selective. There still remain at least twenty bur oaks in the area 55 cm dbh and up, many of which are 200 years old or more. Some small isolated patches of timber, such as in the vicinity of bur oaks 250 and 253, appear undisturbed. On the ridgetop and upper east

and west slopes, the canopy is from 17 to 20 meters high. Trees here spread out more, branch at a lower level, and do not have the straight columnar trunks desirable for saw timber. Although some of the old bur oaks sampled were 25 to 40 cm dbh at the time Childs was logging, he culled them regardless of their size.

Although the northern tip of this region was burned severely in 1939, there are not more than a handful of bitternut seedlings scattered about the entire area. There was probably no seed source nearby in the 1940's to contribute to bitternut invasion.

7. Clifton-Childs' Property, Outside the Pasture

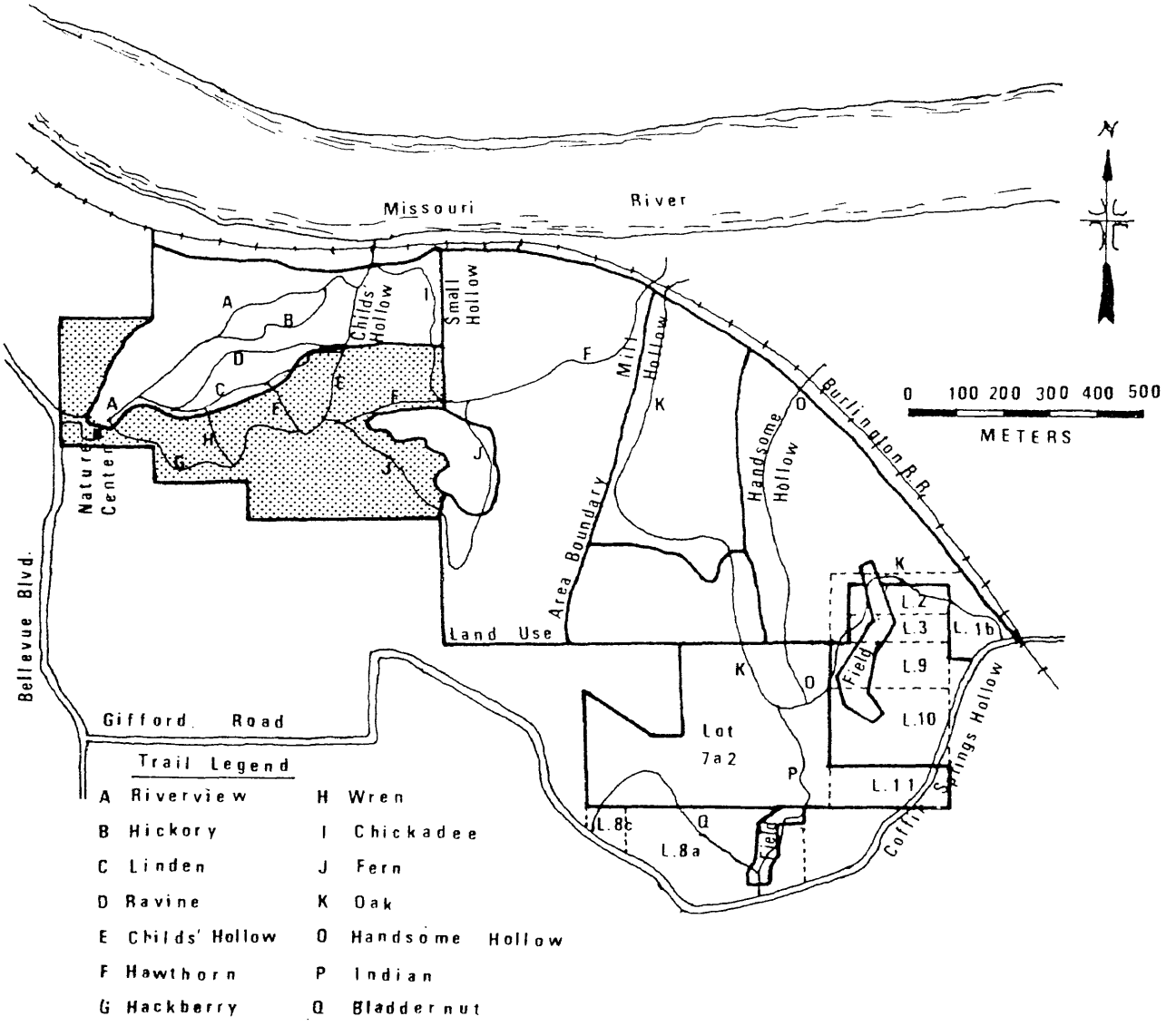
Area Boundaries: This region of roughly 20.6 hectares (51 acres) in section 14, is bounded on the north by a remnant of wire fence running along the south side of Linden Trail, on the west by the Forest boundary, on the south by the Forest boundary, and on the east by section 13 and the Fern Trail remnant (Maps 4 and 12).

Ownership History: This region is part of the southeast $\frac{1}{4}$ of section 14, which was first homesteaded by Daniel Clifton in July, 1857. In December, 1862, Clifton sold 55.0 hectares (136 acres) of this homestead to Charles Childs. (Part of the 55.0 hectares is now outside of the Forest boundary.)

Recall from the biographical sketch of Charles Childs, that his son Lowrie began operating a dairy farm on his father's land in 1884. The dairy cattle were pastured on some of the 55.0 hectares that Childs bought from Clifton in 1862. This 20.6 hectares, however, is land that lay outside the pasture to the south.

Map 12

Location of Clifton-Childs' property, outside pasture (shaded)



Physical Evidence of Human Occupation: Loggers once used Childs' Hollow and the ravine along Fern Trail to skid logs north toward the river and then east to the mill. East of Childs' Hollow near Fern Trail, eroded ruts resulting from skid roads are still visible running up into a second growth stand of walnut (Map 4). During the discussion of the Fern Trail remnant, I mentioned this cutting of walnut and some bur oak in side ravines on the lower slope near Fern Trail. This gives the west boundary of the remnant a lobed appearance.

Land Use History of Clifton-Childs' Property: The ten stump sprouts listed in Table XX were selected from 49 sprouts sited on the property. Most of the sprouts are bur oak, and a few are red oak and black walnut found on lower slopes near Childs' Hollow and Fern Trail. There may be from 15 to 20 more bur oak sprouts in the area, but these have only one stem, the other stems having rotted away, leaving only knotted scars near the base of the surviving stem. These are not indicated on Map 5.

Seven of the ten sprouts sampled give positive dates of 1859-1860. The other three probably date to 1860 or 1861, but the borer passed wide of the pith.

Of ten trees sampled that were present in the stand during the logging operation, (Tables XXI and XXII), only two released. A bur oak, Number 394, released slightly in 1859, and another oak, Number 398, showed a slight growth increase beginning in 1862 (Table XXI). Both these trees are east of Childs' Hollow on the lower slope near Fern Trail in amongst the second growth black walnuts.

The absence of release in trees west of Childs' Hollow suggests that the forest near the prairie-forest border was somewhat open, and

Table XX

Core samples from stump sprouts from the Clifton-Childs' property, outside the pasture

Field #	Species	DBH in cm	Age
462	Bur oak	42	1859P
100	"	45	1860(1859)
212	"	43	1861(1860)
102	"	52	1862(1860)
463	"	42	1862(1859)
464	"	35	1863(1860)
216	"	43	1865(1860)
109	"	35	1867+
135	Black walnut	45	1869++
175	Red oak	40	1875++

Table XXI

Core samples from single trunk bur oaks from the Clifton-Childs' property, outside the pasture

Field #	Species	DBH in cm	Age	Release Date
390	Bur oak	74	1734++	
394	"	73	1748(1746)	1859
393	"	77	1800++	
380	"	61	1800++	
187	"	54	1806++	
398	"	56	1857+	1862
P.8	"	44	1861++H	
190	"	36	1862(1859)	
188	"	44	1873+	
282	"	65	1876+	
P.8	"	23	1898+	
P.28	"	34	1900++	

Table XXII

Core samples from single trunk species other than bur oak from the Clifton-Childs' property, outside the pasture

Field #	Species	DBH in cm	Age
289	Shagbark hickory	64	1811P
297	Shagbark hickory	52	1861+
299	Hackberry	81	1870++
P.28	Shagbark hickory	28	1872+
P.8	Shagbark hickory	38	1872+
P.9	American elm	46	1873++H
298	Red oak	55	1874+
392	Red oak	68	1883++H
P.9	Red oak	52	1889++H
P.31	Honey locust	41	1920
273	Honey locust	54	1922+
P.31	Green ash	31	1931(1930)

the canopy discontinuous.

Evidence from the increment core samples shows clearly that this area was logged before Childs purchased the land in December, 1862. I believe it possible that Childs and Clifton had an agreement for Childs to do the logging and saw the largest oaks and walnuts into lumber at his mill.

After purchasing the land in 1862, Childs did not return to it to cut more trees because evidently there were no more of suitable size. Observing this land today, it is apparent that the logging operation of 1859-1860 was very thorough.

In the entire stand between the Nature Center and Childs' Hollow there are only two trees that were of any size at the time of logging. A bur oak, Number 187, was 24 cm dbh in 1860, and a shagbark hickory, Number 289, was 23 cm dbh. (This hickory is the largest and oldest hickory in the Forest. It is on the south side of Hackberry Trail, about half-way down the slope from the Nature Center.) The rest of the stand west of Childs' Hollow is entirely second growth, the oldest trees dating from the 1850's. The stand east of Childs' Hollow is also second growth, with the exception of two or three old bur oaks, such as Number 194, growing on the lower slope near Fern Trail.

The only part of the entire 20.6 hectares that could be considered an unlogged remnant, is the top of a high, narrow ridge between Childs' Hollow and Fern Trail. This small area is outlined on Map 5. Bur oak Number 390, growing on this ridge, dates from 1734++, making it one of the oldest trees in the Forest. (++ indicates that the tree is estimated to be more than 10 years older than date given.)

The large number of stump sprouts in the area also indicates that

loggers cut everything of commercial value, including fence post-sized trees. As mentioned earlier in the Methods section, small trees are likely to sprout prolifically when cut. Many of the oaks cut here were probably young trees of 1830's-1840's vintage, which are still numerous in less heavily logged sections of Childs' property.

Fire History of the Clifton-Childs' Property: I found no evidence of any historic, post-settlement fire in this region.

The Clifton-Childs' Property Today: The five bur oaks listed first in Table XXI are unusually old for this area. Otherwise the stand is entirely even-aged, second growth. In other parts of the Childs' property, I noted that bur oak reproduction dropped off after the 1850's. In this region however, the 1850's mark the beginning of bur oak reproduction, nearly all the older oaks having been cut.

On Map 4, note that Hackberry Trail runs between the Nature Center and Childs' Hollow about mid-slope. As a general rule, the stand upslope from this trail to the old pasture fence is a bur oak-shagbark hickory association, and that below the trail a red oak-American linden association.

The red oak-American linden community consists of tall trees, up to 30 meters, with lower trunks free of branches. Black walnut and elm are also common on the lower slopes.

The bur oak-shagbark association is a dense stand, with the mature trees 30 to 40 cm dbh. These trees are 20 to 22 meters tall, and have confined crowns. Plot 8, on the upper slope, contained 3 mature oaks, and 3 mature hickories. Plot 28, also on the upper slope, contained 4

mature oaks and 3 mature hickories. In places shagbark forms pure stands, with 8 to 12 mature trees confined to an area only 10 x 20 meters. There are also bur oaks and shagbarks in the understory that are 15 to 20 cm dbh. These two species were probably reproducing until the early 1900's.

The dense bur oak-shagbark stand ends abruptly at the pasture fence. The bur oaks along the fence line, near the pasture clearing are larger in girth; some of them, for example Number 282, up to 65 cm dbh. However, these larger trees are the same age as the 30 to 40 cm dbh trees growing under more crowded conditions in the stand away from the fence. The large oaks along the fence line are lopsided, with most of their crown development toward the former pasture clearing (Fig. 12).

8. Clifton-Childs' Property, Pastured Land

Area Boundaries: Childs' pasture contained roughly 18.2 hectares (45 acres). It was bounded on the north by the edge of the steep bluff, on the west by a fence, on the south by a fence running parallel to Linden Trail, and on the east by a fence running along the top of the bluff above Small Hollow. This latter fence also makes the east boundary of section 14 (Maps 4 and 13).

Ownership History: This pasture contains parts of two different properties. The north 10.2 hectares were owned by Childs and Company by the end of 1857. The south 8.0 hectares are on part of the tract that Childs purchased from Clifton in 1862. A dashed line on Map 13 indicates the boundary between the two properties. This boundary was never fenced.

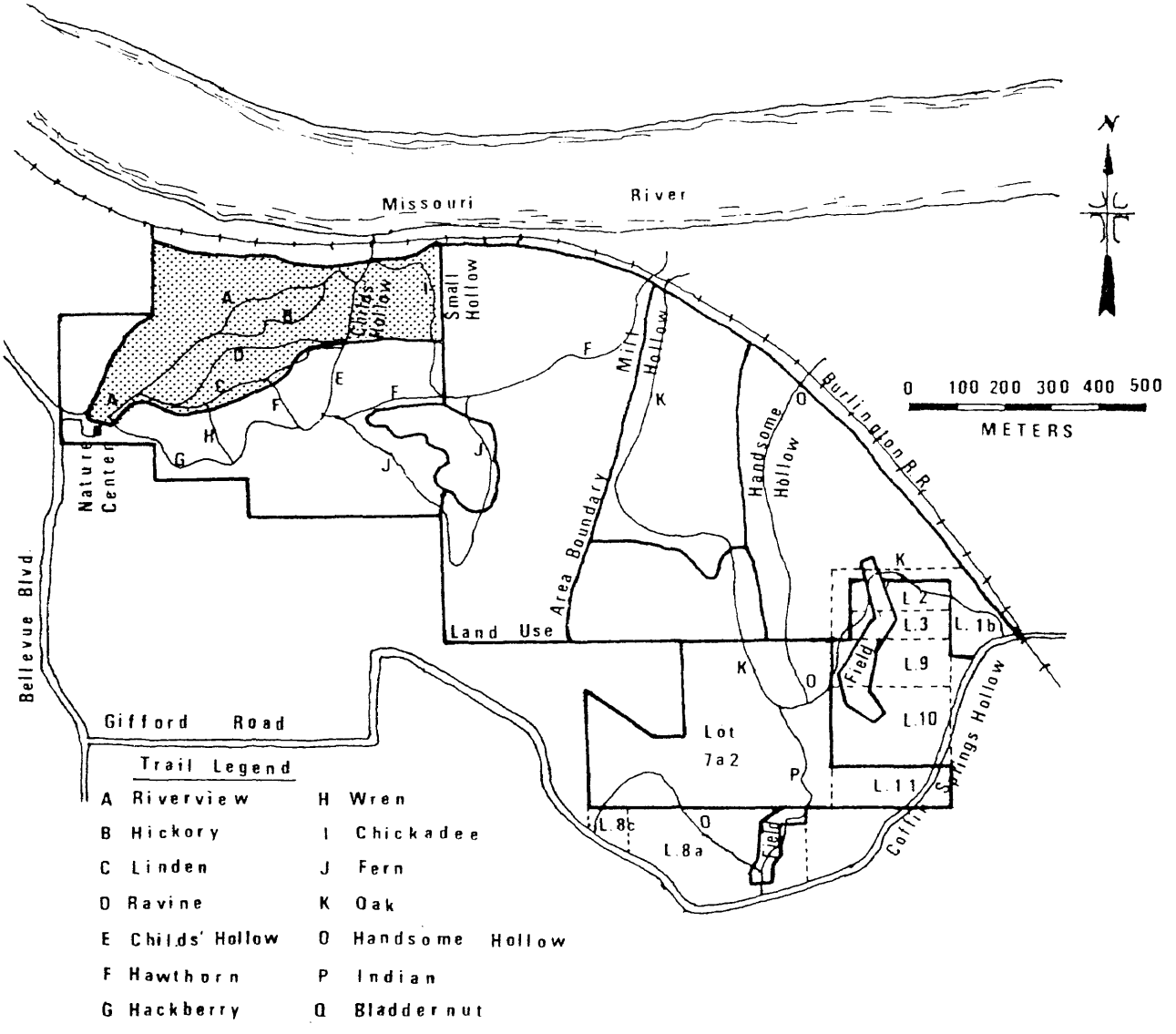
Fig. 12

Bur oaks growing along south side of former pasture fence near present day Linden Trail

(Note development of crowns toward the former pasture clearing left of the oak trees)

Map 13

Location of Clifton-Childs' property, pastured land (shaded)



Physical Evidence of Human Occupation: There is evidence of an old road, used by Childs and perhaps others, that began near the Nature Center and ran parallel to Riverview Trail (Fig. 13). From Riverview Trail it went down Hickory Trail for a short distance, then in the vicinity of tree Number 294, made a 180° turn down the slope to the present-day Ravine Trail. There is severe erosion where the road hits the ravine and the entire length of this ravine is also severely eroded because of cattle and vehicles. At the lower end of the ravine, the former ravine floor can be seen as a bench, two meters above the present gulley bottom. Several side ravines branching away from Ravine Trail show signs of erosion probably caused by cattle, and on both sides of Childs' Hollow there is a faint path just inside the pasture fence, made by cattle walking along it. On the lower slope east of Childs' Hollow an old skid road leads up into a walnut grove.

As already mentioned, the dairy farm buildings once stood on the site of the present Nature Center. An old house, now used for storage and ranger's quarters, was built around 1903 to house the tenant of the farm. It replaced a house that had burned down on the same site (C. E. Childs, personal communication).

Land Use History of Childs' Pasture on the East Side of Childs' Hollow:

Logging: There are only two stump sprouts in the entire 4.0 hectares east of the hollow. A bur oak sprout, Number 217, dates from 1877(1875) (Table XXIII). It is on the fence line at the top of the slope. There is also a black walnut sprout about mid-slope, but it is hollow.

Fig. 13

A view of Childs' pasture about 1918 (top) and the same view today (Note old road in right foreground of 1918 photo. Eroded path in present photo is Riverview Trail. The tree in the left foreground of both photos is a linden, and in the left background, a black walnut. Top photo by Louis Bostwick.)

Table XXIII

Core sample from a stump sprout in Childs' pasture on the east side of Childs' Hollow

Field #	Species	DBH in cm	Age	Release Date
217	Bur oak	48	1877(1875)	1884

A bur oak released, probably following logging, in 1867 (Table XXIV). It is in plot 22, on the lower slope. Four other trees released in the mid-1870's at the same time that Number 217 was cut. Fig. 14 charts the growth rate of bur oak Number 378, which released in 1874.

The logging pattern here appears similar to that on the lower slope near Fern Trail a few hundred meters south. Logging here was for black walnut and some bur oak between 1874 and 1877. Most of the pre-logging bur oak population is still intact, but the walnuts are all second growth. One of the largest walnuts on the lower slope, Number 138, dates back to the late 1870's.

Grazing: Note on Tables XXIII and XXIV that trees of several species scattered throughout the pasture east of Childs' Hollow released in 1884-1885. Fig. 15 charts the growth rate of a large bur oak on the upper slope in plot 24, which released in 1885. This growth increase occurred, I believe, after Lowrie Childs and his helpers (see biographical sketch) cleared the area of all the undesirable underbrush and understory trees, in order to convert the forest to bluegrass pasture. The brush was probably stacked and burned. Photos, Fig. 16, taken in the pasture around the turn of the century by Lowrie's son C. E. Childs, show the area as being park-like with scattered trees. Around Omaha, one may find similar woodland pastures where all the forest trees except bur oak have been cleared, and the land sown in bluegrass. (Outside the Forest boundary, just west of Fern Trail, is a pasture with scattered trees and grass, which probably looks much like Childs' pasture did 70 or 80 years ago.)

Table XXIV

Core samples from single trunk trees in Childs' pasture on the east side of Childs' Hollow

Field #	Species	DBH in cm	Age	Release Date
374	Bur oak	93	1750++	
379	"	71	1812++	1884
137	"	55	1830++	1884
P.22	"	70	1834+	1867/1884
P.24	"	60	1835++	1885
378	"	65	1842(1839)	1874
386	"	57	1870++	1885
383	"	54	1877++	1884
382	Shagbark hickory	42	1835(1832)	1875/1885
384	American elm	55	1848+	1877/1884
375	Red oak	92	1867++	1875
138	Black walnut	62	1880+	
385	Honey locust	53	1907++H	
P.21	Bitternut hickory	36	1910(1908)	
P.21	Green ash	29	1916P	
106	Bitternut hickory	39	1920P	
P.22	American elm	32	1921+	
P.24	Red oak	40	1933(1930)	

Table XXIV cont.

Field #	Species	DBH in cm	Age	Release Date
376	Red oak	37	1932+	
377	Green ash	53	1932+	
P.24	Green ash	19	1922(1930)	
P.22	Red oak	37	1935+	
P.23	Green ash	27	1937+	

Fig. 14

Growth rate chart of bur oak Number 378

(Release begins in 1874)

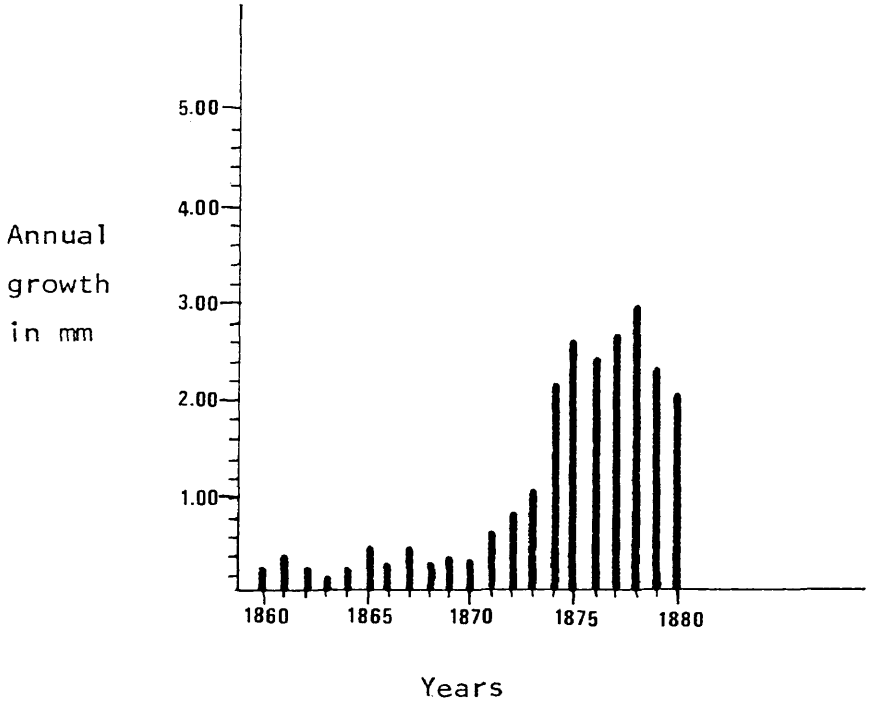


Fig. 15

Growth rate chart of bur oak in plot 24

(Release begins in 1885)

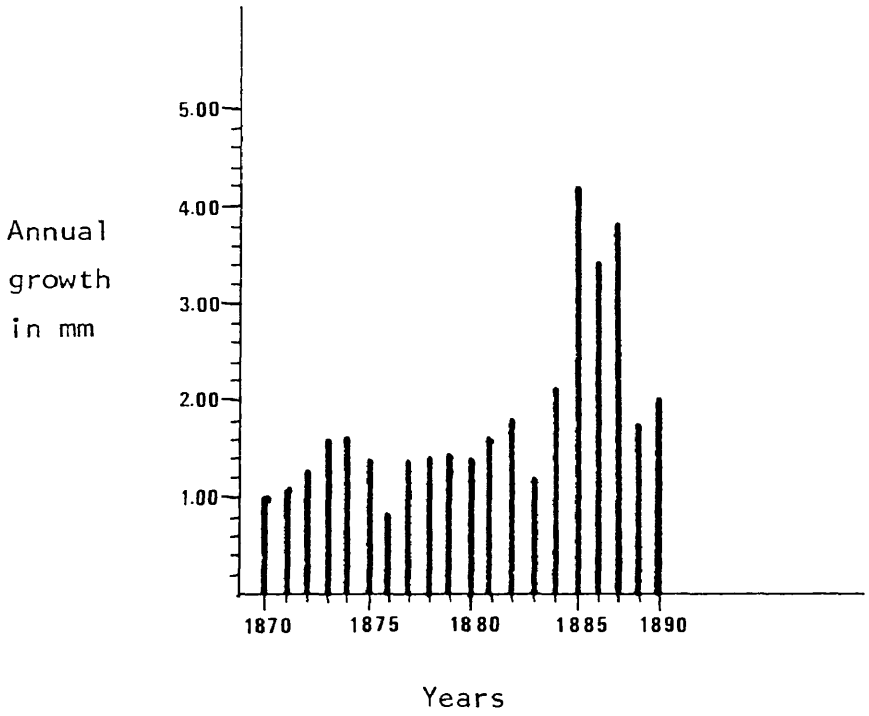


Fig. 16

Two views of Childs' pasture about 1905

(The top photo was taken north of present day Riverview Trail. The bull in the bottom photo is on the slope between present day Riverview and Hickory Trails. Photos by C. E. Childs.)

Five of the trees that released in 1884-1885, were young saplings at the time, but three of the bur oaks were already large, mature trees. In 1884 Number 379 was 32 cm dbh, and the oaks in plots 22 and 24 were both nearly 20 cm dbh. Young, suppressed saplings are expected to release following cutting, but here is an example of large, canopy height trees releasing after the understory was removed from around them. This suggests that the forest stand here in 1884, could not have been very open, and that even the mature trees were crowded.

The present appearance of some of these large bur oaks also reveals something about the events in 1884. Fig. 17, is a photo of a bur oak, 70 cm dbh, in plot 22 on the lower slope. Like most of the oaks in this region, its growth form indicates that it matured under somewhat crowded conditions. It is a tall tree, about 24 meters, and its lower trunk was once clear of branches. Main branching begins 9 to 10 meters above the ground. These large branches grow upward, forming a rounded, symmetrical crown. Its form is much like the oaks in the Oak Trail remnant. But about 3 and 6 meters above the ground the tree bears tiers of smaller branches, 5 to 10 cm in diameter. These superimposed branches, which are now dead, stick out from the tree at an unusual 90° angle. The younger branches began growing before the turn of the century, probably after the understory was cleared away, and increased sunlight to the lower strata caused previously dormant buds on the lower trunk to sprout. A number of the other bur oaks in the pasture also bear these small superimposed branches on their lower trunks. Most of these small branches are now dead, probably because of shading by other trees that have invaded the pasture since grazing stopped.

Fig. 17

Bur oak in pasture east of Childs' Hollow today

(This tree is located in plot 22 on lower slope)

Fire History of the Pasture East of Childs' Hollow: Although there are no fire sprouts in this region, some of the large trees do bear old fire scars at their bases. I was interested in dating the fire that caused these scars because there is a grove of bitternut hickory on the lower slope near plot 21. It seemed possible that the fire had preceded and triggered the bitternut invasion.

The oldest tree in the region, Number 374, has an old fire scar on its northeast side. The callous margin is 10 cm thick over the burned surface, and the scar is almost completely covered over. By taking several increment samples at 2 cm intervals outward from the center of the scar, I determined that the oldest ring of the callous margin formed in 1906. On samples that passed through unscarred wood outside the outer edge of the callous margin, the ring formed in 1905 was intact but discolored by weathering. The fire apparently occurred after the 1905 growing season, and before the spring of 1906. Someone may have set this fire deliberately in order to clear the pasture of underbrush.

Several of the largest bitternut hickories were sampled and cores from two trees were kept. The oldest bitternut, 36 cm dbh, is in plot 21. This tree dates from 1910(1908). It is possible that the pasture fire in the winter of 1905-1906 contributed to the onset of bitternut invasion a few years later.

The Pasture East of Childs' Hollow Today: The most striking feature about the forest here is that the canopy stratum is comprised of two distinct generations of trees, with a 35 to 40 year hiatus between, during which there was very little reproduction.

The age of the old pre-logging, pre-pasture stand ranges from the

mid 1700's to about 1880. This stand is mostly bur oak, some red oak and shagbark hickory, and second growth black walnut. The crowns of the oaks and walnuts are full and symmetrical. Shagbark has a somewhat more confined, but symmetrical, crown. These widely spaced trees were left deliberately by the Childs' family as shade trees for cattle. These older trees range in girth from 40 to 93 cm dbh. They were free from competition from 1884, until as late as perhaps the 1940's, when the younger generation trees began taking their places in the canopy stratum.

The post-pasture generation consists mainly of red oak, green ash, linden and elm that began invading the region in the 1920's and early 1930's. These trees are now as tall as the older trees, 22 to 24 meters, but are closely spaced, and have narrow, confined crowns as a result of crowding. These younger canopy height trees range in girth from 15 to 40 cm dbh.

The bitternut population reaches its greatest density in plot 21. This 10 x 20 meter plot contained five large bitternuts in the canopy stratum, five in the understory, four saplings, and five seedlings. The population extends down the slope into Childs' Hollow and up the slope above the plot, gradually thinning out (Map 6).

Land Use History of Childs' Pasture on the West Side of Childs' Hollow: The west 14.2 hectares of the pasture has had a slightly different history of human disturbance.

Logging: This region was logged heavily between 1859 and 1862. At that time, the south half of the area belonged to Clifton, and the north half to Childs. Childs and his crew probably did the cutting on

both properties. Most of the terrain here slopes toward Ravine Trail, and the logs were either rolled or skidded down into the ravine, then on out Childs' Hollow to the sawmill. (A portion of a skidroad is pictured in Fig. 13.)

The seven stump sprouts listed in Table XXV were selected from a large population of sprouts in the area. There are at least 32 positive bur oak stump sprouts and perhaps as many as 45, counting those with only one remaining stem.

Of 11 trees sampled that were present in the stand in 1860, none released (Table XXVI). This suggests an open, discontinuous canopy of scattered trees. Two bur oaks, Numbers 286 and 287, released in 1876. (Fig. 18 charts the growth of 286). They are growing near one another in a side ravine along Hickory Trail. Childs probably cut down a few trees near them at about the same time he was cutting the walnut and bur oak east of Childs' Hollow.

Grazing: Tables XXV and XXVI list 27 trees that were present in the area in 1884. Seventeen were post-logging saplings at the time, yet only two bur oaks, Numbers 295 and 296, released in 1884/85 when the understory was presumably cleared to prepare the land for pasture. These two oaks are near one another along Linden Trail. The absence of widespread release suggests that the stand west of Childs' Hollow was relatively open compared to the stand east of the hollow, or perhaps the understory was also sparse, and little clearing was necessary.

Tables XXV and XXVI list five bur oaks that released in 1888-1889. Two of these oaks, Numbers 277 and 291, are growing 25 meters apart on a knoll near Riverview Trail. (See Fig. 19 for a growth chart of Number

Table XXV

Core samples from stump sprouts in Childs' pasture on the west side of Childs' Hollow

Field #	Species	DBH in cm	Age	Release Date
81	Bur oak	58	1861(1859)	
80	"	43	1862P	
459	"	42	1862(1860)	1889
460	"	33	1862(1860)	
213	"	35	1863(1860)	
461	"	42	1869++	

Table XXVI

Core samples from single trunk trees in Childs' pasture on the west side of Childs' Hollow

Field #	Species	DBH in cm	Age	Release Date
276	Bur oak	82	1751++	
285	"	73	1800++H	
286	"	67	1818+	1876
291	"	76	1830+	1889
294	"	77	1834++	
277	"	72	1835++	1888
287	"	69	1837(1834)	1876
214	"	49	1837+	
P.26	"	63	1842+	
292	"	55	1841+	
275	"	75	1860(1857)	1889
284	"	58	1864(1860)	1888
P.25	"	52	1866++	
288	"	55	1866++	
290	"	71	1866+	
283	"	62	1868P	
P.27	"	49	1874+	

Table XXVI cont.

Field #	Species	DBH in cm	Age	Release Date
295	Bur oak	61	1874P	1884
296	"	60	1875+	1885
P.27	"	49	1880++H	
P.25	"	14	1920(1918)	
P.27	"	20	1924++H	
P.25	"	13	1931P	
P.25	"	5	1952P	
293	Shagbark hickory	55	1867+	
P.26	Green ash	15	1933	
P.26	American linden	25	1937+	
P.25	Green ash	10	1937P	
P.26	Red oak	29	1939+	

Fig. 18

Growth rate chart of bur oak Number 286

(Release begins in 1876)

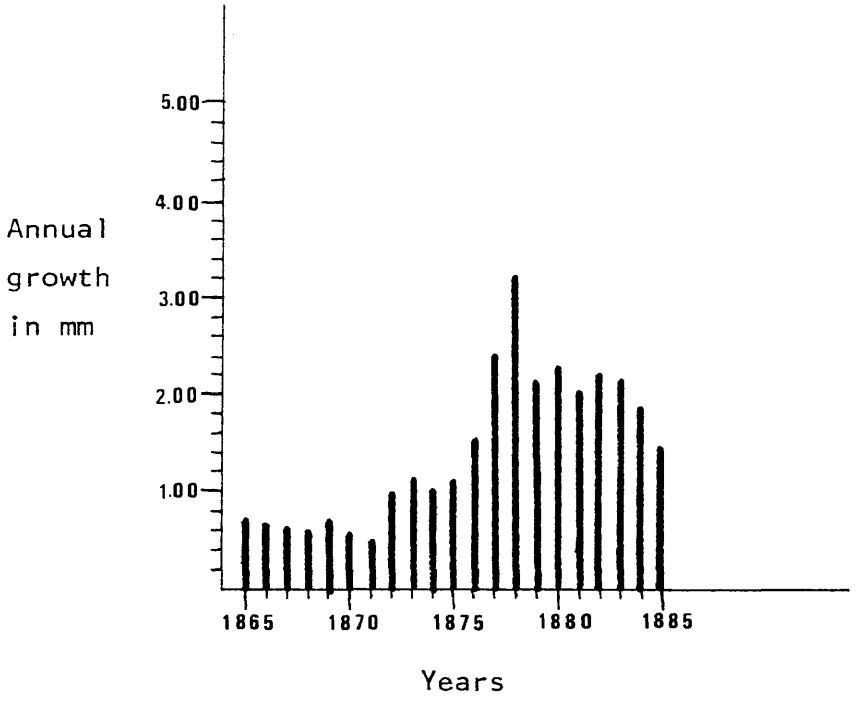
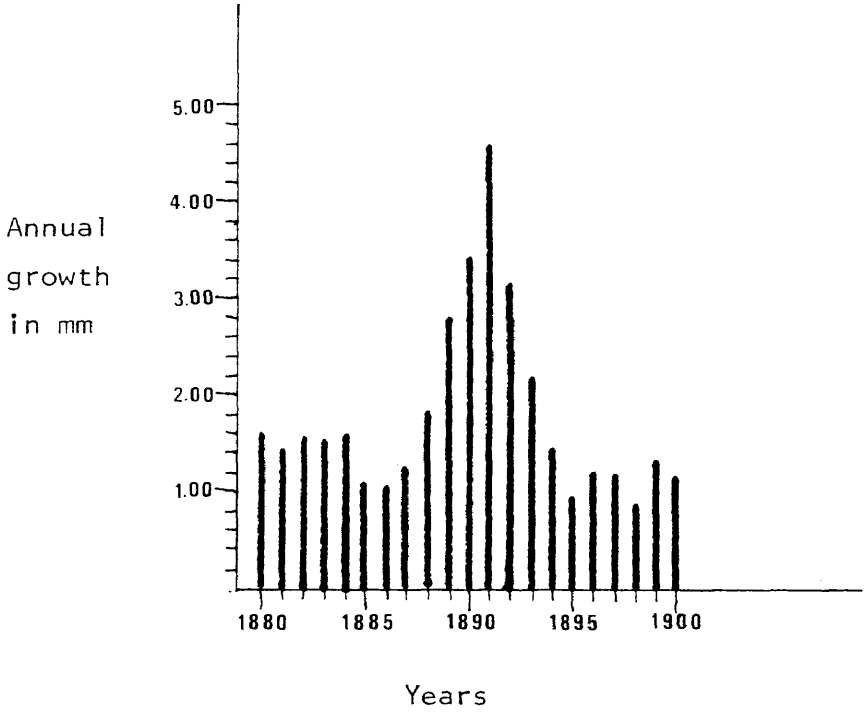


Fig. 19

Growth rate chart of bur oak Number 291

(Release begins in 1889)



291.) Two others, Numbers 275 and 284, are 15 meters apart on level ground between Riverview and Linden Trails. The fifth tree, Number 459, is a stump sprout growing away from the others in the northeast part of the pasture between Riverview and Hickory Trails.

Recall from the discussion of the logged portion of Fern-Hawthorn Trail ridgetop, that Tables X and XI listed eight bur oaks that released in 1889-1890. There is likely a common cause of the release of trees in the pasture and the Fern-Hawthorn Trail area. The most likely cause was renewed logging, yet I found no stump sprouts dating back to those years in either area. However it is possible that large, old trees were cut and the stumps did not produce sprouts. Another possibility is that unwanted underbrush and trees were cleared from the pasture in 1888 and 1889. However, this does not explain the 1889 and 1890 release on Hawthorn ridge. I questioned C. E. Childs about this, but he did not recall cattle being anywhere on the property except within the fenced enclosure. Nor are there any fences in the Hawthorn ridge area to indicate that the region was ever used for grazing. Human disturbance likely caused the releases in the two areas between 1888 and 1890, but the reasons for the disturbance remain a mystery.

Fire History of Childs' Pasture on the West Side of Childs' Hollow: The only evidence of recent fire is in a small area on top of the knoll above tree Number 103. Pinickers used to build fires there in the 1920's and 1930's, and a fire may have gotten out of hand, scarring a few trees and producing a few sprouts. I did not attempt to date the fire.

The Pasture West of Childs' Hollow Today: What was said about the appearance of the old pasture on the east side of Childs' Hollow, applies to the grazed land west of the hollow as well, except that there are few bitternut hickories west of the hollow.

The canopy stratum west of the hollow consists of two generations. The oldest generation is the pre-pasture trees, mostly bur oak, that were spared during the general clearing to provide shade. These range in age from the mid-1700's to about 1880. The younger generation began invading the pasture in the 1920's and 1930's, some 10 or 15 years after the cattle were removed. These trees are mostly red oak, ash, and linden. The photographs, Fig. 20, show a part of Riverview Trail in the early 1920's, not long after the cattle were removed, and the same area as it appears today.

The shagbark hickory population, which forms a dense stand outside the pasture, is confined here to a southwest facing slope in the vicinity of plot 25. Both shagbark hickory and bur oak are still reproducing on this slope.

Over most of the pasture the large bur oaks range in size from 55 to 75 cm dbh, and are spaced from 15 to 20 meters apart. Almost all are second growth, dating from the 1850's and 1860's, but they matured under open conditions, which explains their large diameter. They have full, spreading crowns, and on many, the lower branches are being shaded out by the dense growth of younger trees, and are dead.

It was the present appearance of Childs' pasture that prompted Nature Center naturalists in the 1960's, to express a theory regarding the development and life history of Fontenelle Forest's plant community.

Fig. 20

A view of Riverview Trail in the 1920's (top) and the same view today (The bur oak in the right foreground in both photos is Number 291. Bur oak Number 276 to the right of the three hikers is nearly obscured by young trees in the present day photo. Top photo by William Coons.)

I mentioned this theory briefly in the introduction to this manuscript. Basically, the naturalists assumed that pre-settlement prairie fires had prevented the growth of all woody species except bur oak, and that the dense stand of younger trees of other species had invaded the forest soon after settlers plowed the prairies, thus stopping the fires.

This theory had merit, for in pre-settlement days in areas throughout the midwest where forest and prairie came into contact, prairie fires burned frequently into the forest, hindering the growth of all but the most fire-resistant woody species. The frequent burning of exposed portions of the upland forest in the prairie-forest border region resulted in open, park-like stands of oak, with a ground cover of prairie grasses and herbs. These stands were called "oak openings" (Gleason, 1913).

Cottam (1949) described the course of species invasion following cessation of prairie fires in an oak woodland known as Stewart's Woods in southeastern Wisconsin. The entire woodland, described by frontier surveyors as a park-like, oak opening in 1833-1834, was drastically changed when Cottam examined it. In summarizing he stated (p. 286),

> "The oak woods in southeastern Wisconsin have been transformed from widely spaced oak openings to dense woods in the last one hundred years. These oak openings contained scattered, broad crowned trees. The herbs and shrubs were mostly prairie plants. Some of the old, open-grown trees remain in the present woods, but are now surrounded by tall, relatively unbranched forest-grown trees. The present understory is mostly forest shrubs and herbs."

Childs' pasture, in which open-grown oaks are now surrounded by tall, relatively unbranched forest-grown trees, fits Cottam's description of an over-grown, former oak opening to perfection (Fig. 21). Since no one on the Nature Center staff knew of Charles Childs; of his sawmill and pasture,

Fig. 21

Bur oaks in Childs' pasture west of Childs' Hollow today (The large, open-grown oak in the left foreground is Number 275. Bur oak Number 283 is in the right background.)

it was logical to assume that this part of the Forest had once been an oak opening.

A promotional pamphlet published by the Fontenelle Forest Association (1968) states,

> "Two hundred years ago we speculate, only bur oaks and prairie grass grew here. Almost nothing else survived because prairie fires set by the Indians for self defense and for herding bison killed almost everything else that tried to grow. When the white man came, these ravages ceased and the seeds brought in on the fertile west wind and by birds populated the Forest with dozens of plants native to the Temperate Zone of North America."

Since none of the remnant trees inside and outside the pasture west of Childs' Hollow released following logging between 1859 and 1862, it seems likely that the forest here actually was more open than other areas such as the Smith property or the Handsome Hollow region. This region is nearest the edge of the former prairie, and the Riverview-Linden Trail ridge area was directly in the path of incoming ground fires.

The early Nature Center staff may have been partly correct in their theory, but for the wrong reasons. The present appearance of the forest in this region has little to do with anything that happened in pre-settlement times, and much to do with what transpired in the region since. Another weakness in this theory, is that the forest community was much too heterogeneous then, as it is now and all tree species in the forest today were present in pre-settlement times too. Some of the less fire-resistant species may have spread after settlement from protected ravines into exposed areas where they had difficulty growing before, but they were in the forest all along; their seeds need not have been carried in by animals or blown-in by wind.

SUMMARY AND CONCLUSIONS

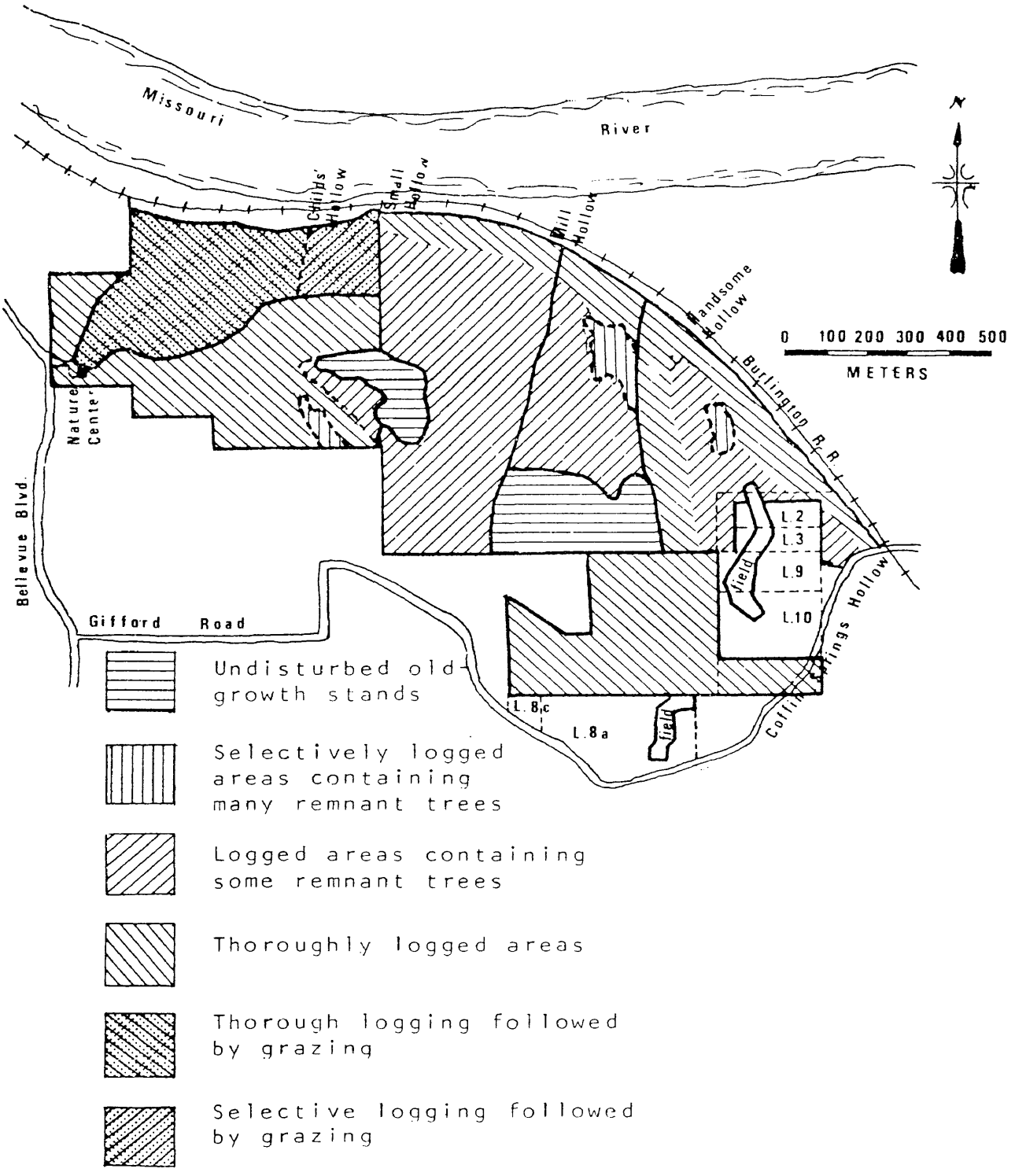
A 130.3 hectare tract of oak-hickory upland forest in the north half of a protected reserve known as Fontenelle Forest was studied to determine what types of human-related disturbances had occurred in the area between the time of settlement in the mid-1850's, until about 1913, when the reserve was established. The study was initiated because very little was known of the persons who owned the land prior to 1913, or of their impact on the native flora. Persons employed by the Fontenelle Forest Association believed that the timber stand was largely undisturbed and had reached its present state of development by natural plant succession, beginning with the invasion of a pre-settlement, park-like, oak opening by less fire-resistant species following settlement. This invasion supposedly occurred when the prairies west of the Forest were plowed, halting the ground fires that burned into the woodland. A land use history and a partial fire history of the tract was accomplished using combinations of biological, historical and dendrochronological methods.

It was determined that two former landowners had settled on or near the tract and over a period of several decades harvested the timber resources, significantly altering the original pre-settlement forest.

Charles E. Smith, owner of 19.5 hectares in the southeast corner of the study area, thoroughly logged his property of commercially valuable trees between approximately 1866 and 1877, (Map 14), leaving only young saplings under 10 cm dbh to replenish the stand. Today,

Map 14

Composite land use pattern of study area



these saplings, and other trees that invaded soon after the disturbance, comprise a mature, even-aged, secondary stand.

Charles Childs, owner of the remaining 110.8 hectares, operated a sawmill and gristmill, supplying lumber from trees cut on his property to nearby communities, and occasionally grinding flour for local farmers. He cut trees over a nineteen year period beginning in 1857 and ending approximately 1876, logging parts of his property at different times and in different degrees of intensity. Over-all Childs was more selective in his cutting than Smith, leaving behind undesirable trees regardless of their size. Today, some of these culled remnants of the pre-logging forest exceed 200 years in age.

In addition to logging, a 18.2 hectare area in the northwest corner of Childs' land was used as a pasture for dairy cattle from 1884 until about the time Childs' estate was purchased as a forest reserve. In preparing the land for grazing, Childs' son apparently removed all undesirable undergrowth, leaving only scattered, second-growth bur oaks, and then sowed bluegrass. These large, open-grown bur oaks are now surrounded by a denser stand of young, forest-grown trees which invaded following removal of the cattle. The pasture's present appearance suggests an over-grown, former oak opening, and gave rise to the belief that the stand was a result of natural post-fire succession, and had not been disturbed by humans.

With two exceptions this study did not attempt to assess the actual impact of land use on the flora. The exceptions concerned the influence of human disturbance on the distribution of bitternut hickory and on the reproduction of bur oak. In the case of bitternut hickory, it was

discovered that the species occurs in isolated groves and is not site specific, as was suggested by Aikman (1926), but grows well on a variety of sites, provided the site has been altered to some degree by human disturbance and later burned. In the case of bur oak reproduction, it appears that in undisturbed remnant stands, this species has had virtually no seedling survival since the late 1850's. In areas disturbed by logging or grazing, bur oak is still reproducing. Although bur oak is still a dominant in undisturbed stands, many of the oaks are over 200 years old. A number of them have already fallen and are not being replaced by more bur oak. The eventual loss of this species in these stands is of concern both for aesthetic and practical reasons. Large, spreading bur oaks are a striking feature of the Forest landscape and its seeds an important food source for many mammals and birds.

This study emphasizes the importance of knowing the history of a timber stand before embarking on a phytosociological study. The impact of land use disturbance, particularly if it occurred long ago, is easily overlooked. Too frequently the ecologist focuses only on natural factors such as climate, soil, slope, fire and disease. Only when the possibility that a stand has been altered by human disturbance is considered, may a true picture of the stand's ecology be developed.

APPENDIX A

Explanation of Column Headings and Symbols Listed in the Tables of Increment Core Samples.

First column. Field number. Field # is the brass tag nailed to each tree. Unmarked trees that are in the thirty 20 x 30 meter sample plots are identified by the plot number; P.25, P.26, etc.

Second column. Species. Because bur oak was the predominant tree sampled, all bur oaks are listed first according to age. Following bur oak, all other species are listed, also according to age.

Third column. DBH in cm. The tree's diameter at breast height in centimeters.

Fourth column. Age. The date given is the year that the innermost ring on the increment core was formed. This date is followed by qualifying notations.

For example:

1838++H - The tree is hollow and therefore older than date given.

1838++ - The borer passed wide of the pith. The tree is estimated to be more than ten years older than date given. This estimate is based on the curvature of the rings on the increment core.

1839+ - The borer passed wide of the pith. The tree is estimated to be between five and ten years older than date given.

1838(1836) - The borer passed only slightly wide of the pith. The tree is estimated to be between one and five years older than date given. The date in parenthesis is the estimated true age.

1839P - The borer passed directly through the pith.

Fifth column. Release date. The year the tree shows a noticeable acceleration in its annual growth rate.

APPENDIX B

Scientific Names of Trees Listed in Tables of Increment Core Samples.

American Elm. . . . . .*Ulmus americana* L.

American linden . . . . . .*Tilia americana* L.

Bitternut hickory . . . . . .*Carya cordiformis* (Wang.) K. Koch

Black walnut. . . . . .*Juglans nigra* L.

Bur oak . . . . . .*Quercus macrocarpa* Michx.

Green ash . . . . . .*Fraxinus pennsylvanica* Marsh.[6]

Hackberry . . . . . .*Celtis occidentalis* L.

Honey locust. . . . . .*Gleditsia tricanthos* L.

Red oak . . . . . .*Quercus borealis* Michx. f. var. *maxima* (Marsh.) Ashe

Shagbark Hickory. . . . . .*Carya ovata* (Mill.) K. Koch

[6]It is difficult to distinguish green ash, *Fraxinus pennsylvanica*, from white ash, *F. americana*, particularly during the winter months when most of the core sampling was done. However, the species sampled is most likely green ash. Pool (1951) lists white ash in the Fontenelle Forest area but states that it is uncommon. Stephens (1973) lists white ash as growing no further north than Nemaha county in the southeast corner of Nebraska.

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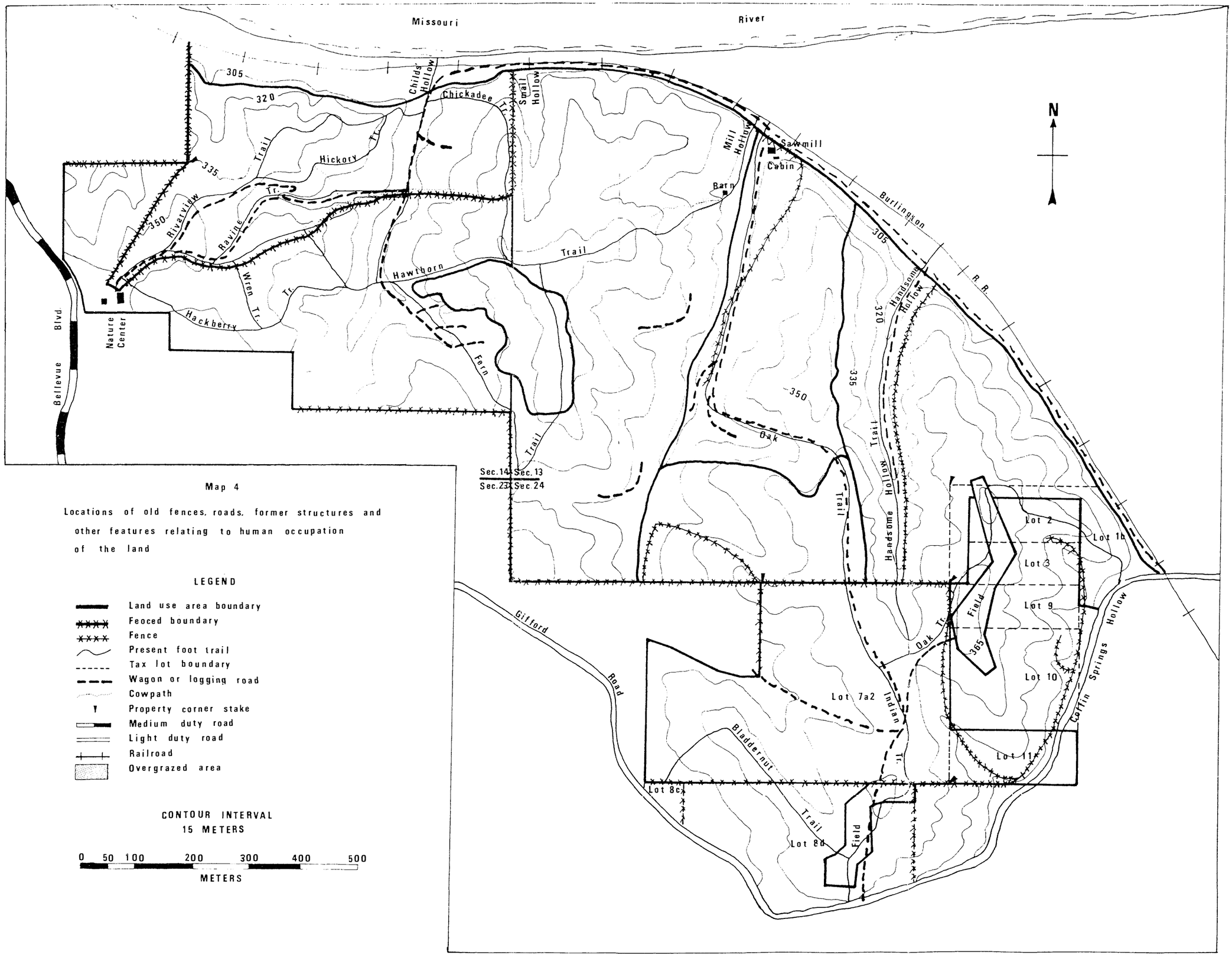


Map 4

Locations of old fences, roads, former structures and other features relating to human occupation of the land

LEGEND

- Land use area boundary
- Feoced boundary
- Fence
- Present foot trail
- Tax lot boundary
- Wagon or logging road
- Cowpath
- Property corner stake
- Medium duty road
- Light duty road
- Railroad
- Overgrazed area

CONTOUR INTERVAL
15 METERS

0 50 100 200 300 400 500
METERS

Map 5

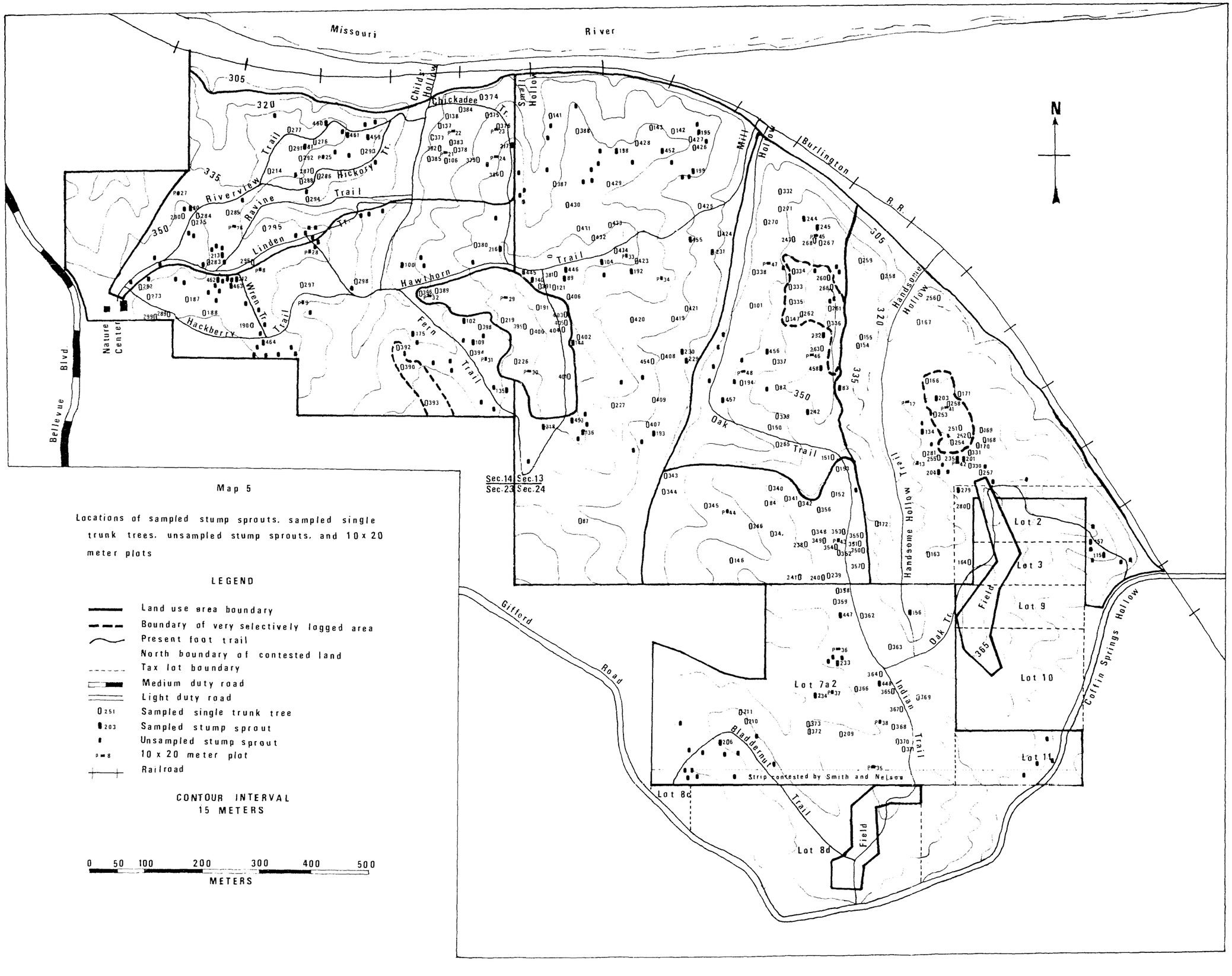
Locations of sampled stump sprouts, sampled single trunk trees, unsampled stump sprouts, and 10 x 20 meter plots

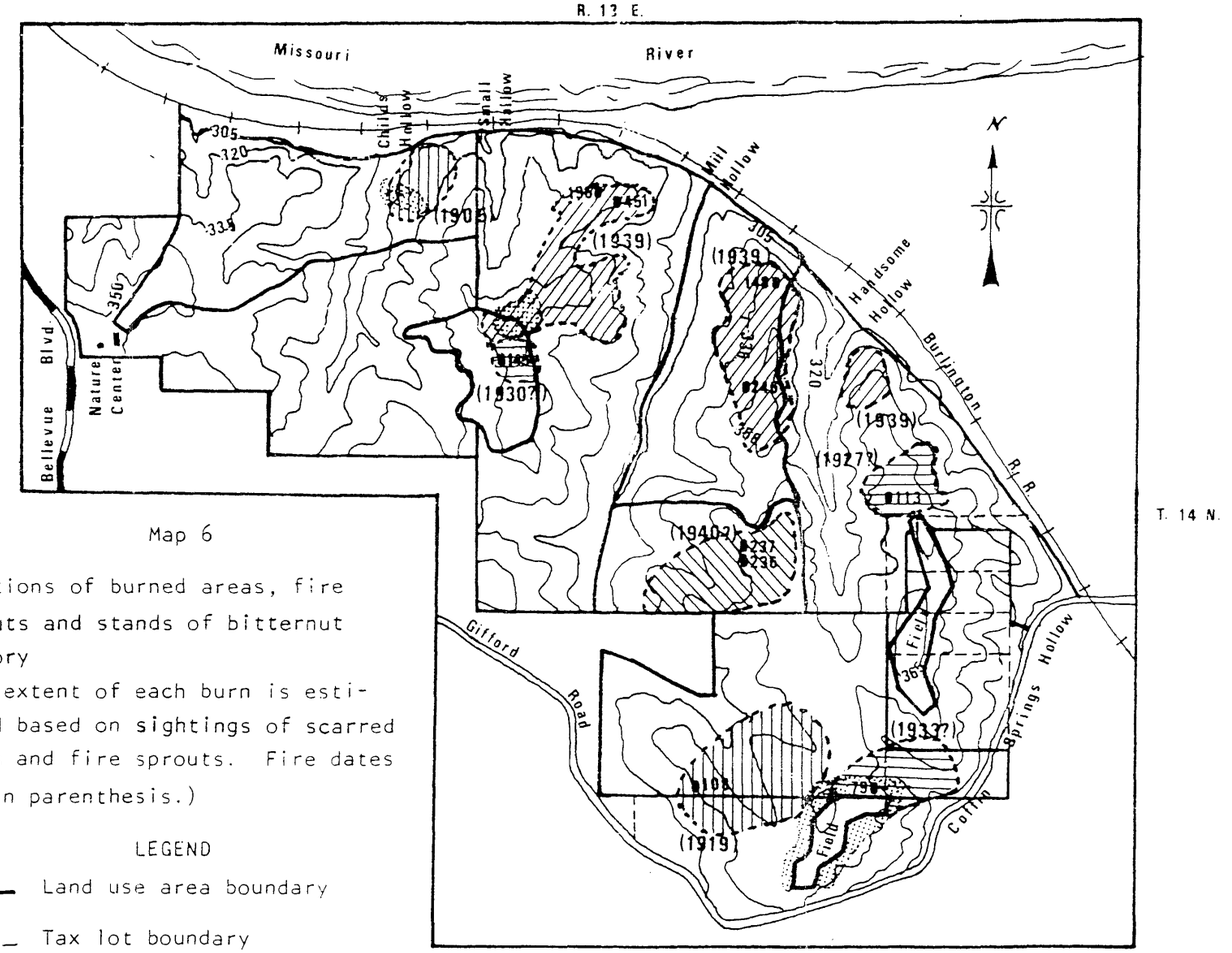
LEGEND

- Land use area boundary
- Boundary of very selectively logged area
- Present foot trail
- North boundary of contested land
- Tax lot boundary
- Medium duty road
- Light duty road
- 0251 Sampled single trunk tree
- 0203 Sampled stump sprout
- Unsampled stump sprout
- P=8 10 x 20 meter plot
- Railroad

CONTOUR INTERVAL
15 METERS

0 50 100 200 300 400 500
METERS





Map 6

Locations of burned areas, fire sprouts and stands of bitternut hickory

(The extent of each burn is estimated based on sightings of scarred trees and fire sprouts. Fire dates are in parenthesis.)

LEGEND

- Land use area boundary
- Tax lot boundary
- Burned area
- Stands where bitternut hickory is a dominant
- Sampled fire sprout