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Inventory of the Woody Plants of the Denison University Biological Reserve

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Chapter Two

A Reference Collection of Herbarium Specimens

A reference collection of species listed in Chapter One is located in the Polly Anderson Field Station at the Denison Biological Reserve. Only 97 species of 107 observed species are represented by herbarium specimens. Representatives for each species were not collected because the inconvienent location of leaves, flowers, and branches did not enable me to collect an individual. In other cases, no reference specimen was collected because the individual was the only representative of the species in the reserve. It certain cases, it was decided that collecting sample might possibly be a detriment to the individual. The reference collection will remain in the reserve's field station to assist future researchers in their and assessment of the reserve.

Chapter Three

Annotated Species List of the Woody Plants Found in the Denison University Biological Reserve

The annotated bibliography is a listing of the species that are present in the Denison University Biological Reserve. Information on the location, status, and the date each species was found is given in this chapter. Important information about identification, uses, and historical facts are also given in this chapter.

"Found" indicates where the species was observed in the biological reserve. The location is described in reference to the closest trails and/or noticable landmarks. See the Trail Guide for an explanation of trail names and their abbreviations. Many individuals were found far from any landmarks or trails. In these cases a general location was described.

"Status" indicates the species' present situation in the reserve. Descriptions include: Common, Uncommon, Rare, and Only one observed. If the species is a planted/cultivated species, then that is indicated.

"Date" indicates the date that the species was first observed and identified. Many times this date is simply the first date that a voucher specimen was collected.

Trail Guide

Trail Name	Abbreviations
White Tail Loop	WTL
Catalpa Trail	CT
Waxwing Loop Trail	WXL
Gravel Quarry Trail	GQT
Woodcock Trail	WT
Sugar Bush Trail	SBT
Hyacinth Trail	HT
Crinoid Hill Trail	CHT
Ovenbird Loop Trail	OL
Norpell Woods Loop Trail	NWL
Taylor-Ochs Loop Trail	TOL

The plant families are listed in the order that is presented by Gleason and Cronquist (1991). Species in each family are listed in alphabetical order.

Family Ginkgoaceae

Ginkgo biloba L. Ginkgo or Maidenhair Tree

Found: Near Rt. 661 by the side entrance to the reserve.

Status: Only one in the reserve; not native to the Americas.

Date: 9-15-96

Ginkgo is the only member of its family. This species is the sole survivor of a group of plants more primitive than the conifers. It is believed that the ginkgo was saved from extinction by monks in China. They cultivated seeds and grew trees, thus saving this species. All ginkgos in this region of the world are the result of cultivation. The fan-shaped leaves distinguish this tree from all others in the forest. The female trees bear fleshy plumlike seeds that produce a potent stench in autumn when they rot (Coombes 1992).

Family Taxaceae

Taxus canadensis Marsh. Yew

Found: Near Rt. 661 by the side entrance to the reserve.

Status: Only two in the reserve; introduced species.

Date: 9-15-96

Almost all parts of the yew are poisonous except for young needles. The underside of yew needles of yew are green. This distinguishes it from hemlock needles, which have two white lines on their underside (Braun 1961).

Family Pinaceae

Larix laricina (DuRoi) K. Koch. Tamarack or Larch

Found: Near Rt. 661 by the side entrance to the reserve.

Status: The only known individual in the reserve.

Date: 9-15-96

Tamarack grows further north than any other tree in North America. It has even been found above the Arctic Circle. Its needles are not as long as pine needles, and they are clumped on side shoots. This distinguishes it from other gymnosperms in the reserve. Also, unlike other gymnosperms, tamarack sheds its needles during the autumn months leaving the tree bare in the winter. Tamarack is an important timber tree. It is used to make poles, railroad ties, and posts. The Native Americans used the roots to sew strips of birch bark together for their canoes. Tamarack sap was used to heal wounds and draw out poisons.

Picea abies (L.) Karst. Norway Spruce

Found: Near OL across from the TOL sign.

Status: Uncommon; planted in the reserve.

Date: 7-12-96

One distinguishing characteristic of all spruces are four-angled needles. During the Great Depression the Works Projects Association (WPA) and the Civilian Conservation Corps (CCC) planted Norway spruce all over the country. They are not a native species of Ohio, but the climate suits their growth habits (Peattie 1964).

Picea pungens. Engelm. Blue Spruce

Found: Near Rt. 661 by the side entrance to the reserve.

Status: Only one found in the reserve; planted.

Date: 9-15-96

This Spruce is distinguished from the Norway spruce primarily by the bluish tint of its needles. Like Norway spruce, blue spruce is considered to be an excellent ornamental. It is a long-lived tree, often reaching ages of 600-800 years. Its natural range is in the Rocky Mountain region (Petrides 1988).

Pinus resinosa Ait. Red Pine

Found: In the pine plantation.

Status: Common in pine plantation; rare elsewhere.

Date: 8-29-96

All red pines are clones of each other. Most likely, red pines were isolated into one small population during glaciation, and no genetic variability occurred (Burns and Honkala 1990). Often, red pine is confused with white pine. The observant can easily tell the two apart by the number of needles per fascicle. Red pine has two, while white pine has five (Braun 1961). Furthermore, red pine has reddish pulpwood, while white pine has white pulpwood (Peattie 1964).

Pinus strobus L. White Pine

Found: Near NWL close to Hankinson Rd.

Status: Common; planted in the reserve.

Date: 7-19-96

For over three centuries white pine was the most important timber-producing tree. In the virgin forests of years past, these trees were the most abundant woody plants. They grew to heights similar to the redwoods of California (up to 240 feet). They were logged extensively and exported to European countries. The wood was used to build wooden sea vessels. Masts of these ships were made exclusively out of white pine trunks. The wood is strong, yet light, making it an ideal wood for builders. White pine was used as the framework for the first railroad tracks (Peattie 1964).

Family Cupressaceae

Juniperus virginiana L. Red Cedar

Found: Near TOL by the pond, in the forest edge.

Status: Uncommon tree in the reserve.

Date: 7-12-96

Due to its endurance when exposed to rain and soil, red cedar was used to build log cabins and to make shingles. Because of its finished beauty and its ability to repel moths with its odor, its wood is used to make countless numbers of cedar chests. It has also been used to manufacture pencils. Cedars are often infected by cedar-apple rust. This fungal disease disfigures the trees by causing galls to form. Spores from this fungus are harbored within these galls, and then released to infect the leaves of apple trees. This can prove fatal to apple trees, but not to red cedars. Unfortunately, in the past, as a way to combat the disease, red cedars near orchards were cut down without scrutiny. The red berries are an important source of food for wildlife, especially the cedar waxwing, a bird that got its name from red cedar (Peattie 1964).

Family Magnoliaceae

Liriodendron tulipifera L. Tuliptree

Found: Near HT in the edge of the forest.

Status: Common; originally planted in the reserve.

Date: 7-5-96

Tuliptree is the tallest hardwood tree in North America, growing to heights of 200 feet. Many refer to the tree as a yellow poplar, white poplar, or popple. In fact, the tree is not a poplar and does not share similar characteristics with poplars. It is a valuable lumber species, because the trunk grows relatively straight with few branches. Pioneers used to hollow out the trunk to make light-weight canoes. It is also used for making boxes, furniture, toys, musical instruments, and crates to store perishable goods. The wood of the

tuliptree is the softest of "hardwoods" and is compared to the wood of white pine (Peattie 1964). Its real magnificence is shown in the spring when it is in bloom. The blossoms are large and beautiful.

Magnolia acuminata (L.) L. Cucumber Magnolia

Found: In the forest between the ponds and the clay fields; near Clay Run.

Status: Uncommon; only a few in the reserve.

Date: 8-16-96

Cucumber magnolia is aptly named for its fruits. Early in their development, the fruits look like small cucumbers. Cucumber magnolia is often used for the same purposes as tuliptree (see above). Although it is not of the same quality, it is often passed off as a tuliptree. This magnolia's range is more northern than any others in its genus.

Family Annonaceae

Assimina triloba (L.) Dunal. Pawpaw

Found: Next to WTL across from the pine plantation.

Status: Common; fruiting individuals are rare.

Date: 7-25-96

Pawpaw may become an economically important tree. Its fruit is similar to that of a banana. The fruit has a taste that is a blend of banana, mango, and pineapple. Work is being done to market the fruit of this plant in similar ways that blueberries, cranberries, and raspberries have been marketed (Petrides 1988). Research is also being done to develop anti-cancer drugs and botanical pesticides from the twigs of the pawpaw tree (Burns and Honkala 1990).

Family Lauraceae

Lindera benzoin (L.) Blume. Spice-bush

Found: Near the GQT just in front of the woods.

Status: Very Common in forest areas.

Date: 7-5-96

Spice-bush plays host to a beautiful species of butterfly known as the Spice-bush Swallowtail. The tree also has aromatic leaves and stems (Petrides 1988). Crushing the leaves or tearing the stems produces a scent that allows this shrub to be easily identified.

Sassafras albidum (Nutt.) Nees. Sassafras

Found: Near WXL past the first hill, on the right.

Status: Common tree of the forest.

Date: 6-27-96

Sassafras oil was once believed to be the cure-all for illnesses. Because of this, it was in high demand during the 17th century. The aroma of sassafras was said to drive away evil. This belief started with the Egyptians and was sustained throughout the era of the bubonic plague. Sassafras was the first export from the American colonies. Tea and root beer made from the roots was a high commodity (Peattie 1964). Now, it is known to be a carcinogen (Burns and Honkala 1990). Like spice-bush, sassafras has aromatic leaves and stems that easily distinguish it from other species.

Family Berberidaceae

Berberis thunbergii DC. Japanese Barberry

Found: Next to WTL by the pine plantation.

Status: Common shrub in wooded areas

Date: 7-5-96

This is an alien species that has moved into our area. The native species *Berberis canadensis* (American Barberry) is an alternate host of wheat rust or black stem rust (Braun 1961).

Family Menispermaceae

Menispermum canadense L. Moonseed

Found: Near TOL north of the pipeline.

Status: Uncommon in the reserve.

Date: 7-12-96

There has been some debate as to whether moonseed is a woody plant or an herbaceous plant. Its stems often freeze and it does not persist through the winter months. Its fruit is a blue-black drupe that is bitter and poisonous (Braun 1961).

Family Platanaceae

Platanus occidentalis L. Sycamore

Found: Near HT in the edge of the forest.

Status: Common tree, but few saplings.

Date: 7-5-96

The distinguishing mark of this tree is its bark. It continually "sheds" its bark, resulting in patches of white smooth bark surrounded by light gray bark. Sycamores are tolerant of wet soils. They grow in flood plains, along rivers and streams, and in lowlands (Peattie 1964). Hairs on the seeds act as parachutes, and the wind distributes them. However, many seeds may be carried by water and deposited on mud flats (a suitable place for growth). The wood of the sycamore is very hard and difficult to split. It has been used for crates, barrels, and boxes. Hollow trunks of old giant trees are homes for chimney swifts (Burns and Honkala 1990).

Family Hamamelidaceae

Liquidambar styraciflua L. Sweet Gum

Found: In southeast corner of Norpell Woods.

Status: Rare; only three seen in reserve.

Date: 8-8-96

Sweet gum has star-shaped leaves that are very distinctive. The name sweet gum is derived from the resin it produces, which has been used as a treatment for sores and skin troubles, chewing gum, adhesives, perfumes, fuel, and most notably, as a flavoring for tobacco. Now, it is primarily used as lumber, to be made into cabinets, boxes, and crates (Peattie 1964).

Family Ulmaceae

Celtis occidentalis L. Hackberry

Found: Near the rt. of WTL between the WXL and GQT in the forest edge.

Status: Few saplings seen; most 5-10 years old

Date: 6-26-96

Hackberry is the host of four gall-producing insects: *Pachypsylla celtidisgemma, P. celtidismamma, P. celtdisvesicula,* and *P. venusta.* Normally, these galls are harmless to the tree (Burns and Honkala 1990). Hackberry is also subject to a phenomenon known as "witches' broom," which is an abnormal cluster of twigs and branches caused by mites and pathogens. Many animals eat the fruit of the hackberry, and the fox squirrel even feeds on an occasional gall. The wood is used to make furniture, millwork, and athletic equipment. The name is derived from "hagberry" and is Scottish for cherry (Peattie 1964).

Ulmus americana L. American Elm or White Elm

Found: Near WTL by the ponds.

Status: Species is dying out: few viable saplings

Date: 7-5-96

American elm is susceptible to a fungus called *Ceratocystis ulmi.* The fungus gains access to the sap stream of the elm via its host, the elm bark beetle *Scolytus multistriatus.* The beetle burrows into the bark to lay eggs (Burns and Honkala 1990), and then the larvae of the beetle leave "engravings" under the bark, marking their movements. Holes in the bark show where the larvae have emerged. Early symtoms of the fungal disease are wilting of leaves and death of branches. The disease is fatal to the tree. Before the emergence of Dutch elm disease, the tree was used as a street-side shade tree because of its vase-like crown. It was fast-growing, sturdy, and tolerant to stress. The wood is used to make furniture, paneling, and containers (Peattie 1964). American elm can be distinguished from its sister red elm, by many vegetative characteristics. Red elm bark is red-brown, whereas American elm bark has layered light and dark brown colors. The leaves and twigs of American elm are not as rough as those red elm, and the fruit of American elm is more elliptical than the round samaras of red elm (Braun 1961).

Ulmus rubra Muhl. Red Elm or Slippery Elm

Found: Near WTL in grove of trees to the rt. just before the ponds.

Status: Common tree of the forest.

Date: 6-25-96

Red elm or slippery elm has mucilaginous leaves and twigs that distinguish it from any other tree in the forest. Only sassafras has a similar mucilaginous characteristic, but its leaves are easily distinguished from that of the elm. The "slime" has been used to dress wounds and treat cholera. A soothing drink can also be made that is said to help with sore throats, stomach pains, and indigestion. The wood is used for the same purposes as American elm: furniture, paneling, and containers (Peattie 1964).

Family Moraceae

Maclura pomifera (Raf.) C.K. Schneider. Osage-Orange or Hedge-Apple

Found: Next to WTL by the ponds.

Status: Common; planted along fence-rows.

Date: 7-5-96

With its large green balls, this tree's fruit is unmistakable. Osage-orange or hedge-apple was once planted along fence-rows as a field hedge. It is a many-branched tree with thorns. These thorns have kept out unwanted pests, and actually led to the invention of barbed wire. The hedge-rows were also used as wind-breaks and for soil erosion control. The heartwood is the most decay-resistant of all North American trees, and it is resistant to termites. The branches were used by the Osage Indians to make bows. Some archers still prefer to use its wood for their bows today. Settlers made yellow dye from the root bark (Peattie 1964). Chemical extracts from the tree and its fruits are use to make antifungal agents and a non-toxic antibiotic used in food preserves. The leaves also produce a white latex when damaged (Burns and Honkala 1990).

Morus alba L. White Mulberry

Found: Near WTL by the ponds.

Status: Most common member of the genus in the reserve.

Date: 7-5-96

White mulberry is an alien species brought from Asia (Braun 1961). When looking at a white mulberry in the summer, it is quite common to see large balls of silky webbing on the branches and leaves. These are caused by silkworms form whom the white mulberry plays host.

Morus rubra L. Red Mulberry

Found: Beside OL by close to the green trash can on the NWL.

Status: Uncommon in the reserve.

Date: 9-23-96

Red mulberry is the only native species of mulberry. It can be distinguished from the white mulberry, because its leaves are "sandpapery" on the upper surface, and hairy on the lower surface (Braun 1961). The leaves prove to be unsuccessful in providing food for silkworms, which is why red mulberry is not host to them. Its fruits are reddish-purple and edible (Peattie 1964).

Family Juglandaceae

Carya

Hickories have alternate compound leaves that help to identify them. In general, hickories have strong and hard wood. They are used for charcoal and fuel wood, because they burn with an intense flame and leave very little ash. The lumber is used to make furniture, paneling, dowels, ladders, and tool handles. Most hammers with wooden handles are made with hickory wood. Early settlers used oil extracted from the nuts to make fuel for oil lamps (Peattie 1964).

Carya cordiformis (Wangenh.) K. Koch. Bitternut Hickory

Found: Near TOL south of the picnic/campsite.

Status: Most common Hickory in the reserve.

Date: 7-12-96

The distinguishing mark of this hickory is the golden color of the terminal bud (Braun 1961). The saplings are extremely tolerant to shade and can withstand many years of growing in the understory awaiting a chance to grow when a gap opens (Burns and Honkala 1990).

Carya laciniosa (Michx. f.) Loudon. Shellbark Hickory

Found: Near TOL to the south of the picnic/campsite.

Status: One of the reserve's hickory species; uncommon.

Date: 7-12-96

The distinguishing mark of this hickory is the orange hue of its twigs. This hickory and shagbark hickory are often confused. Another means to distinguish shellbark hickory is that it usually has seven leaflets, whereas shagbark hickory has 5 leaflets (Braun 1961).

Carya ovalis (Wangenh.) Sarg. Sweet Pignut Hickory

Found: To the rt. of WTL between the WXL and GQT in the forest edge.

Status: One of many hickory species in D.U.B.R; uncommon.

Date: 6-26-96

This hickory is often considered to be the same species as *Carya glabra.* If taken together, the two can be distinguished from other hickories because of the lack of pubescence. Usually the under-surface of the leaflets is glabrous (Braun 1961). The sweet pignut hickory got its name during Colonial times because its nuts were a favorite of pigs (Peattie 1964).

Carya ovata (Miller) K. Koch. Shagbark Hickory

Found: To the rt. of WTL between WXL and GQT in the forest edge.

Status: One of the many hickory species; common.

Date: 6-27-96

This hickory can be distinguished from other hickories by of its bark. The bark is exfoliating; that is to say, it is "shaggy." It appears as thought it is being peeled away from the tree. Only shellbark hickory has a similar feature; but even then, it is not as pronounced (Braun 1961).

Juglans cinerea L. Butternut

Found: Near WTL on the west side of the ponds.

Status: A rare species due to disease; very few seen in the reserve.

Date: 6-28-96

Butternut has Federal and Ohio threatened species status due to rarity caused by butternut canker disease and bunch disease. Butternut canker disease is caused by the fungus *Sirococcus clavigignenti-juglandacearum.* Cankers first develop on branches in the lower crown. The fungus then spreads to the stem and causes the tree to die. Bunch disease is caused by a mycoplasma-like organism which causes yellow "witches' brooms" to form, keeping branches active in the autumn. This renders them helpless to frost (Burns and Honkala 1990). Butternuts have a dark brown pith, terminal leaflets, and elongated terminal buds (12-20 mm). This distinguishes them from black walnuts which have a cream colored pith, usually no terminal leaflet, and shorter terminal buds (less than 10 mm) (Braun 1961). The nuts of butternut are used to make maple-butternut candy. The wood is used to make cabinets, toys, and novelties. Oil extracted from this tree was used by Native Americans to annoint their heads for various ceremonies (Peattie 1964).

Juglans nigra L. Black Walnut

Found: Near WTL by the ponds.

Status: Very common; found in every section.

Date: 6-27-96

Black walnut is not susceptible to butternut canker, and it is resistant to bunch disease. The tree produces an allelotoxin which keeps a variety of other plants from growing near it (Burns and Honkala 1990). The lumber of black walnuts is extremely valuable. It is used to make fine furniture, veneer, gunstocks, paneling, and specialty products. It is also considered to be excellent cabinet wood (Peattie 1964). The nuts are also of value. Not only are they used for food, but the shells have also been used to clean

airplane pistons, deburr precision gears, and as filter agents for scrubbers in smokestacks (Burns and Honkala 1990).

Family Fagaceae

Fagus grandifolia Ehrh. Beech

Found: Near HT near the creek adjacent to trail.

Status: Very common tree in the reserve.

Date: 7-5-96

The smooth gray bark of beech is this tree's distinguishing feature. This tree tends to grow in good farming soil. Many have been felled by farmers to clear the way for crops (Peattie 1964). Often, people find the bark quite useful for script. Many have carved their initials or short messages on the bark. It is thought that the word *book* was derived from an early name for beech. *Book* comes from the Anglo-Saxon word *boc* , which means letter or character. This comes from the Anglo-Saxon word *beece*, for beech. The wood is used to make flooring, veneer, furniture, plywood, railroad ties, and fuel wood. Creosote made from beech wood is used as a medicine for many ailments, and the nuts were chewed as a worm expellent by Indians (Peattie 1964).

Quercus

Oaks easily hybridize making them difficult to identify. Even non-hybrids can be tough to distinguish because the foliage of oaks is variable, even on the same tree. In general, oaks are divided into two main groups, white oaks and red oaks. The white oak group does not have leaf veins extending beyond the leaf margins, the cup scales of acorns are woody, the inner surface of the acorn shell is smooth, and the fruit matures in the first year. The red oak group is characterized by having leaf veins extending beyond the margin like bristles, the cup scales are thin, the inner surface of the acorn shell is hairy, and the fruit matures in the second year (Braun 1961). Oaks are considered to have heavy, hard,

and durable wood. Barrels designed to contain liquid were made mostly of oak trees. Oak furniture is considered to be some of the best in the world. Oak acorns are known to be eaten by over 180 different kinds of animals; thus they are ecologically important. Many oaks are planted as ornamentals (Peattie 1964). They are often aesthetically pleasing in the fall when the leaves change colors.

Quercus alba L. White Oak

Found: Near TOL in clearing by picnic/campsite

Status: Uncommon tree in the reserve

Date: 7-12-96

The bark of white oak is light gray to whitish, giving way to its name. White oak was used extensively in the American Colonies for shipbuilding. The gun deck of the *U.S.S. Constitution* was made entirely of white oak. Many ships, even durning the World War II era, used oak in their keels. Barrels for alcohol were also made of this oak. White oak is considered to be the best all-around hardwood of North America (Peattie 1964).

Quercus rubra L. N. Red Oak

Found: Near TOL at the start of the trail.

Status: Uncommon tree in the reserve.

Date: 7-12-96

This oak has a couple of distinguishing features. Its bark is not as deeply furrowed as other oaks (dark brown and scaley). The acorn is large and has a shallow cup (Braun 1961). The wood is not as useful as other oaks, because it is not as strong and tends to be more porous. However, it still maintains the general characteristics of oak and is still of decent quality (Peattie 1964).

Quercus velutina Lamarck. Black Oak

Found: Near WTL by the ponds.

Status: Uncommon; most common of the oaks in the reserve.

Date: 6-28-96

The bark of this oak is deeply furrowed, and the inner bark is yellow or orange. If you scratch a twig you should be able to see this color and distinguish it from other oaks (Petrides 1988). Its wood is not as useful as other oaks because it is crooked and knotty (Peattie 1964).

Quercus muehlenbergii Engelm. Yellow Oak or Chinkapin Oak

Found: Near NWL on NE corner of Norpell Woods.

Status: Only individual in reserve.

Date: 8-2-96

The bark of this oak is thin and light gray. It breaks off into thin white flakes and is rarely furrowed. The wood was often used as a fuel for steam boats traveling on the Ohio River. Many early fences were made from the wood of this tree (Peattie 1964).

Quercus saluei Schneid. Oak Hybrid

Found: Near NWL on NE corner of Norpell Woods.

Status: Only specimen in reserve.

Date: 8-2-96

This oak is a hybrid between white oak and chestnut oak. As with every oak hybrid, it shares similar characteristics with both its parents. Identification is often quite difficult because the leaves are variable in shape and size (Braun 1961).

Family Betulaceae

Carpinus caroliniana Walter. Hornbeam, Musclewood, or Ironwood

Found: Near HT by the creek.

Status: Common; has "muscular" wood.

Date: 7-5-96

Hornbeam is recognized by its stems, which look like twisted muscles. The name, hornbeam, fits its appearance; "horn" means toughness, and "beam" means tree. This tree's wood is extremely strong and is used to make levers and tools (Peattie 1964). Because it is an understory tree, it is not seen as a valuable timber tree. Deer like to browse the twigs and foliage, and grouse, pheasants, and quail eat the nutlets (Coombes 1992).

Ostrya virginiana (Miller) K. Koch. Hop-hornbeam

Found: Near TOL by the first stream.

Status: Common tree in wooded areas.

Date: 7-12-96

The wood of hop-hornbeam is the hardest wood in North America, with the exception of dogwood. Much like hornbeam, this tree does not grow to great size, so it is not seen as a valuable timber tree. Occasionally, craftsmen will use the wood for tool handles, since it can withstand a lot of strain (Peattie 1964). The catkins provide winter food for grouse, and many forest animals eat the small nuts in the autumn months. Distinguishing hop-hornbeam from hornbeam can be difficult at times. The bark of hop-hornbeam shreds longitudinally whereas hornbeam's bark is smooth and "muscular." The leaves of the two look similar, but hop-hornbeam's are pubescent. The fruit cluster of hop-hornbeam resembles hops. This further distinguishes it and is the origin of its name (Braun 1961).

Family Tiliaceae

Tilia americana L. Basswood

Found: Near HT near the creek adjacent to trail.

Status: Uncommon tree in the reserve.

Date: 7-5-96

The scent from the orange blossoms of this tree can be detected from over a mile away. Honeybees and moths are busy when the tree is in bloom, and honey produced from the basswood's nectar is some of the best. The wood is very soft and is used for hand carving. The inner bark can be used to make rope, baskets, and mats. Basswood has become a popular ornamental tree in yards and along city streets (Peattie 1964).

Family Salicaceae

Populus deltoides Marshall. Cottonwood

Found: Off WTL just past the ponds.

Status: Common tree of the reserve

Date: 7-12-96

Cottonwoods were the salvation of the pioneers heading west. The wood is not of the greatest quality, but because the tree grows tall and wide, it proved useful. Many cabins, barns, churches, fences, tools, and toys were made from cottonwood (Peattie 1964). The hollow of its trunk is home to many species of birds. Cottonwood is the fastest growing of all trees (4-5 feet/year) (Burns and Honkala 1990). When the seed pods burst, the downy seeds are spread by the wind. These downy seeds are the reason this tree is called cottonwood (Peattie 1964). The leaves are in constant motion even in the slightest of breezes. This constant motion is believed to be a defense against herbivory from catepillars (Burns and Honkala 1990).

Populus grandidentata Michx. Bigtooth Aspen

Found: Near WTL across from the CT.

Status: Uncommon in the reserve

Date: 7-5-96

Bigtooth aspen seems to live in the shadow of its more popular and more useful sister, quaking aspen. The two trees are of similar appearance. Both are used to make cellulose pellets for cattle feed. The lumber is also made into pulp for paper (Burns and Honkala 1990).

Populus tremuloides Michx. Quaking Aspen

Found: Near WTL by the ponds.

Status: Mainly seen by the ponds in a grove of similar trees.

Date: 7-3-96

Quaking aspen is aptly named due to the constant "quaking" of its leaves. Like cottonwood and bigtooth aspen, this tree's leaves have flat petioles, allowing the slightest of winds to put the leaves into motion (Peattie 1964). Aspen stands make good fire breaks, because they contain little burnable fuel, and fire-killed stands are rapidly revegetated. Most playground structures and sauna benches are made of quaking aspen because it does not splinter easily. Its bark, twigs, and buds are eaten by a number of wildlife (Burns and Honkala 1990).

Salix

The willows are dioecious. They are also champions at vegetative reproduction. If you break off a willow branch and stick in the ground, chances are that it will grow (Peattie 1964). Humans have used willows in two key ways. First, willows are excellent trees for erosion control. Their roots are strong and dense, and the trees have been known to withstand large-scale floods. Previous to artificial production of salicyclic acid, aspirin

was made primarily from *salicin*, which was the basic ingredient of aspirin. *Salicin* was extracted from the bark and leaves of the willow (Burns and Honkala 1990).

Salix babylonica L. Weeping Willow

Found: In N.W. corner of Taylor-Ochs section.

Status: Rare in the reserve; only one has been seen.

Date: 7-12-96

This tree is mainly used as an ornamental tree. It is commonly found planted by ponds and streams (Peattie 1964). The drooping or "weeping" branches are a distinctive characteristic of this tree.

Salix discolor Muhl. Pussy Willow

Found: On the side of the Wood Duck Pond.

Status: Uncommon; only found by the ponds.

Date: 8-30-96

Pussy willow is distinguished by its velvety soft bud scales and a bluish-silvery tint on the underside of the leaves (Braun 1961). Often this willow forms galls due to the insect *Rhabdophaga strobiloides*. This gall usually looks like a pine cone and is often mistaken for a fruit (Peattie 1964).

Salix discolor var. *latifolia* Anderss. Willow Hybrid

Found: On the side of the Wood Duck Pond.

Status: Uncommon; only found by the ponds.

Date: 8-30-96

This tree is a variation of pussy willow that has glaborous leaves, buds, and twigs (Braun 1961).

Salix eriocephala Michx. Diamond Willow

Found: Found by the ponds.

Status: Uncommon in the reserve.

Date: 8-16-96

This willow is often confused with *Salix discolor* var. *latifolia*. There is no clear-cut way to tell the two apart (Braun 1961).

Salix nigra Marshall. Black Willow

Found: Near WTL by the ponds and close to Clay Run.

Status: Only found in areas that are damp and have ample sunlight.

Date: 6-25-96

Black willow is known as the "Father of Water." It commonly makes its home along streams and rivers. Along with the general uses of willows, the black willow was also used for artificial limbs, because it is light and does not splinter easily. Pioneers used charcoal from this wood to make gun powder (Peattie 1964).

Family Ericaceae

Rhododendron maximum L. Great Rhododendron

Found: Near OL heading north from the trash can.

Status: Only two in the whole reserve.

Date: 7-19-96

Often, this tree is called laurel by the old mountaineers of the southern Appalachians. When growing together in large numbers, Rhododendrons can create an almost impenetrable fortress. Because of that, many people have been lost within the thickets of Rhododendron forests. The large and beautiful flowers make this tree a favorite among ornamentals. The nectar makes a poisonous honey (Peattie 1964).

Family Grossulariaceae

Ribes cynosbati L. Gooseberry

Found: Near TOL just north of OL.

Status: Common shrub of the reserve.

Date: 7-12-96

Gooseberry is an alternate host for white pine blister rust. Due to the disease, the Bureau of Entomology and Plant Quarantine has implemented a program to eradicate all gooseberries and currants in white pine regions. The bluish fruit of the gooseberry is prickly, yet edible (Strausbaugh 1952).

Family Rosaceae

Amelanchier arborea (Michx. f.) Fern. Downy Serviceberry

Found: Near HT by the spring box.

Status: Uncommon shrub of the reserve.

Date: 7-26-96

Serviceberry is also known as the shadbush, shadblow, or juneberry. The tree bursts into bloom in early spring "when the shad run." It blooms even before its leaves have come out (Peattie 1964). When the leaves do come out of the bud, they are covered with silvery down (Braun 1961). The fruit matures by June and is edible (Petrides 1988).

Crataegus

The hawthorns are an extremely difficult genus to key to species. There are more than 1,100 species in North America alone. The reason behind the large number of species and difficulty in keying them out is apomixis (Braun 1961). Apomixis is the production of seeds without fertilization. These plants are triploid; however, some trees are diploid and reproduce by normal sexual means. This makes the genus, as a whole, difficult to sort out. The name for the genus, *Crataegus*, comes from the Greek word *Kratos* meaning strength.

Sharp thorns are distinctive of hawthorns. The thorns have been used by some birds to impale prey. Fruit from hawthorns has also been used to make preserves (Peattie 1964).

Crataegus phaenopyrum (L.F.) Medileus. Washington Thorn

Found: Near WTL next to the pine plantation.

Status: Common genus of the reserve.

Date: 7-5-96

Washington thorn got its name due to its popularity as an ornamental in the Washington D.C. area. It has been described as the daintiest of all hawthorns (Peattie 1964).

Crataegus sp. L. Hawthorn

Found: Near WTL across from the pine plantation.

Status: Common genus of trees.

Date: 7-1-96

This is one species of hawthorn that is difficult to key to species.

Prunus serotina Ehrh. Black Cherry

Found: Near WXL on top of the first hill

Status: Common in every section of the reserve.

Date: 6-25-96

Black cherry produces drupes. Drupes are a type of "stone-fruit" where the seed is enclosed in a hard covering. This hard covering is enclosed by a fleshy covering (Braun 1961). Peaches and plums are prime examples. Many drupes look like berries, as is the case with black cherry. The berries are eaten by a variety of wildlife and have been used by humans to make jelly and wine. The leaves, bark, and twigs contain cyanide bound in cyanogenic acid. The bark has been used to make cough suppressants, tonics, and

sedatives. The fruits have been used to make jellies. It is for the wood however, that the cherry is prized. It is used to make the finest cabinet wood. The wood is smooth-grained, stains well, and does not warp after being finished (Peattie 1964).

Pyrus coronaria L. Wild Crabapple

Found: Near TOL just past the pipeline.

Status: Common in Taylor-Ochs section.

Date: 7-12-96

Wild crabapple is known for its beautiful bloom. Just as the leaves come out, the flowers explode into a vivid color of pink. The crabapples have commonly been pressed and used to make cider. They have also been used to make preserves. Many songbirds nest in these trees, because they provide a dense shelter with their thorns (Peattie 1964).

Pyrus malus L. Apple

Found: Near to the rt. of WTL between WXL and GQT in the forest edge.

Status: Common in former orchard areas of the reserve.

Date: 7-5-96

There are many varieties of apples including, Granny Smith, Red-Delicious, Golden-Delicious, and Macintosh. As with all members of the *Pyrus* genus, this apple has showy flowers and produces a fruity pome (Braun 1961)

Rosa multiflora Thunb. Multiflora Rose

Found: Near GQT in the field before the woods.

Status: Very Common; an introduced species.

Date: 7-5-96

Multiflora rose was planted as a border for wildlife. It has escaped cultivation and is currently invading many of our forests. Now conservationists are looking for ways to

eliminate this foreign invader from our wooded areas and fields (Strausbaugh 1952). This rose covers most of Denison's Biological Reserve and has overrun many areas. It can be distinguished from other roses by its fimbriate-pectinate stipules and united styles (Braun 1961).

Rosa palustris Marshall. Swamp Rose

Found: Near WTL past the ponds on the left.

Status: Uncommon rose of the reserve.

Date: 7-11-96

This rose is native and grows in and near swamps and wetlands. It is not a pest like the Multiflora Rose. It can be distinguished from other roses by its decurved prickles (Braun 1961).

Rosa setigera Michx. Climbing Prairie Rose

Found: Near WTL just before the pine plantation.

Status: Uncommon rose species in the reserve.

Date: 7-1-96

This rose is native and grows in drier soils. It can be distinguished from other roses by its united styles and entire stipules (Braun 1961).

Rubus

The blackberry and raspberry are similar plants. Usually they have biennial stems from perennial roots. The primocanes are the first year stems that do not flower and usually have compound leaves. The floricanes are the second year stems that flower and produce fruits (Braun 1961). Usually the stems of these plants have prickles, and the leaves look similar to those of a rose. There is an easy way to distinguish between blackberries and raspberries. If the fruit easily separates from the receptacle, it is a

Raspberry. If the receptacle is included with the fruit when separated from the stem, it is a Blackberry. Like *Crateagus*, the *Rubus* genus is also difficult to key out to species. Again, this is due to cross-breeding and apomictic individuals (Strausbaugh 1952).

Rubus allegheniensis T.C. Porter. Blackberry

Found: Near WTL near the field station.

Status: Common; only blackberry species in the reserve.

Date: 7-10-96

Wild blackberries provide food for birds and other wildlife. Humans have utilized the berries to make jam and pies.

Rubus occidentalis L. Raspberry

Found: Near WTL near the field station.

Status: Common; only raspberry in the reserve.

Date: 7-10-96

Raspberries, like blackberries have been used to make jam and pies. Taking walks through re-forested areas and fields always seems to yield a few, if not many, raspberry plants. Surrounding wildlife also appears to notice and seek out this valuable form of food.

Family Caesalpiniaceae

Cercis canadensis L. Redbud

Found: At the base of the big hill on WTL. It overhangs the trail.

Status: Uncommon tree in the reserve.

Date: 7-1-96

Redbud is sometimes referred to as Judastree, because it was believed that Judas Iscariot hanged himself on a branch of this tree. Redbud's showy red flowers come out

before the leaves. In the fall, this tree becomes distinctive because its leaves turn bright yellow. The bark of this tree has been used to treat dysentery. The flowers can be put into salads or fried. Various animals eat the seeds, and bees use the nectar to produce honey (Peattie 1964).

Gleditsia triacanthos L. Honey locust

Found: Off the right of WTL between the WXL and GQT in the forest edge.

Status: Common along forest edges by fields.

Date: 6-26-96

Honey locust is one of the only trees that is bipinnately compound. Its thorns are large and strong. The pulp between the seeds is very sweet. It is eaten by cattle and hogs. The pods are rich in protein and carbohydrates. The thornless variety of this tree is often planted as an ornamental. The wood of honey locust is strong and durable, but because of its scarcity, it is used only locally and not commercially (Peattie 1964). This tree grows many stump sprouts when it is cut down. This is important for clear cut areas, because it holds the soils (Burns and Honkala 1990).

Gymnocladus dioica (L.) K. Koch. Kentucky Coffeetree

Found: Near NWL by the Hankinson Road exit.

Status: Only one observed in the reserve.

Date: 9-14-96

This tree got its name because pioneers used to take its seeds and roast them to make coffee. This is one of the few members of the pea family that does not host nitrogen-fixing bacteria. This is one of the few trees that can be distinguished by its large bipinnately compound leaves (Peattie 1964).

Family Fabaceae

Robinia pseudo-acacia L. Black Locust

Found: Near TOL in Dogwood Meadows.

Status: Common in the reserve.

Date: 7-12-96

The wood of the locust was used to build the first homes in Jamestown, Virginia. Because of its durability, black locust is used to make fence posts. Black locust wood was also used to make wooden nails for sailing ships. In fact, the British blamed their defeat on Lake Champlain in the War of 1812 on the locust nails used by the American fleet (Peattie 1964). Not only is the locust used for its lumber, but it is also used to re-develop wildlife habitats on mine spoils because it has soil-improving properties. One interesting characteristic of black locusts is that the leaves are said to "sleep" at night. They droop on their petioles at night fall. Like honey locust, this tree grows stump sprouts which help to hold the soil in clear cut areas (Burns and Honkala 1990).

Family Elaeagnaceae

Elaeagnus angustifolia L. Russian-olive

Found: In the open fields past the ponds.

Status: Uncommon; introduced species to the reserve.

Date: 7-11-96

Russian-olive is not a native species. It has escaped cultivation and now invades the wilds of North America. It can be identified by its silvery colored leaves and branches. Even from a distance, it appears to have a silver-like shine (Braun 1961).

Family Cornaceae

Cornus

Dogwoods are known for their shock-resistant wood. Because of this trait, they were used to make the heads of wooden golfclubs and chisel handles. The textile industry utilized the wood to make shuttles (Peattie 1964). Now dogwoods are commonly planted as ornamentals. They provide wildlife with an abundance of food. The seeds, fruit, flowers, bark, twigs, and leaves are all food for a variety of wildlife (Burns and Honkala 1990). One unique trait of all dogwoods, is the "leaf vein trick." If you break the leaf in half width-wise the veinlets will keep the two halves attached. Distinguishing one dogwood from another is very difficult. Generally, one must have a fruit, flower, and leaf to accurately identify one dogwood from another.

Cornus alternifolia L.f. Alternate-leaf Dogwood

Found: Near WTL across from the pine plantation.

Status: Uncommon in the reserve.

Date: 7-26-96

Alternate-leaf dogwood is the only member of the genus with alternate leaves. Another distinctive feature of these trees is that the leaves are clustered at the end of the branchlets (Braun 1961).

Cornus amonum Miller. Knob-styled Dogwood

Found: Near WTL near the ponds.

Status: Only one observed in the reserve.

Date: 8-22-96

This tree often hybridizes with *C. obliqua*, the silky dogwood, making it difficult to distinguish between the two. One possible way to distinguish it from other dogwoods are the "rusty" hairs on the underside of the leaf (Braun 1961).

Cornus drummondi C.A. Meyer. Rough-leaf Dogwood

Found: Near WTL by the athletic bridge.

Status: Uncommon; only individual seen.

Date: 7-24-96

This tree has two distinctive features: the leaves are rough on the upper-surface, and the fruit is white (Braun 1961).

Cornus florida L. Flowering Dogwood

Found: Near WXL on top of the first hill.

Status: Fairly common tree of newly forested areas and forest edges.

Date: 6-25-96

This tree is known for its beautiful flowers. The bark is also distinctive because it is thin and shredding. Recently, flowering dogwood has been attacked by a basal stem canker. This canker is caused by the fungus *Phytophthora cactorum* and has proven to be very lethal (Burns and Honkala 1990).

Cornus stolonifera Michx. Red-osier Dogwood

Found: Near WTL past the ponds and fields.

Status: Rare in the reserve

Date: 7-5-96

This dogwood is characterized by the red hue of its branchlets. The leaves are whitish beneath, and there are usually 5-7 branchlets (Braun 1961).

Nyssa sylvatica Marshall. Sourgum

Found: In the forest edge to the rt. of WTL when heading towards the ponds.

Status: Rare; only one individual seen.

Date: 6-28-96

Sourgum tends to grow in swampy woods. Its wood is cross-braided and is nearly impossible to split; therefore it has not been used as a lumbertree. However, because it does not split easily, it is often used to make heavy-duty tool handles (Peattie 1964).

Family Celastraceae

Celastrus orbiculata Thunb. Oriental Bittersweet

Found: In the forest edge to the southwest of the ponds.

Status: Common; introduced species is more common than the native species.

Date: 6-28-96

This woody climber is not native to North America. It can be distinguished from its relative *Celastrus scandens* by the round "orbicular" leaves and fruits borne in the axils of the leaves (Braun 1961).

Celastrus scandens L. American Bittersweet

Found: Near WTL just before the entrance to WT.

Status: Uncommon; native species of *Celastrus*.

Date: 7-12-96

This is the native species of bittersweet. Its leaves are more lancelate, and the fruits are in terminal clusters (Braun 1961).

Euonymous alatus (Thunb.) Siebold. Winged Burning Bush

Found: Found on the path to the dump.

Status: Uncommon in reserve.

Date: 8-16-96

This bush is not native to North America. It has escaped cultivation. One distinguishing feature is the "winged" branches (Braun 1961).

Euonymous obovatus Nutt. Running Strawberry Bush

Found: In Norpell Woods.

Status: Common shrub/vine.

Date: 8-9-96

The running strawberry bush is native to North America. It is characteristically a trailing vine (Braun 1961).

Family Aquifoliaceae

Ilex opaca Aiton. American Holly

Found: Near WTL just before WT in the forest edge.

Status: Rare; only a few planted individuals.

Date: 8-2-96

The decorative foliage of this tree has been used for years in Christmas wreaths. Because people harvest its leaves and berries relentlessly, the holly is endangered. The wood is not strong, but is hard and tough. It has been used to make wooden crafts and piano keys. Birds and other wildlife eat the berries of the holly (Peattie 1964). The holly's leaves are nearly evergreen and very thick making them extremely distinctive from all other leaves in the forest.

Family Rhamnaceae

Rhamnus

Buckthorns are generally small shrubs or trees with greenish flowers. Most have thorns or spines and a fruit that is a drupe (Braun 1961).

Rhamnus caroliniana Walter. Carolina Buckthorn

Found: Near HT in the edge of the forest.

Status: Uncommon in the reserve

Date: 7-5-96

Ironically, Carolina Buckthorn has no thorns. Its berries are red and resemble the berries of American Holly (Braun 1961).

Rhamnus cathartica L. Common Buckthorn

Found: In Norpell Woods along north fence-row.

Status: Rare shrub of the reserve.

Date: 8-5-96

This buckthorn does have thorns. It was introduced from Europe. Its cathartic fruits are distinctive. The buds are opposite or subopposite, which distinguishes it from other buckthorns (Braun 1961).

Rhamnus frangula L. European-Alder Buckthorn

Found: In the pine plantation.

Status: Common in the pine plantation.

Date: 7-25-96

This buckthorn was also introduced from Europe. Its fruits which turn purple/black distinguish it from other buckthorns (Braun 1961). Like Carolina buckthorn, this species does not have thorns. Its bark and berries were once used as a laxative (Peattie 1964).

Family Vitaceae

Parthenocissus quinquefolia (L.) Planchon. Virginia Creeper

Found: Next to HT near the edge of the forest.

Status: Very common vine of the reserve.

Date: 7-5-96

Virginia Creeper is a vine that climbs by using tendrils tipped with adhering pads. The leaves are palmately compound with five leaflets, often resembling the shape of poison ivy leaves (Braun 1961). The fruit is a bluish berry that is inedible for humans, but a viable food for birds and other wildlife (Strausbaugh 1952).

Vitis

Vitis is a genus of woody vines that climbs other plants using tendrils. Distinguishing between the different species can be difficult at times, so leaf shape and size of the diaphragm must be studied carefully (Braun 1961).

Vitis riparia Michx. River-bank Grape

Found: On WTL near the ponds.

Status: Common, but not as common as *Vitis vulpina*.

Date: 7-10-96

River-bank grape is lobed, and the lobes form an acute angle with the leaf apex. The diaphragm at the stem nodes is 0.5-1 mm wide (Braun 1961).

Vitis vulpina L. Frost Grape

Found: Near WTL by the ponds.

Status: Very common; grows on other woody plants along forest edges.

Date: 6-25-96

Frost grape is characterized by heart shaped leaves that generally are not lobed. The diaphragm at the stem nodes is 4-6 mm wide (Braun 1961).

Family Hippocastanaceae

Aesculus glabra Willd. Buckeye

Found: At the north entrance to the HT.

Status: Common only in the HT area.

Date: 7-5-96

Buckeye is the state of Ohio's floral emblem. An extract from the bark may have been used in the past as a stimulant for the cerebro-spinal system. The bark and fruit are both poisonous to humans. Many Ohio settlers used to carry a piece of the bark with them to ward off rheumatism (Peattie 1964).

Family Aceraceae

Acer

Maples are a group of trees that are sometimes difficult to distinguish between species. The leaves of this genus are very distinctive. All maples are capable of producing maple syrup, although sugar and black maples are the primary sap producing trees (Burns and Honkala 1990). The wood is generally tough and durable, so it has been used in various facets of the lumber industry. There was a time when maple lumber was the most popular and widely used wood for cabinets, flooring, and furniture. In many ways, it is the poor man's wood because it is abundant and relatively cheap. The wood is not as glamorous as other lumbers, but it is often referred to as being multipurpose lumber (Peattie 1964). The fruits of maples are also distinctive. The double samaras are commonly called "helicopters."

Acer negundo L. Box-Elder

Found: Near WTL by the ponds.

Status: Common; found in successional areas.

Date: 7-24-96

Box-elder is the only maple with compound leaves (Braun 1961). Its wood is very soft and is rarely used for making wooden products (Peattie 1964).

Acer nigrum Michx. f. Black Maple

Found: Near WTL by the clay fields.

Status: Rare; only one seen in the reserve.

Date: 7-24-96

Black maple can be distinguished from sugar maple by its decurved leaf blades (Braun 1961). Black maple and sugar maple are the primary sources of sap used to make maple syrup (Burns and Honkala 1990).

Acer rubrum L. Red Maple

Found: Near WTL by the ponds.

Status: Common tree of the reserve.

Date: 6-25-96

Red maples are the only maples with v-shaped sinuses. All other maples have u-shaped sinuses (Braun 1961). Red maple is planted as an ornamental, as its foliage turns a beautiful "red" color in the fall.

Acer saccharinum L. Silver Maple

Found: In the forest edge to the right of WTL when heading towards the ponds.

Status: Uncommon maple in the reserve.

Date: 7-2-96

Silver maple can be distinguished from other maples because its leaves are silvery-white beneath, and the leaf lobes are elongated and narrow (Braun 1961). The leaves often look dainty when compared to the broad leaves of the sugar maple. Silver maple is the most important maple to wildlife. Squirrels feed on the buds in the late winter when other food supplies are exhausted. This tree is a very common ornamental and is also used as a windbreak on farms (Peattie 1964).

Acer saccharum Marshall. Sugar Maple

Found: Near WXL past the first hill, on the left.

Status: Most common maple species in the reserve.

Date: 6-27-96

Sugar maple has the most awe-inspiring display of autumn foliage. It surpasses all other trees displaying a of variety of colors in the autumn. Sugar maple is the primary source of sap for maple syrup (Burns and Honkala 1990).

Family Anacardiaceae

Rhus glabra L. Smooth Sumac

Found: Near the entrance to the CT.

Status: Common in successional areas.

Date: 6-28-96

This sumac is almost identical to staghorn sumac except that it does not have pubescence and its fruits have short red hairs. Raw sprouts were eaten by Native Americans in salads. The berries can be used to make "lemonade" (Peattie 1964). Deer find sumac to be very palatable, browsing the twigs and fruit througout the year (Petrides 1988).

Rhus radicans L. Poison Ivy

Found: Near WTL by the pine plantation.

Status: Very common species in the reserve.

Date: 7-5-96

This member of the genus contains an oil that is a skin irritant. Many people have experienced the itching and scratching caused by contact with some part of the plant. The old saying, "leaves of three, let it be," helps to identify this plant and help people from coming into contact with it. Washing with soap shortly after touching the plant can reduce

the symptoms, but washing with water alone tends to spread the oil. Interesting enough, its fruits are eaten by a variety of birds. The poison sumac is another member of this genus. It looks much like the smooth sumac and is more irritating to human skin than poison ivy is. However, it usually grows in swampy wet areas, and it is rather unlikely that humans will come into contact with it (Braun 1961).

Rhus typhina L. Staghorn Sumac

Found: Near WTL by the entrance to CT.

Status: Common near the CT..

Date: 7-25-96

Staghorn sumac can easily be distinguished from the smooth sumac by its obvious pubescence (Braun 1961). The species name, *typhina,* comes from the belief that this tree cured typhoid fever. Indians used the leaves of this sumac along with tobacco leaves in their peace pipes. More modern uses of the tree include extraction of its tannins for leather tanning and the use of its fruits to make a drink similar to lemonade (Peattie 1964).

Family Simaroubaceae

Ailanthus altissima (Miller) Swingle. Tree-of-Heaven

Found: Near TOL in lowlands past the pipeline.

Status: Uncommon; only seen in Taylor-Ochs section.

Date: 7-12-96

Tree-of-heaven originally was not a native organism. It was brought to the U.S. for urban forestry projects. It is valuable in this regard, because it grows extremely fast and is tolerant of air pollutants, poor soils, and low moisture areas. It is now invading our native forests and has become a weed of sorts (Burns and Honkala 1990).

Family Oleaceae

Fraxinus

The ashes are a group of trees with opposite compound leaves. This characteristic tends to be valuable when distinguishing them from other trees. Each of the ashes has its own distinctive features that makes it identifiable. In general, the ashes are very adaptable trees. They can grow in a wide variety of environments. The wood is light and extremely hard. It has been used for tool handles, and to make baseball bats (Peattie 1964).

Fraxinus americana L. White Ash

Found: Near WTL by the ponds on the rt. side of trail.

Status: Very common; grows in most woody areas of the reserve.

Date: 6-25-96

White ash has deeply concave leaf-scars (smiley face shape) which sets it apart from green ash (Braun 1961). Because it was believed that rattlesnakes found white ash leaves offensive smelling, people have placed the leaves in their pockets and boots in an attempt to ward off snakes. White ash is the best of the ash woods used in making baseball bats (Peattie 1964).

Fraxinus nigra Marshall. Black Ash

Found: Near TOL in lowlands area past the pipeline and before the ponds.

Status: Rare in the reserve; only seen on TOL.

Date: 7-12-96

This ash has sessile leaflets, and the winter buds are black. The black ash got its name because its heartwood is very dark. Many woven chair bottoms are made from strips of black ash. Black ash grows best in swampy areas (Peattie 1964).

Fraxinus pennsylvanica Marshall. Green Ash

Found: Near TOL in woods before pipeline.

Status: Very common; most common ash in the reserve.

Date: 7-12-96

Green ash has convex leaf-scars that lie below the buds and bud-scars (Braun 1961). Green ash has been used in re-vegetation of spoil banks created from strip mining (Burns and Honkala 1990).

Fraxinus quadrangulata Michx. Blue Ash

Found: Near TOL just past the pipeline.

Status: Rare in the reserve.

Date: 7-12-96

This is perhaps the easiest ash to distinguish, because it has square and winged stems (Braun 1961). The sap turns blue when exposed to the air. Pioneers used the bark to make a blue dye (Peattie 1964).

Fraxinus profunda (Bush) Bush. Pumpkin Ash

Found: In Taylor-Ochs section of the reserve.

Status: Rare; only individual observed.

Date: 9-21-96

It is very easy to distinguish this ash from others, because its twigs are hairy/velvet-like. This ash usually grows in moist and shaded areas (Braun 1961).

Ligustrum vulgare L. Privet

Found: To the right of WTL between WXL and GQT in the forest edge.

Status: Common shrub in the reserve

Date: 6-27-96

This is not a native shrub to the northern U.S. The leaves are evergreen/semi-evergreen. It can be distinguished easily in the early winter from other woody shrubs, because its leaves remain on the plant (Braun 1961).

Family Bignoniaceae

Catalpa speciosa Warder. Northern Catalpa

Found: Near CT near the start of trail.

Status: Common; found primarily along the Catalpa Trail.

Date: 6-25-96

Northern catalpa's range does not normally extend northward into Ohio. It was widely used as an ornamental and for fence posts. The leaves of the catalpa, which are opposite/whorled and broad ovate, distinguish it from other trees. Another distinguishing feature is its large aromatic white tubular flowers (Braun 1961).

Campsis radicans (L.) Seemann. Trumpet-creeper

Found: Found opposite the clay fields.

Status: Uncommon in reserve

Date: 8-16-96

Trumpet-creeper is a woody climber that has distinguishable orange "trumpet-shaped" flowers (Braun 1961).

Family Caprifoliaceae

The honeysuckles are distinguished by their opposite leaves and hollow piths. This genus tends to be a pest in most areas (Braun 1961). They have flourished in our woods and fields. When left unattended they grow in thick clumps making it difficult to navigate through and amongst them.

Lonicera japonica Thunb. Japanese Honeysuckle

Found: Near WTL by the ponds, close to Clay Run.

Status: Common in the reserve.

Date: 6-25-96

This is a vine honeysuckle, and the only one without red berries. Its upper leaves are not united, as is the case with many honeysuckles. The leaves tend to be evergreen (Braun 1961).

Lonicera morrowi A. Gray. Eurasian Fly Honeysuckle

Found: To the right of WTL between WXL and GQT in the forest edge.

Status: Very common; found in every section of the reserve.

Date: 6-25-96

This honeysuckle is a shrub. In Ohio, many confuse it with *L. maackii*. In Denison's Biology Reserve, we recognize *L. morrowi* to be the predominant shrub-like honeysuckle. In either case, this honeysuckle is a definite pest. Its red berries, which stay on the plant for most of the summer, are very distinctive of honeysuckles. The fruits are borne in pairs. If the petiole is longer than the pedicel then it is *L. maackii*; if the pedicel is longer than the petiole, then it is *L. morrowi* (Braun 1961). This is the easiest way to tell the two species apart.

Sambucus canadensis L. Common Elder

Found: Near WTL by the ponds on the left side of trail.

Status: Common; usually grows near other trees.

Date: 6-25-96

Common elder has edible fruits. They can be used to make jam, jelly, pies, and wines. Many birds also find the fruits palatable (Peattie 1964).

Viburnum

The viburnums are a group of woody shrubs that are quite difficult to tell apart. There is no single vegetative characteristic that includes all members of the group. However, all of them do have small fleshy fruits that contain flat seeds (Braun 1961).

Viburnum acerfolium L. Maple-leaf Viburnum

Found: Near HT by the spring box.

Status: Uncommon; one of four viburnums in the reserve.

Date: 7-26-96

This is perhaps the easiest viburnum to identify. As its common name suggests, its leaves are shaped like those of a maple (Braun 1961).

Viburnum dentatum L. Arrow-wood

Found: Near OL in Norpell Woods.

Status: Common; part of the *V. dentatum* complex.

Date: 8-2-96

This viburnum is part of the *dentatum* complex, which includes a number of viburnums that look very similar. Distinguishing these is extremely difficult, and many taxonomists are content with leaving them as *V. dentatum* or placing them into the complex (Braun 1961).

Viburnum prunifolium L. Black Haw

Found: Near HT in the edge of the forest.

Status: Uncommon shrub of the reserve.

Date: 7-5-96

This viburnum has edible fruits which an abundance of wildlife utilize. Black haw is also the most widely distributed of all the viburnum species in Ohio (Braun 1961).

Viburnum recognitum L. Arrow-wood

Found: In the forest edge to the right of WTL when heading towards the ponds.

Status: Uncommon; part of the *V. dentatum* complex.

Date: 6-28-96

This viburnum is part of the *dentatum* complex and can be distinguished from *V. dentatum* by seed structure and locality (Braun 1961). Its shoots were used by Native Americans for arrow shafts (Peattie 1964).

Family Smilacaceae

Smilax

Members of the *Smilax* genus are some of the few woody members of the lily family that are monocots. They are climbing vines that have stems armed with prickles. The petioles have tendril-like appendages which help the plant climb and keep hold (Braun 1961). The greenbriars very important to wildlife. They provide food and shelter to a variety of animals. The fruit and seeds are eaten by many species of birds. The vegetative parts of the plant are vital to deer during the winter months The stems and leaves contain high percentages of protein and water. Even humans have utilized the greenbriars for food. The roots can be ground and dried to make a pudding or put into breads and cakes (Strausbaugh 1952).

Smilax hispida Muhl. Bristly Greenbriar

Found: In the forest to the southwest of the ponds, near Clay Run.

Status: Common vine of the reserve.

Date: 6-28-96

Bristly Greenbriar can be distinguished from *S. rotundifolia* by a more dense covering of prickles. However, these prickles are not stout (Braun 1961).

Smilax rotundifolia L. Greenbriar

Found: Near WTL by the CHT.

Status: Less common than *S. hispida.*

Date: 8-30-96

This Greenbriar is distinguished from *S. hispida* because the branches are somewhat four-angled, and the prickles are more stout and fewer in number (Braun 1961).

Chapter Four

Woody Plant Diversity and Complexity in the Denison University Biological Reserve

Introduction

A community is a group of populations existing in a particular area or habitat. Quantification of the diversity, dominance, composition, and relative abundance is necessary to characterize and describe a community. By quantifying these structural aspects of a community, ecologists can investigate the biotic and abiotic factors responsible for the maintenance and changes within a community.

Successional theories, models that examine the process of directional change in vegetation, attempt to explain the reasons that successive communities replace previous communities as a result of natural and progressive development (Braun 1950). These models predict that these directional changes finally lead to a climax community that will remain unchanged unless the environmental conditions fluctuate enough to limit the dominance of climax species. These models predict that early species will either facilitate, inhibit, or be out competed by later establishing species. the establishment of later species (Connell and Slayter 1977).

One model, the facilitation model suggests that preceding species modify the environment in such a way as to provide a more conducive environment for the establishment of later species. Over time, as later species replace their predecessors, succession will occur (Connell and Slayter 1977). The major assumption of this model is that species will replace one another because at each stage of succession, the current species change the environment, making it more suitable to other species and less suitable for themselves (Krebs 1994).

Alternatively, in the inhibition model, early species hinder the successful colonization by later species. In this case, succession is more idiosyncratic because community structure is largely determined by which species establish themselves first. By modifying the environment, early arriving species limit the ability of later species to compete. The succession of old fields in North Carolina is characterized by horseweed

inhibiting the growth of asters (Krebs 1994). This inhibition can either cause succession to occur at a decreased rate or prevent further succession from occurring (Connell and Slayter 1977).

A third model, the tolerance model, suggests that species that are more tolerant of the environmental conditions will survive and out-compete other species. In beech-maple forests, maples usually are more dominant in the understory than beeches because they are more tolerant to shade (Poulson and Platt 1996). This one example of how a more tolerant species can dominate a community. Thus, the climax community, that is, the final stage of succession, consists of those species best suited to the constraints that the environment places on those species. Although any species is able to start the process of secondary succession, the most competitive species will eventually dominate the climax community (Connell and Slayter 1977).

Succession can be categorized into four stages: pioneer, consolidation, subclimax, and climax (Dansereau 1957) . Using this terminology, any community can be placed into a particular stage of succession. Use of these stages allows ecologists to easily classify a community's state of succession making it a convenient way to describe a community. In reality, however, a plant community is continually changing, sometimes making it difficult to place a community accurately within a particular stage of successional development (Spurr and Barnes 1973).

For the unglaciated portions of the Allegheny Plateau mixed-mesophytic forests are the climax forest community. Beech-maple forests are characteristic of the glaciated Wisconsin and Illinoian Till Plains and the glaciated portion of the Allegheny Plateau. In this area of Ohio, beech-maple forest is considered to be the climax forest community (Braun 1961). Beech-maple forests are distinguished from mixed-mesophytic forests by beech being a more dominant canopy and subcanopy along with sugar maples. Both beech and sugar maple are considered to be codominants (Braun 1950).These climax forests are derived from postglacial colonization of mixed-mesophytic species (Braun 1950). The

subclimax forest (i.e. mixed-mesophytic forest) can contain a wide variety of hardwood species, including the following codominants-dominant canopy species: beech, tuliptree, sugar maple, basswood, red oak, white oak, white ash, red elm, and wild cherry. This subclimax forest type is highly variable and canopy species composition fluctuates from region to region (Braun 1961). The successional process in the beech-maple forest community begins with invasion of mixed-mesophytic forests into the glaciated areas. Because of favorable environmental conditions in these glaciated areas and the relatively high tolerance of beech and maple, the mixed-mesophytic forest communities are succeeded by beech and maple, which become the two dominant canopy species.

This study examined the community composition for the three sections of the Denison University Biological Reserve (DUBR). Utilizing the characteristics of the woody plant community of the DUBR, I determined whether the forests of the DUBR characteristic of a beech-maple climax forest community. Provided that they were not at a climax beech-maple forest, I compared the three sections to determine if they were all at similar successional stages. Further more, I examined demographic information to suggest what community changes can be expected in the future. In addition, I discuss potential areas of research that could more effectively predict future forest compositional changes.

Methods

Site and Species

The Denison University Biological Reserve is located approximately one mile north of Denison's campus, east of Ohio St. Rt. 661. In 1966, Denison's Board of Trustees allocated 220 acres of land to establish the reserve. The reserve now encompasses 350 acres of land situated in three contiguous sections: Alrutz, Norpell Woods, and Taylor-Ochs. Prior to Denison's aquisition of the land, the sections that made up the reserve were primarily farmland. These farms were maintained until the early-1900's (Bautista and Vogelgesang 1991). During the 1900's plantations of white and red pine were established

in the Alrutz and Norpell Woods sections, and tuliptrees were planted in the Norpell Woods section; these plantations are still characteristic parts of the reserve. Three large fields located within the Alrutz section are maintained in different stages of succession (Schultz 1994). In addition, there is one unmaintained field in the Taylor-Ochs section, but none occur in the Norpell Woods section. Small streams and ponds located in the reserve are additional features that affect the distribution of woody plant species (See Map 1).

The DUBR is located on the glaciated part of the Allegheny Plateau. It lies approximately 11 miles east of the unglaciated portion of the Allegheny Plateau (Forsyth 1970). Two glacial movements, the Illinoian and Wisconsin, are mainly responsible for the soil types of this region of Ohio. Most of the reserve is characteristic of either Brownsville channery silt loam, having slopes of 18 to 25 percent, or Mechanicsburg silt loam which have slopes of 6 to 12 percent (Parkinson et. al. 1992).

Design of Experiment

During July and August of 1996, prior to sampling species diversity, I identified specimens of woody plants in the DUBR to develop my identification skills. During this time, and throughout the study, I collected herbarium specimens of woody species to aid in the inventory of species and to facilitate the examination of the forest community.

To sample species diversity of the three sections, I designed a systematic sampling scheme, in which each section of the reserve was divided into 20 subsections (see Map 2). In the lower right corner of each subsection, I created a 10 x 10 meter quadrat. To ensure that the total area sampled for each section remained constant at 2000 meters squared, I varied the size of subsections in relation to the area of each section (see Table 1). Although this sampling method provided biased data, implementing a random sampling technique in this study would have been difficult because the reserve is not marked in a way that allows for identification of specific locations. Random sampling techniques pick quadrats at random. Because the reserve was so large and the terrain difficult, it was not reasonable to

divide and mark the reserve into individual 100 square meter quadrats necessary for the random sampling technique.

From late August to early October, I collected "quadrat data." To determine the location of each quadrat, I paced off the distance from a known grid (a fenced corner within each section). A compass was used to ensure that a straight line was maintained along the grid axes. For each quadrat, I created a 10 meter by 10 meter square using a compass and a tape-measure. Within each quadrat, the number of individuals for each woody plant species was counted. For each species, individuals were placed into stage/size categories: seedling/woody vines (less than one cm diameter at breast height - dbh), subcanopy trees/woody vines (between one and 10 cm dbh), and canopy trees (greater than 10 cm dbh). For each individual in the largest size class, diameter at breast height was recorded. For plants known to send out runners, (e.g. roses, Virginia creeper, poison ivy, and honey suckle), individual plants could not be distinguished from runners. Therefore, each individual shoot/stem arising from the ground was considered as one individual. In addition, clumps of stems were considered one individual plant.

Statistical Analysis

To determine whether sample size was large enough, I performed a species-area curve for all three sections. The cumulative number of species was plotted against the cumulative size of the area sampled. Sample size is considered sufficient when the curve reaches a sustained plateau (Brower et. al. 1990).

Demographics is the study of population changes and their causes throughout the life cycle of the species (Silvertown 1982). The demographic data from this study looks at species abundance in three different life-stage classes. To investigate community structure for each section, I evaluated demographic data for each potential canopy species. Forest classification is based on dominant canopy species, so potential canopy species were examined to determine the forest type (i.e., species that have the ability to occupy space in the forest canopy). The data was manipulated to create stage/size categories for each

potential canopy species. Over time, monitoring of those stage/size classes enables ecologist to create transition matrices. These matrices suggest which species will increase or decrease over time (Silvertown 1982).

To quantify the diversity in each section, I utilized the Margalef index (Margalef 1957). The Margalef index measures the species richness (that is, the number of species). Margalef's index can be calculated as follows:

$$D_a = (s - 1)/\log N$$

where s = the number of species and N = the total number of individuals sampled across all the species. For this index, the larger the number of species the greater the diversity.

Although the Margalef index gives a basic summation of species richness (i.e., the number of species), it is unable to differentiate between two communities that have the same number of species but different abundances. More effective measurements of diversity take into consideration both species richness and the evenness of those various species, (i.e., the distribution of individuals among species). A community in which individuals are distributed evenly among species is considered to have greater species diversity than a community with the same number of species unevenly distributed (Brower et. al. 1990). Because the Shannon index incorporates eveness of individuals into its equation, the Shannon index was used to give a more accurate measure of species diversity.

The Shannon index describes the average degree of uncertainty in predicting the species of a randomly picked individual from the community. Uncertainty increases as the number of species increases and as the number of individuals/species becomes more equally distributed (Cox 1996). The Shannon index is calculated as follows:

$$H' = (N \log N - \sum n_i \log n_i)/N$$

where n_i = the number of individuals per species and N = the total number of individuals. This index ranges from values of zero for communities where there is complete certainty in predicting the identity of a randomly picked individual (i.e., communities with only one

species) to increasingly larger values for communities with little certainty in identifying a randomly selected individual of species with increasingly even distributions of individuals per species (i.e. communities with increasingly greater numbers of species). In other words, more diverse communities have large values for the Shannon Index.

I used *t*-tests to compare Shannon diversity values between sections of the DUBR (Zar 1984). Because I made three paired comparisons between sections of the reserve, overall, each test was done at a 99% confidence level to maintain a 95% confidence level. If each comparison was tested at an alpha of 0.05 the overall confidence would only have been 86% (i.e., 0.95 x 0.95 x 0.95 = 0.86). Analysis of variance is typically used to compare among three or more factors. I was limited to using a *t*-test because of the variance model used.

To determine how similar the three sections of the reserve were to each other, I examined indices of community similarity . One similarity index, the Jaccard coefficient (Mueller-Dombois and Ellenberg 1974), is calculated as follows:

$$CC_J = c/S \times 100$$

where *c* is the number of species common to both communities (sections) and *S* is the total number of species found in both communities. The value of CC_J ranges from 0% (when no species are found in common between two communities) to 100% (when all the species are found in common between two communities).

The Jaccard coefficient only evaluates community similarity based on the total number of species found in two communities and which species those communities had in common. The distribution of individuals among species is also important when comparing two communities. If two communities have many species in common and the individuals are distributed evenly among those species, then those communities will be similar. However, if two communities have many species in common, but individuals are not distributed evenly between the species in both communities, then those communities will not be similar.

The Horn index utilizes the Shannon index to evaluate community similarity based on species they have in common and eveness of distribution among individuals (Horn 1966). The Horn index is calculated using the following steps:

1) the Shannon indices for each community are calculated separately (H_1' and H_2')

$$H' = (N \log N - \sum n_i \log n_i)/N$$

where n_i = the number of individuals per species and N = the total number of individuals.

2) the Shannon index is calculated for the sums of the species abundances for each species using the following equation:

$$H_3' = [N \log N - \sum(x_i + y_i) \log (x_i + y_i)]/N$$

where N = the total number of individuals in both communities. H_3' treats the two communities as one combining two communities' species abundances and calculating the Shannon index for that combined community.

3) the Shannon index is calculated to determine the H_{max} value obtainable from the given species abundances (each x_i and y_i value) using this equation:

$$H_4' = (N \log N - \sum x_i \log x_i - \sum y_i \log y_i)/N$$

H_4' provides a value that assumes that the two communities are combined and that they share no common species. Thus, H_4' gives an estimate of maximum diversity for the combined community.

4) the Shannon index is calculated for the maximum overlap of x_i and y_i to give an H_{min} value using the following equation:

$$H_5' = (N_1H_1' + N_2H_2')/N$$

H_5' estimates what the diversity for the combined community assuming that species from one sub-community are the same as the species from the other sub-community.

5) the Horn index of community similarity "overlap" is then calculated:

$$R_0 = H_4' - H_3'$$

$H_4' - H_5'$

The value of the Horn index (R_0) ranges from zero (when two communities have no species in common) to a maximum of one (when all the species are found in both communities and the relative abundance of those species is identical). As H_3' approaches the H_{max} value (i.e. as the two communities are less and less similar to each other), the numerator moves closer to zero; the R_0 value moves closer to zero as the similarity between two communities decreases. As the H_3' value approaches the H_{min} value (i.e., as the two communities are more and more similar), the numerator approaches the value of the denominator; the R_0 approaches one (Brower et. al. 1990).

Results

The species-area curves for Alrutz, Norpell Woods, and Taylor-Ochs sections indicated that 20 samples (each of 100 m^2) were sufficient for determining the number of species found in those sections. The species-area curve for the Alrutz section clearly plateaued after 16 samples, and a total of 50 species were found in the Alrutz section (Figure 1). For the species-area curve for the Norpell Woods section, the number of new species added per sample rapidly rose for the first four samples. The number of new species then leveled off between 16 - 18 samples (Figure 2). Although the species-area curve for the Taylor-Ochs section showed a gradual and steady increase in the number of new species found after each sample (Figure 3), the curve leveled at 18 samples.

The Margalef index indicates that all three sections have a high degree of diversity (Table 2). The Alrutz section has a Margalef value of 14.07; the Norpell section has a value of 11.97; and the Taylor-Ochs section has a value of 12.74. The Shannon index values for the three sections were: Alrutz--1.27 ± 0.0084, Norpell Wood--1.12 ± 0.0075, and Taylor-Ochs--1.19 ± 0.0073. These values are very similar; however, variance was very reduced due to large sample size, resulting in significant differences in diversity variance for all comparisons between sections (Table 2).

Alrutz and Norpell Woods sections had 58% of their species in common, while the Alrutz and Taylor-Ochs sections were 56.5% similar in their species, and the Norpell Woods and Taylor-Ochs sections were 64.3% similar in species present (Table 3). Of the 68 species found in the study, 31 species were found in common among all three sections. (For a complete list of species found in each section, see the Appendix). The Horn index values for the each comparison were $R_0 = 0.86$ (Alrutz vs. Norpell), $R_0 = 0.90$ (Alrutz vs. Taylor-Ochs), and $R_0 = 0.87$ (Norpell vs. Taylor-Ochs) (Table 3). These values are relatively close to 1.0 indicating that these communities are very similar in species composition and relative abundances.

The demographic data of potential canopy species showed that certain species were most abundant in all three stage classes, while others were either more abundant in the sapling/seedling stage (less than 1 cm dbh) or present only in the canopy stage (greater than 10 cm dbh). In the Alrutz section, sugar maple was by the far the most abundant species in each of the three stage classes (Table 4). Green ash and red elm each made-up a large proportion of the sapling/seedling stage, but they were less abundant in the later stages (Table 4). Both white pine and red pine were abundant in the canopy stage, but were not abundant in the earlier stages (Table 4). Black walnut and black cherry were also important canopy species. However, black walnut was completely absent from the sapling/seedling stage, and black cherry had lower abundance in the two earliest stage classes (Table 4). In addition, flowering dogwood was nearly absent in all three stage classes.

Results for examining the abundance of potential canopy species in each stage class for the Norpell Woods section are similar to those for the Alrutz section. Overall, sugar maple was the most abundant species (Table 5). Both green ash and red elm were important in the sapling/seedling stage, but were less abundant in the later stages (Table 5). Although beech was abundant in the subcanopy stage, it was not abundant in the other size classes (Table 5). Tuliptree was the most abundant species in the canopy stage, but was absent from the subcanopy stage and nearly absent from the sapling/seedling stage

(Table 5). White pine was abundant in the canopy stage, but was nearly absent in the two smaller size classes. Similarly, black cherry was abundant in the canopy stage, but less abundant in the earlier stages (Table 5).

Sugar maple was the most abundant species in the Taylor-Ochs section (Table 6). Green ash and red elm were abundant in the sapling/seedling stage class, but were not abundant in the later stages (Table 6). As in the Alrutz and Norpell Woods sections, black cherry was a very abundant species in the canopy stage, but was less abundant in the earlier stages (Table 6). Flowering dogwood was abundant in the subcanopy stage class however, it was nearly absent in the sapling/seedling stage (Table 6).

Discussion

The species-area curves indicated that 20 quadrats were a sufficient sample size for each section of the DUBR. Because the curve did not plateau until approximately 20 quadrats (2000 m^2), future researchers should use at least 20 quadrats per section to ensure a large enough sample size.

All three sections were fairly similar in species diversity (Table 2). The small but significant differences in diversity may be due to the Alrutz section having more forest edge than any other section because of the large amount of open field in the middle of this section. Open fields create more forest edges. In turn, increased forest edge can cause increased species diversity compared to contiguous forests due to increased variation in habitat type (Matlack 1994). The fact that the Alrutz section has more of these open fields (three quadrats were sampled) than the Norpell Woods (no fields) and Taylor-Ochs (one quadrat was sampled) might explain why Alrutz had the highest diversity followed by Taylor-Ochs. In addition, the tuliptree plantations of Norpell Woods may explain its low diversity. Since tuliptree would be present in all forests, these plantations do not add to the number of species in Norpell Woods, but the plantations do decrease the eveness of

species. Furthermore, total area of each section may explain the difference in diversity values; Alrutz is the largest section, followed by Taylor-Ochs and Norpell Woods. Since larger areas have increased likelihood to include more habitats and more habitats will probably provide niches for more species, Alrutz could be expected to have the highest species diversity followed by Taylor-Ochs.

The community similarity indices, like the species diversity indices, indicated that all three sections were similar. The reserves three sections are all adjacent to one another and should be considered as one single forest community. The community similarity indices clearly indicate that the woody plant communities within each section are similar. All three sections should be studied and monitored as one single community of woody plants.

Sugar maples were abundant in all the stage classes for all sections of the reserve. Because maples were so prolific in the sapling/seedling, subcanopy, and canopy size classes, these forests can be considered maple forests at present. Whether the forest type should be classified as only a maple forest depends on the presence and relative abundance of other species in the canopy stage class. Beech was not found as an abundant species in any of the sections of the reserve. Because beech-maple forests are the climax forest community for glaciated sites in this area of Ohio the forest community of the DUBR is not a beech-maple climax. However, since many other species are codominant with sugar maple, this forest is characteristic of a pre-climax maple-mixed-mesophytic forest (Table 4, 5, and 6).

The pine plantations of the Alrutz and Norpell Woods sections are not regenerating themselves; the general absence of sapling/seedling and subcanopy individuals indicates that these species will not remain canopy dominants after this planted cohort dies. In other pine forests, invading species out compete pines in the understory layer (De Steven 1991). Pines seldom reproduce themselves under their own canopy except in the most open stands and on dry sites (Spurr and Barnes 1973) At the DUBR, many species (e.g. sugar maple,

green ash, and red elm) have been establishing themselves in light gaps located in the pine plantations. One area of the Norpell Woods section, where a partial clearing of the understory occurred, some pine recruitment from the subcanopy stage class is occurring. Even so, no sapling pines were found in any quadrant in either the Alrutz or Norpell Woods sections. Since pines are not the typical canopy species of hardwood forests of Ohio, they probably are not be able compete with other species of the reserve. Generally, pines are early colonizers during succession, often acting as facilitative species by enhancing the environment, thus enabling other species to colonize (Spurr and Barnes 1973).

Tuliptree exhibited the same pattern as pines. Tuliptrees were planted in the Norpell Woods section and were the most abundant species in the canopy stage class. In the smaller size classes, tuliptree was much less abundant, suggesting that it did not compete well with other understory species. These results concur with the literature; typically, tuliptrees are early successional species in mixed-mesophytic forests because they lack the ability to compete with other, more tolerant species (Busing 1995). Because pines and tuliptrees will be lost from the composition of canopy species in the Norpell Woods section and the Alrutz section, the community structure can be expected to change dramatically in the future. Most of the reserve used to be farmland and thus the original forest was cleared by the mid 1800's (Bautista and Vogelgesang 1991). Because of human influence, tuliptrees and pines that were planted had little or no competition with other species. They were able to establish themselves before other colonizing species could invade. After the land in the DUBR was no longer under direct human influence, the process of succession started. Through succession, more tolerant species have been able to occupy the sapling/seedling and subcanopy stages.

As with tuliptrees and pines, black walnut also appears to be outcompeted in the sapling/seedling and subcanopy stages. Because black walnut trees produce an allelotoxin that can inhibit the growth of other species near black walnuts (Burns and Honkala 1990),

the loss of this inhibitory species could potentially increase the rate of succession towards the climax community. Additionally, it could also increase the overall species richness.

Black cherry, like white pine, red pine, tuliptree, and black walnut, does not appear to be replacing itself from smaller size classes. If true, black cherry will be lost as a major component of the canopy. Other research concurs with this view, stating that black cherry are a pioneer species in old field succession (Spurr and Barnes 1973). Because their abundance is relatively low in the sapling/seedling stage, it suggests that the reserve is past the pioneer stage of successional development.

Currently, green ash and red elm are not an important canopy species. They might be the next species in the successional progression of the forest community. In the future, these species would fill the larger size classes and potentially be codominants-dominants with or dominants with sugar maple. Alternatively, green ash and red elm might be unable to compete in the canopy stage class thus, only a small percentage of individuals from the sapling/seedling stage make it to the next stage class. To determine which hypothesis is correct it would be beneficial to create a transition matrix for these species. Matrix models allow researchers to evaluate the changes in a population over time, through stage/size classes. These models help to predict which stage classes will increase and which will decrease over time (Silvertown 1982). Utilization of these models would help to determine whether green ash and red elm are going to become abundant in the canopy or whether the earlier stage/size classes die out before reaching the canopy. It is important to study the demographics because it can predict community structure changes. In the future, if the demographic data remains similar to its current composition, then the forest of the DUBR might be at its climax. However, dramatic changes in demographics would indicate that the forest is still progressing through successional development.

In the Alrutz and Taylor-Ochs sections, flowering dogwood was present mainly in the subcanopy stage (Table 4 and 6). However, flowering dogwood was absent to rare in the sapling/seedling stage class. Two non-exclusive hypotheses may explain why

flowering dogwood is declining in abundance in the forests of the DUBR. Flowering dogwood's longevity may be being hindered by a canker disease (Peattie 1964). Alternatively, honeysuckle and multiflora rose may be crowding out flowering dogwood. Both honeysuckle and multiflora rose were exceptionally abundant in many areas of the reserve. These species can form dense thickets that inhibit the growth of many other species that must compete for light and space (Braun 1961). Because both are exotic, flowering dogwood has not evolved under competitive processes from them. Because flowering dogwood is an important species to wildlife (as a viable food source) (Petrides 1988), and because it is aesthetically pleasing (due to its floral bloom in the spring), it is of value to understand the processes leading to the decline of dogwoods in the forests of the DUBR. This raises a question of whether a maintenance program should be created to remove introduced and over-abundant honeysuckle and multiflora rose to ensure the future of flowering dogwood. However, it is possible that flowering dogwood is simply not replacing itself due to other environmental factors. Monitoring of stage/size classes will enable researchers to create transition matrices to monitor the status of flowering dogwood in the reserve. These matrices might determine at which stages flowering dogwood is being lost. This information would prove useful for a flowering dogwood maintenance program.

Many species of woody plants grow best on certain soil types. Some soils types can even prevent certain species from establishing themselves (Burns and Honkala 1990). While the DUBR's soil type is generally a silt loam, some variation does occur among soil types within the reserve (Parkinson et. al. 1992). Mapping woody plant locale on to the soil types of the reserve is beneficial for determining the distribution of the woody plants within the reserve. Correlation of this information could help to predict the successional patterns of the woody plant community of the DUBR. It would also be beneficial to include into any study of the demographics of the reserve's woody plants.

Conclusion

The woody plant community in each section of the DUBR should be considered as one single community. The resulting forest community should be considered a maple-mixed mesophytic forest community because maple is the dominant canopy species while a number of other hardwoods occupy smaller roles in the canopy. The stage/size class information suggests that maple will maintain itself in the canopy. However, the examination of other potential canopy species leads to the conclusion that the species that are currently abundant in the canopy might change in the near future.

Issues centering on succession are important for determining the changes that can be expected for the forest community of the DUBR. To accurately monitor succession, demographic cohort data must be collected. Individuals of beech, red maple, green ash, black cherry, black walnut, and flowering dogwood should be marked and their growth progression monitored in each of three life stages: sapling/seedling, subcanopy, and canopy. Results from such monitoring would enable predictions to be made concerning the successional dynamics of the forest community at the DUBR. Coordinating the soil composition of the DUBR with the woody plant species location would benefit future researchers in determining which species grow more abundantly on a particular soil type. This examination would help determine whether soil factors play a major role in determining community structure at the DUBR.

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Glossary Of Terms

Allelotoxin. A chemical that inhibits the growth plants.

Apomixis. The production of seeds without fertilization.

Axils. The angle above a leaf or the angle between a leaf and a stem.

Bipinnately compound. A compound leaf that is twice pinnate.

Diaphragm. A partition or dividing membrane, as seen at the nodes of grapes.

Dioecious. Flowers on an idividual are either male or female, but not both.

Diploid. An organism containing two sets of chromosomes derived from an egg and a sperm. Typically, the basic number of chromosomes in the nuclei.

Drupes. A fleshy fruit with the seed enclosed in a hard stoney covering.

Exfoliating. Peeling or separating in thin plates or shreds.

Fimbriate-pectinate. Fringed and comb-like.

Gall. Growth of cells caused by some type of gall forming organism.

Heartwood. The hard, inner cylinder of a woody stem, consisting of dead wood.

Hip. The hypanthium of a rose species.

Hypanthium. An expansion of the receptacle.

Lancelate. Leaf that is much longer than it is wide; like a lance.

Leaflets. One part of a compound leaf; resembles a true leaf.

Mucilaginous. "Slime" producing characteristic of a plant.

Node. The part of a stem where leaves are borne.

Opposite. Two leaves at a node.

Palmately compound. A compound leaf whose leaflets radiate from a common point; resembles the digits of a human hand.

Pedicels. The stalk of an individual flower.

Perennial. Occurring yearly.

Petioles. The stalk of a leaf.

Prickles. A sharp outgrowth derived from epidermal cells.

Pubescence. Covered with hairs.

Sessile. Not stalked.

Sinuses. The spaces between lobes of a leaf.

Spines. A sharp woody outgrowth derived from vascular tissue; same as thorn.

Stipules. Outgrowths at the base of the petiole.

Styles. The long part of a pistil (female reproductive structure in flowers) between the stigma and the ovary.

Subopposite. Nearly two leaves at a node; almost opposite.

Tendrils. Coiling/grasping structures modified from leaves or leaflets.

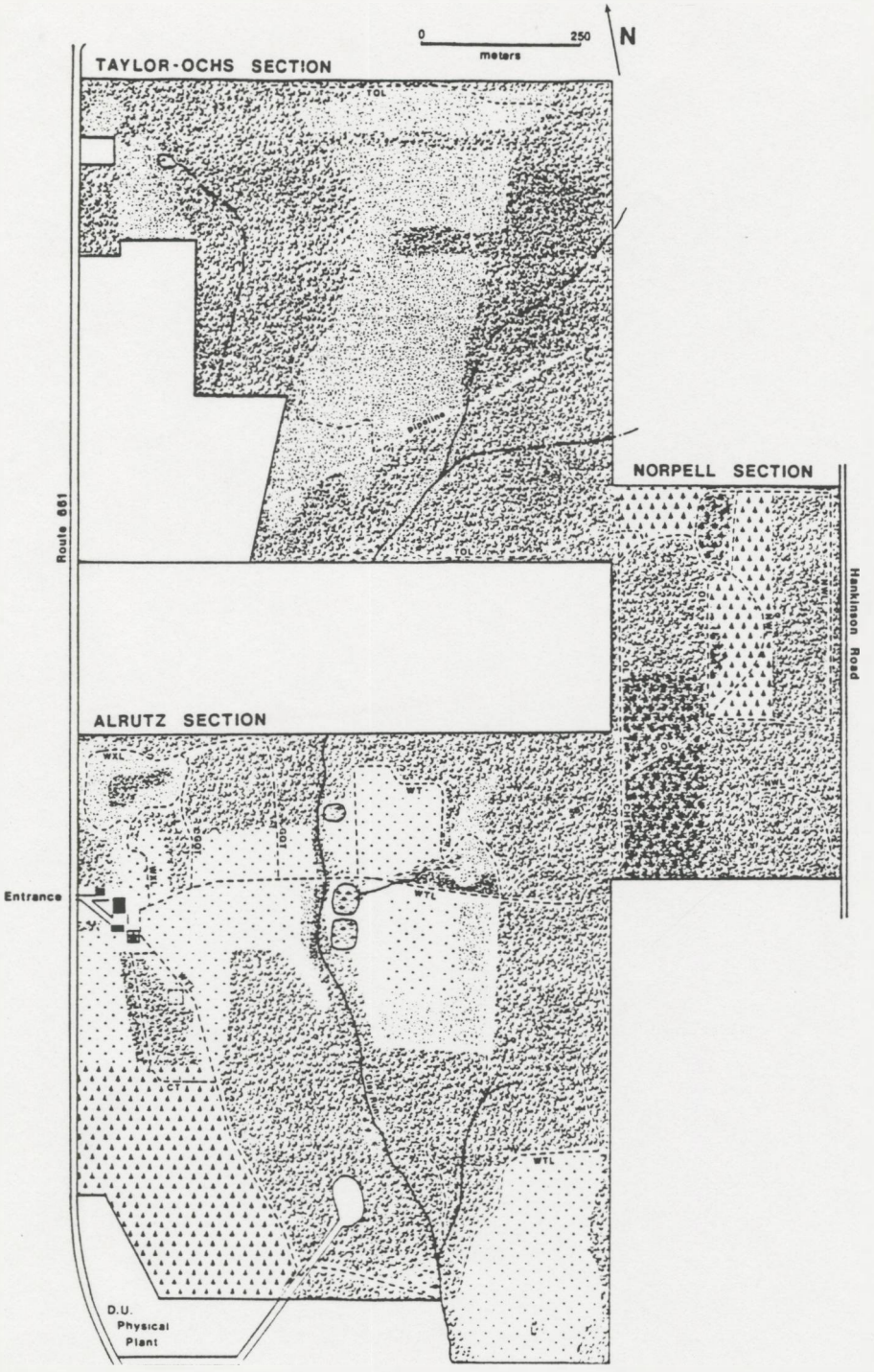
Terminal clusters. Clusters of flowers, fruits, or buds at the end of a stem.

Thorns. A spine.

Triploid. Having three sets of chromosomes; one-third more than the normal number in a typical nucleus.

Veinlets. Small vascular bundles in a leaf; synonymous with veins.

Map 1. A map of the three sections of the Denison University Biological Reserve. The three sections are Alrutz, Norpell Woods, and Taylor-Ochs.



Map 2. A map showing the division of each section of the Denison University Biological Reserve into subsections. Each subsection within a section is numbered 1-20.

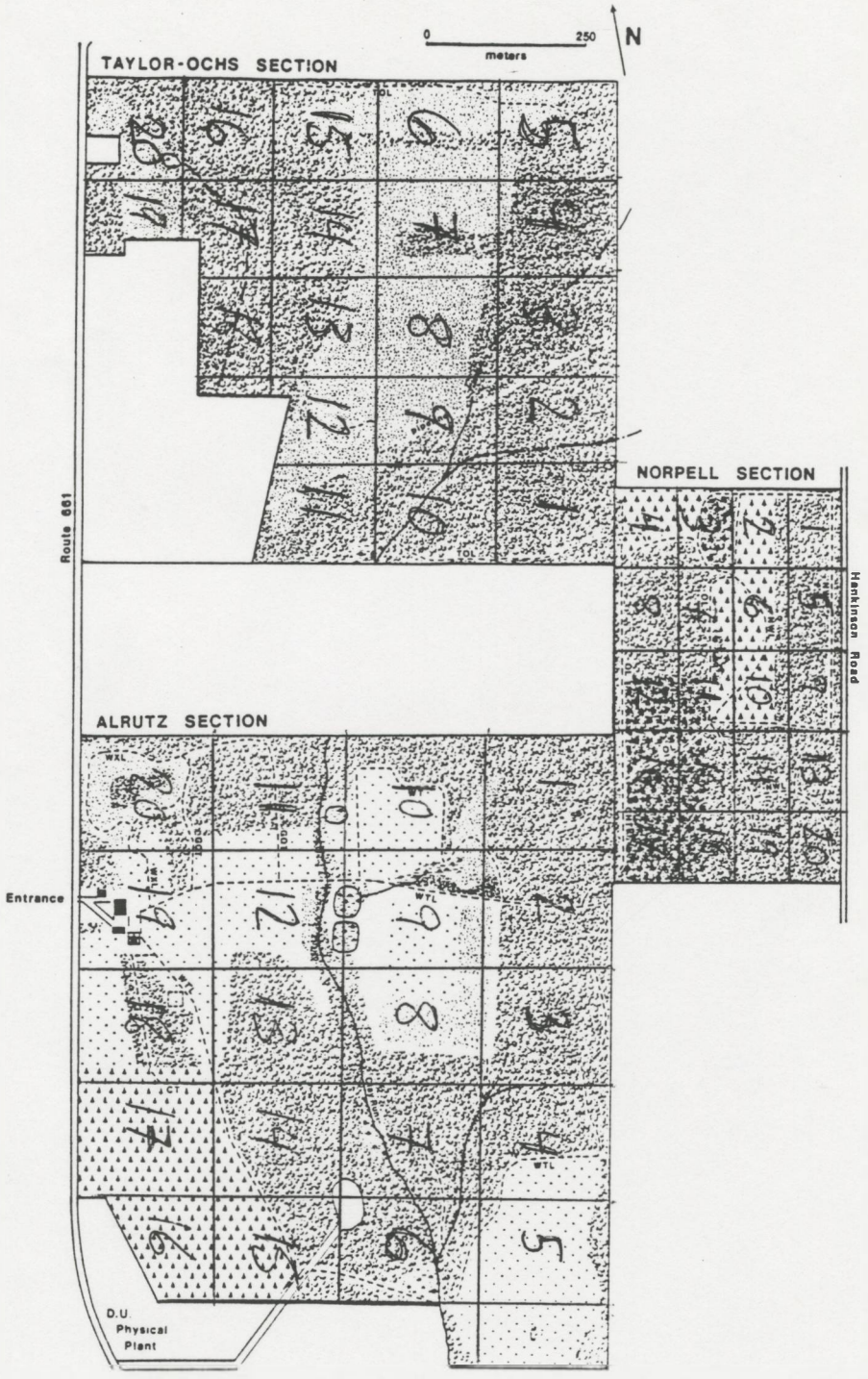


Table 1. Each section of the reserve is divided into 20 subsections. The distance between quadrats is the same as the length and width of a subsection. The lower right corner of each subsection marks the starting point for an individual quadrat.

Section	Length of Subsection	Width of Subsection
Alrutz	170 meters	165 meters
Norpell Woods	125 meters	100 meters
Taylor-Ochs	150 meters	135 meters

Table 2. The results for the diversity indices for the Alrutz, Norpell Woods, and Taylor-Ochs sections of the reserve and t-test comparing diversity indices between sections. T-test values greater than 2.58 indicate a P-value less than 0.05. A = Alrutz; N = Norpell Woods; T = Taylor-Ochs.

Statistical Test	Alrutz	Norpell	Taylor-Ochs	A vs. N	A vs. T	N vs. T
Margalef Index	14.07	11.97	12.74	-----	-----	-----
Shannon Index	1.27 ± 0.0084	1.12 ± 0.0075	1.19 ± 0.0073	-----	-----	-----
Variance (s^2)	0.000071	0.000056	0.000054	-----	-----	------
T-test	-----	-----	-----	13.64	7.27	7.00
df	-----	-----	-----	6940	6582	8768

Table 3. Community similarity indices. The Jaccard Coefficient evaluates community similarity based on the total number of species found and which species were in common. Horn index values (R_0) closer to 1.0 indicate 100% similarity between two sections.

Index	Alrutz vs. Norpell	Alrutz vs. Taylor	Norpell vs. Taylor
Species in Common	35 species	35 species	36 species
Jaccard Coefficient	58.3%	56.5%	64.3%
Horn Index (H_3)	1.22	1.25	1.19
Horn Index (H_4)	1.47	1.52	1.45
Horn Index (H_5)	1.18	1.22	1.15
Horn Index (R_0)	0.86	0.90	0.87

Table 4. Abundance (percent) of potential canopy species in the Alrutz section. The three size categories are based on diameter at breast height (dbh) measurements. Miscellaneous species include black willow, basswood, hickory sp., catalpa, honey locust, hackberry, sycamore, and tuliptree.

Species	Seedling/Sapling < 1 cm dbh	Sub-canopy 1-10 cm dbh	Canopy > 10 cm dbh
Black Cherry	1.3	5.1	9.8
Black Walnut	0.0	1.9	8.3
Bitternut	5.4	1.9	1.5
Buckeye	0.0	22.2	0.0
Flowering Dogwood	0.0	5.7	1.5
Green Ash	17.3	1.9	2.3
Red Elm	22.7	1.9	0.8
Red Maple	2.3	10.8	4.5
Red Pine	0.0	0.0	8.3
Sugar Maple	39.2	20.3	20.5
Sassafras	1.7	1.3	1.5
White Ash	6.8	8.2	4.5
White Elm	0.8	10.1	6.8
White Pine	0.0	0.0	16.7
Miscellaneous	2.5	8.7	13.0

Table 5. Abundance (percent) of potential canopy species in the Norpell Woods section. The three size categories are based on diameter at breast height (dbh) measurements. Miscellaneous species include black walnut, box-elder, Norway spruce, red pine, and sweetgum.

Species	Seedling/Sapling < 1 cm dbh	Sub-canopy 1-10 cm dbh	Canopy > 10 cm dbh
Black Cherry	1.0	2.7	8.4
Black Oak	0.7	1.3	0.8
Beech	0.7	12.8	0.8
Bitternut	6.3	0.0	0.8
Green Ash	40.0	10.7	6.9
Hackberry	.03	2.7	0.0
Hop-Hornbeam	0.8	2.0	0.0
Ironwood	0.4	0.7	0.0
Red Elm	12.5	4.0	3.1
Red Maple	1.1	4.0	0.8
Red Oak	0.5	0.0	0.8
Sugar Maple	20.2	40.3	14.5
Sassafras	5.8	0.0	1.5
Tuliptree	0.2	0.0	24.4
White Ash	5.5	6.7	2.3
White Elm	2.2	6.7	9.9
White Pine	0.05	0.7	13.0
Miscellaneous	0.95	4.7	12.0

Table 6. Abundance (percent) of potential canopy species in the Taylor-Ochs section. The three size categories are based on diameter at breast height (dbh) measurements. Miscellaneous species include black locust, black walnut, butternut, hackberry, Osage-orange, red maple, red oak, and shagbark hickory.

Species	Seedling/Sapling < 1 cm dbh	Sub-canopy 1-10 cm dbh	Canopy > 10 cm dbh
Black Cherry	1.4	3.6	24.5
Black Oak	1.1	0.7	0.0
Beech	2.2	4.7	2.7
Bitternut	4.2	1.1	0.9
Flowering Dogwood	0.6	15.0	4.5
Green Ash	28.0	9.9	6.4
Hop-Hornbeam	1.8	0.4	0.0
Ironwood	1.0	0.4	0.9
Red Elm	10.3	1.1	4.5
Sugar Maple	32.9	43.1	8.2
Sassafras	9.1	2.9	11.8
Tree-of-Heaven	1.1	0.7	0.0
Tulip	1.0	0.4	0.9
White Ash	3.8	3.3	10.9
White Elm	0.2	6.6	7.3
Miscellaneous	1.3	6.1	16.5

Figure 1. Species-area curve for Alrutz. Every 100 square meters equals one quadrat.

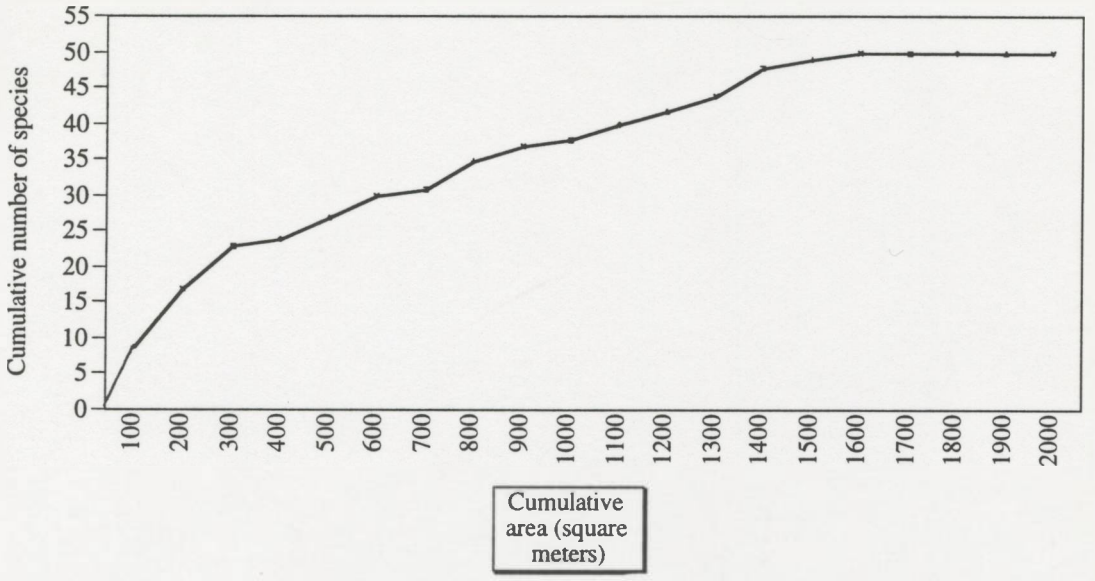


Figure 2. Species-area curve for Norpell Woods. Every 100 square meters equals one quadrat.

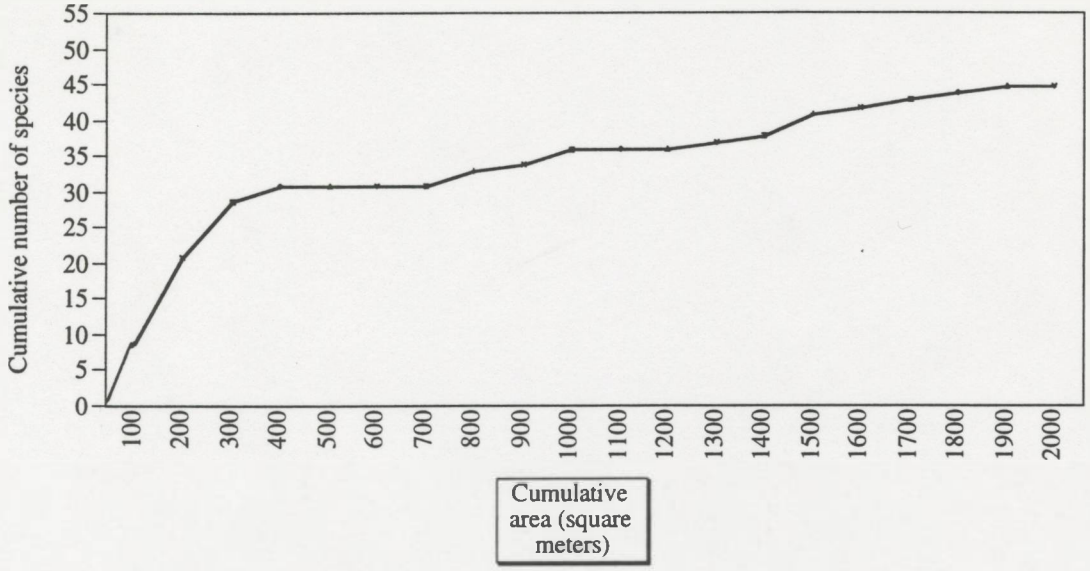
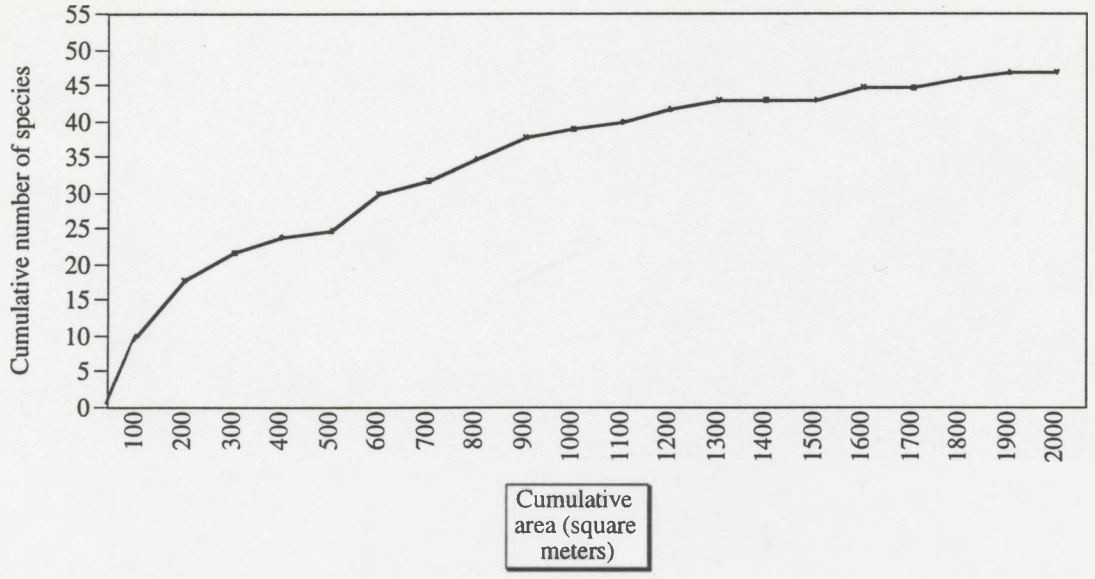


Figure 3. Species-area curve for Taylor-Ochs. Every 100 square meters equals one quadrat.



Appendix. Species found in each section of the reserve. X indicates presence; O indicates absence.

Species	Alrutz	Norpell	Taylor-Ochs
Alternate Dogwood	X	X	O
Arrowood	O	X	O
Black Ash	O	X	O
Black Cherry	X	X	X
Black Locust	X	X	O
Black Oak	X	X	X
Black Walnut	X	X	X
Black Willow	X	O	O
Barberry	X	X	X
Basswood	X	O	O
Beech	X	X	X
Bitternut	X	X	X
Bittersweet (American)	O	O	X
Bittersweet (Oriental)	O	O	X
Blackberry	X	X	X
Box-Elder	X	X	X
Buckeye	X	O	O
Butternut	O	O	X
Catalpa	X	O	O
Crabapple	O	O	X
Flowering Dogwood	X	X	X
Green Ash	X	X	X
Greenbriar	X	O	X

Greenbriar (Bristly)	X	X	X
Gooseberry	X	X	X
Hackberry	X	X	X
Hawthorn sp.	O	X	O
Hickory sp.	X	X	X
Honey Locust	X	O	O
Honeysuckle (European)	X	X	X
Honeysuckle (Japanese)	X	O	X
Hop-Hornbeam	O	X	X
Ironwood	O	X	X
Multiflora Rose	X	X	X
Moonseed	O	X	X
Norway Spruce	O	X	O
Osage Orange	O	X	X
Pawpaw	O	O	X
Poison Ivy	X	X	X
Privet	X	X	X
Red Elm	X	X	X
Red Maple	X	X	X
Red Oak	X	X	X
Red Pine	X	X	O
Raspberry	X	X	X
Redbud	O	X	O
Running Strawberry	X	O	X
Sassafras	X	X	X
Serviceberry	X	O	O
Shagbark	X	O	X

Sourgum	O	O	X
Strawberry Bush	X	O	O
Spice Bush	X	X	X
Sugar Maple	X	X	X
Sumac (Smooth)	X	O	O
Sweetgum	O	X	O
Sycamore	X	O	O
Tree-of-Heaven	O	O	X
Tulip	X	X	X
Trumpet Creeper	X	O	O
Unidentified	X	O	O
Virginia Creeper	X	X	X
White Ash	X	X	X
White Elm	X	X	X
White Oak	O	O	X
White Pine	X	X	O
Wild Grape (Frost)	X	X	X
Wild Grape (Riverbank)	X	X	X
TOTAL # OF SPECIES	50	45	47