Executive Summary

Environmental Management Study for

WINTERTHUR

Museum, Garden & Library

New Castle County, Delaware

NATURAL
LANDS
TRUST

with

Patricia Ann Quigley, Inc.

and

Hyla Associates

February 2000

Acknowledgements

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Winterthur is an American garden and grounds representing a naturalistic style of landscape design based on the rural landscape of the Brandywine Valley. It is of cultural and botanical interest as it is the repository of many of the finest plants available during the first half of the twentieth century, and it reflects an American horticulturist's interest in the ideas of "wild gardening" adapted from Britain to an American setting. Winterthur, an historic garden and grounds of national importance and international concern, represents an example of an American country place and garden and grounds created by an individual of exceptional talent and taste. …

Winterthur is committed to conserving the former estate and residence of Henry Francis du Pont, who created a major museum of American decorative arts, display gardens embodying his concept of artistic gardening and grounds. The museum and gardens and grounds are interrelated as a totality and are connected by a common thread of taste, design, style, and color. The Board of Trustees recognizes that Winterthur is unique among American educational institutions open for the enjoyment of the public. The original design of the gardens and grounds has been substantially retained over the years. It is Winterthur's policy to conserve this design for posterity, while recognizing the elements of change inherent in living organisms. …

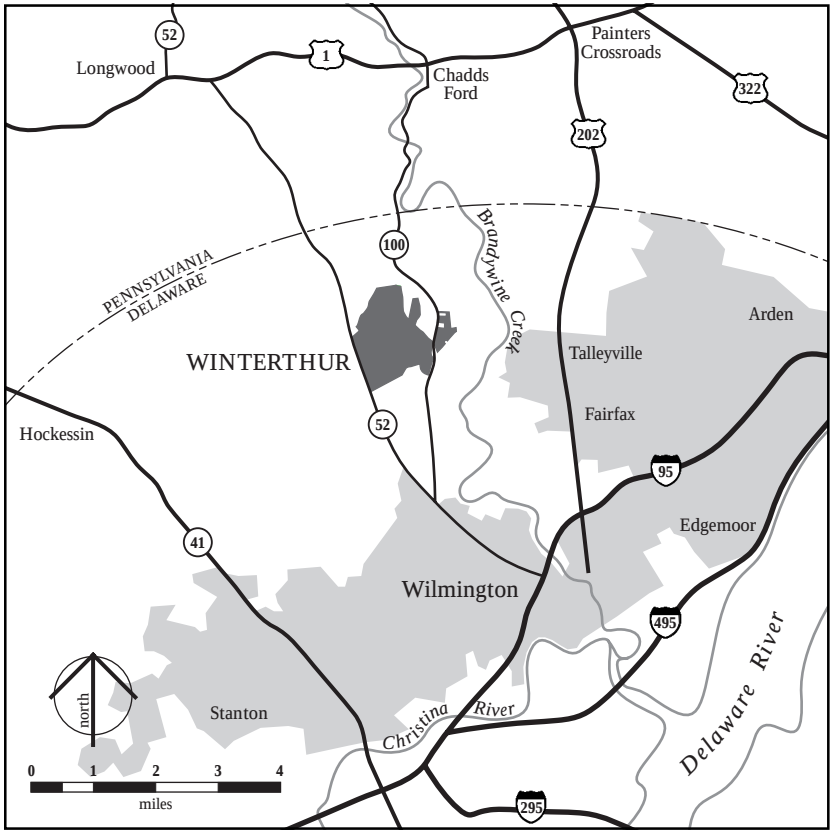
Winterthur pursues a policy of professional management capable of making horticultural, conservation, maintenance, and related decisions commensurate with the rarity and complexity of the gardens and grounds. This policy assures that Winterthur can take advantage of future opportunities which may arise in the continued development and appreciation of its historic resources.

The Board of Trustees recognizes that its gardens and grounds are an educational resource for the public. It is Winterthur's policy to interpret the gardens and grounds to the public. This interpretation should foster a greater understanding and appreciation of landscape design, plant combinations and garden history. The Board is committed to making the garden and grounds as fully open and accessible to the public as resources allow. …

From the Board of Trustees Policy and Guidelines for Winterthur's Gardens and Grounds, May 1987

Executive Summary

FIGURE 1: Location Map



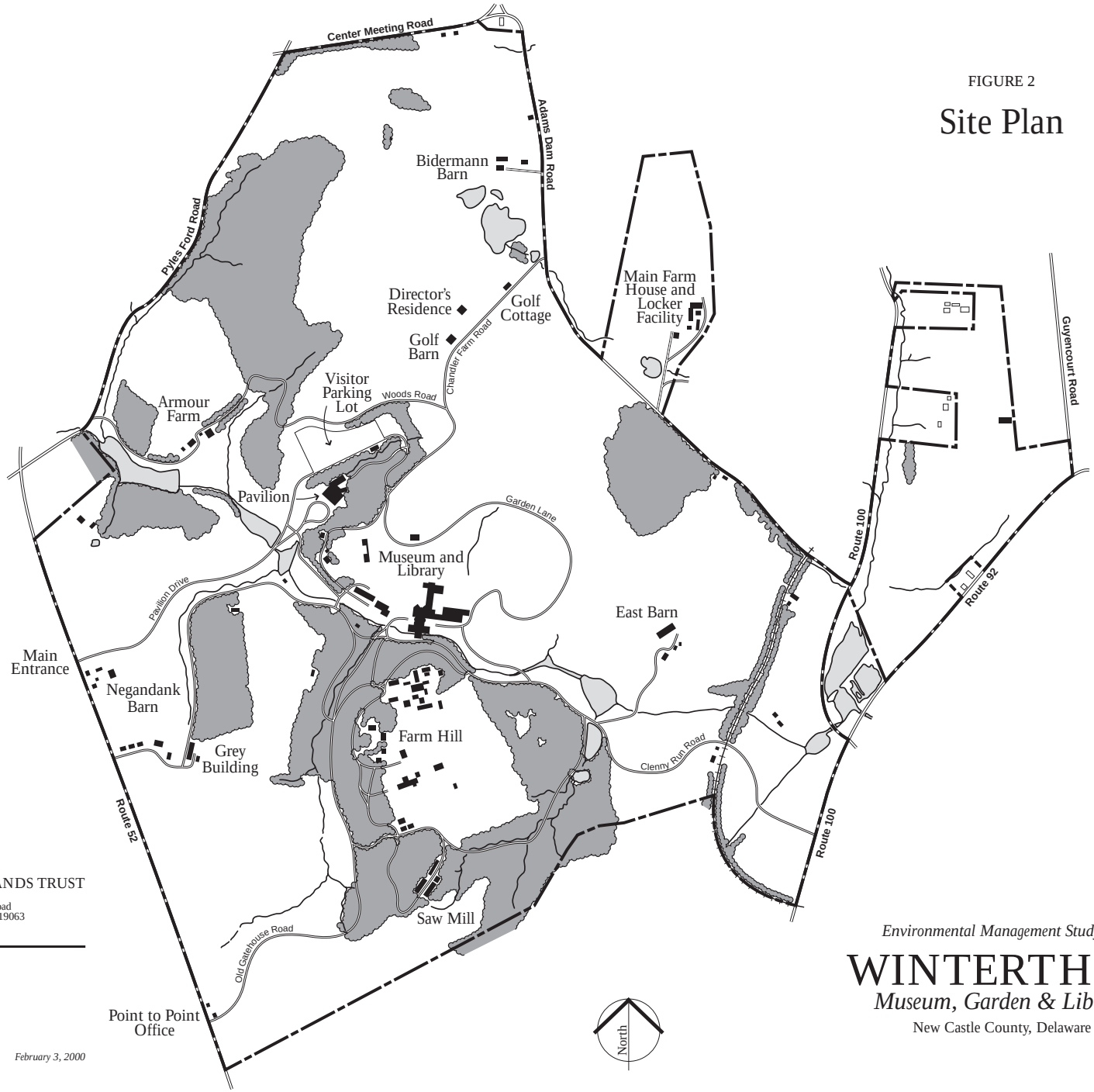
INTRODUCTION

Winterthur Museum, Garden and Library, the former country estate of Henry Francis du Pont (1880–1969), is a ±966 acre property located approximately five miles northwest of the city of Wilmington in New Castle County, Delaware (see Figures 1 and 2). The property features a museum filled with du Pont's collection of American decorative arts made or used in America between 1640 and 1860; a 60-acre naturalistic garden, considered one of the world's finest, that represents the artistic vision of it's creator, H. F. du Pont; and a research library for the study of American art and material culture.

Meadows, woodlands, hedgerows, and ponds and streams comprise almost 70% of the Winterthur property. The steeply rolling topography is covered with native grass meadows and primarily native hardwood forests, many of which can be classified as old growth (>150 years old). Clenny/Wilson Run flows eastward through the property to the Brandywine Creek and

FIGURE 2

Site Plan



Environmental Management Study for

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New Castle County, Delaware

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February 3, 2000

creates the primary feature of the property, a stream valley with steep sides and a series of six ponds. The diversity of wildlife inhabiting Winterthur is relatively high including a number of species of special concern, those that are rare or uncommon and/or threatened within the state.

Winterthur is committed to being a good steward of the land and to fostering a greater understanding and appreciation of our environment. As a result of that commitment, in October 1996, Natural Lands Trust, along with Patricia Ann Quigley, Inc. and Hyla Associates, was engaged to prepare an Environmental Management Study for the property. The purpose of the study is to develop and implement a stewardship plan which will assure that future management, events, and site development will be conducted in an environmentally responsible manner. Winterthur's short term goal for the study is to inventory the environmental resources and review current management practices. The long term goals include using the study as an educational tool, as a baseline for future measurement of the health and quality of the environment, and as a guide for future site development.

Natural Lands Trust's approach to the study was to gain a thorough understanding of the site, its potential, and current management practices, capabilities, and problems, and then develop a stewardship plan that will serve as a long term guide to the future use and management of Winterthur. NLT, along with Patricia Ann Quigley, Inc. and Hyla Associates, conducted an inventory of the biological and physical resources of the property from the fall of 1997 through fall of 1998. Interviews and site visits were held with key personnel to review current management practices and to obtain their input. Work sessions were also held with various staff to discuss existing and potential programmatic uses of Winterthur.

INVENTORY AND ANALYSIS

Biological Resources

Flora

The woodland areas at Winterthur are dominated by hardwood forests, many of which can be classified as old growth (>150 years old). Like most of the mature forests in this area the woodlands occupy those sites that were inappropriate (too steep or wet) for agriculture. Unlike most of the region's forests, the woodlands at Winterthur did not suffer major disturbance (clearcutting, hurricane) over the last one and a half centuries. The result was the creation of a magnificent canopy of large oak, tuliptree, and beech.

The canopy of the woodlands is dominated by native species: oak *(Quercus* spp.*),* American beech *(Fagus grandifolia),* and tuliptree *(Liriodendron tulipifera).* Native species, primarily American beech and some black gum *(Nyssa sylvatica),* red maple *(Acer rubrum),* and hickory *(Carya* spp.*),* also dominate the understory. Norway maple *(Acer platanoides),* an introduced invasive species, is becoming established in the understory of most forested areas and is now the dominant understory species in Browns Woods. The shrub layer is generally sparse and dominated by viburnums *(Viburnum* spp.*),* both native and introduced. Jetbead *(Rhodotypos scandens),* another introduced invasive species, is becoming established in the shrub layer. The herbaceous layer throughout most of the woodlands is sparse.

These woodlands show signs of the degradation which plagues this region's forests. Invasive vegetation, including species from the formal gardens, are well established in the understory.

Regeneration of native tree, shrub and herbaceous species are spotty at best, a result of both competition from exotic vegetation and consumption by white-tailed deer. This raises serious concern for the perpetuation of the existing woodlands.

Hedgerows function as corridors for wildlife to move between woodland patches. Unfortunately, with the introduction of invasive plants, they have become ideal edge habitat for the proliferation of these species. Invasive vines such as Japanese honeysuckle, Oriental bittersweet, and grape thrive along hedgerows and woodland edges where they receive direct sunlight and physical support from the trees. Invasive shrubs such as the shrub honeysuckles and multiflora rose often join these vines.

The hedgerows at Winterthur are chiefly along roads and the railroad and the impact from invasive vegetation is moderate to heavy throughout. While the canopy trees are mostly native, they are experiencing the same lack of native tree, shrub and herbaceous species regeneration as the woodlands.

Meadows (including wet/riparian areas) are the dominant vegetation type at Winterthur. The dominant species in the meadows is the native grass broom-sedge *(Andropogon virginicus)*. Most of the meadows contain a high degree of native herbaceous vegetation, due primarily to the regular mowing schedule. The upland meadows are presently in hay production, with either one or two cuttings each year, and the wet meadows are not hayed but are rotary mowed annually. Some areas, especially those now being allowed to succeed to woodlands, are moderately to severely impacted with invasive species.

Fauna

Field surveys of amphibians, reptiles, birds, mammals, butterflies, dragonflies, and damselflies were conducted on foot, aided by the use of binoculars and spotting scope. Species were identified by visual observation, sound (e.g., frog and bird calls), and signs (e.g., tracks). In addition, live traps (have-a heart and Sherman) were used to capture small mammals and hand nets were used to capture dragonflies. Species of "special concern," those designated by the Delaware Natural Heritage Program as being of 1st, 2nd, or 3rd priority ranking for protection out of 5 ranking categories, were noted.

Overall, the diversity of fauna at Winterthur is good, especially in the woodlands where it appears relatively high. Species of special concern that were observed on the property include:

Amphibians and Reptiles - Northern Red Salamander and Queen Snake

Birds - Great Blue Heron, Great Egret, Black Vulture, Osprey, Bald Eagle, Northern Harrier, Cooper's Hawk, Broad-winged Hawk, American Kestrel, Herring Gull, Common Nighthawk, Hairy Woodpecker, Pileated Woodpecker, White-breasted Nuthatch, Brown Creeper, Veery, Warbling Vireo, Northern Parula, Chestnut-sided Warbler, Black-and-white Warbler, American Redstart, Kentucky Warbler, Hooded Warbler, Yellow-breasted Chat, Chipping Sparrow, and Eastern Meadowlark

Mammals - Red Bat and Red Squirrel

One uncommon species, the Appalachian Azure butterfly, was found to be fairly common in the Azalea Woods portion of the Gardens Area. Although not listed by the Delaware Natural

Heritage Program as a species of special concern, the Appalachian Azure has only been found in one other location in Delaware. Several larvae were found on their host plant, black cohosh.

Aquatic Resources

Aquatic resources within Winterthur consist of streams, ponds, and wetlands. The property almost fully includes Clenny/Wilson Run, a first to second order tributary of the Brandywine Creek. The segment of the stream that flows through the Winterthur grounds (northwest of Routes 92 and 100) is designated by the State of Delaware Surface Water Quality Standards (February 26, 1993) as "ERES" or waters of exceptional recreational or ecological significance. The watershed is part of the highly valued Brandywine Creek system and is largely undeveloped except for the Winterthur property, several golf courses and low density residential development.

The original hydrology within the property has been altered through dam and stream channel construction, the capping or diversion of natural seeps and springs, the deposition of landscaping waste and rubble into wetlands, and the mowing of stream buffers. The latter has created ideal habitat for Canada geese which further degrade water quality.

Overall, Clenny/Wilson Run supports a moderate diversity of piedmont stream fish. Kick net samples of macroinvertebrates were obtained at five locations along Clenny/Wilson Run, one of which is just downstream of Winterthur in Brandywine Creek State Park. Three of these correspond with established Delaware Department of Natural Resources and Control (DNREC) water quality sampling stations. The stations within the property ranged from man-made stream habitat with very poor water quality to natural stream habitat with fair water quality. The downstream off-site station presented good macroinvertebrate habitat with excellent water quality.

All of the twelve relatively small ponds at Winterthur maintain populations of fish. Grab samples of pond water were obtained at the outflow structures of six ponds: Armour Farm Pond, 11th Tee Pond, Upper Pavilion Drive Pond, Lower Duck Pond, East Barn Pond, and the Routes 100/92 Pond.

Total suspended solids, which relate to turbidity, were below the 10 mg/l detection limit in all ponds except East Barn Pond which displayed 12.0 mg/l. Dissolved oxygen levels were generally favorable except for Armour Farm Pond. pH levels, a measure of aqueous acidity and basicity, were generally favorable except for the 11th Tee and Routes 100/92 Ponds which had slightly elevated (more basic) values. Phosphorus is an important nutrient for plant growth, but excessive levels can cause increased algal or macrophyte growth leading to pond eutrophication. Total phosphorus levels were favorable except for East Barn Pond which slightly exceeded the recommended value. Total coliform is a measurement of certain bacteria which are associated with sewage (certain levels of which are always present in healthy aquatic systems). The highest total coliform values occurred within Armour Farm Pond, Lower Duck Pond, East Barn Pond, and the Routes 100/92 Pond. Coliform inputs to the ponds do occur naturally and wide variation in total coliform values is common. However, excessive loadings are occurring through the droppings of resident Canada Geese and probably from off-site septic systems. Chlorophyll a, a plant pigment which converts light energy to chemical energy during photosynthesis, indirectly measures growth, primary productivity, and algal abundance or standing crop. Only the 11th Tee Pond exceeded the level for a healthy non-eutrophic lake or pond.

Due to the large study area, a full-scale point-to-point survey of all regulatory wetlands on the Winterthur grounds was not recommended. To meet the goals of an overall land stewardship plan, it is essential though to have preliminary boundary identification, based on field observations, with detailed observations recorded of the wetland type, dominant species, rare or endangered species, and degree of disturbance. Full-scale surveying of wetland boundaries should be reserved for key areas where potential future facilities development or expansion is considered which may encroach on regulated wetlands.

A diversity of wetland types — swamps, marshes, and ponds — are found at Winterthur. These wetlands occur in association with seeps, streams, and impoundments located in the watershed of Clenny/Wilson Run which drains eastward to Brandywine Creek. Forested wetlands occur where a canopy has remained and wet meadows occur in areas that are periodically mowed. Extensive manipulation of the ground and surface water resources at Winterthur have effected the wetlands. Piping has depleted water from some areas causing wetlands to diminish in area over time while elsewhere, wetter circumstances have been created. Winterthur as a whole has an abundance of water which supports an array of relatively natural wetlands as well as the many lovely, yet unnatural, ponds.

Physical Resources and Features

Geology

Winterthur lies almost completely within the Wissahickon Formation, the dominant rock type in the northwestern geologic Piedmont Province in Delaware. This province, whose name literally means lying at the base or the foot of the mountains, is commonly referred to as “Delaware’s hard rock country.”

The Wissahickon Formation may be greater than 8,000 feet thick and is less resistant to chemical and physical weathering. Thus, deeply incised stream valleys and steep slopes characterize this portion of the basin. Amphibolites and gneisses support ridges while mica schists erode to form deep-sided valleys. The formation has considerable secondary porosity and therefore has capacity to store and transmit groundwater. Although high densities of joints and faults exist in some locations and may be able to support initial groundwater yields of 300 to 400 gallons per minute, groundwater typically yields 10 gallons per minute.

Soils

Winterthur lies with the Glenelg–Manor–Chester soil association. This association is in one large area in the northern and northwestern parts of the county. It consists mainly of gently sloping to moderately sloping soils. On the bottomlands and crests, however, the soils are nearly level, and in some areas above streams they are steep. The major soils in this association are deep, well drained, and micaceous and provide good building sites, though slope is a limitation in places. In most places excavation is not difficult and is not limited by wetness. The soils generally have only slight to moderate limitations to use for sewage disposal by septic tanks.

Topography and Slopes

Winterthur’s topography is very typical of the character of the underlying Wissahickon Formation — deeply incised stream valleys with steep slopes. The primary feature is the main Clenny/ Wilson Run valley running roughly west to east. The ridges to the

north and south of the stream have gentle, 0–8%, slopes on their tops with the side walls typically over 15% with large areas over 25%. The highest elevation is approximately 432 feet, occurring in the northwestern corner of Bidermann Golf Course near the intersection of Center Meeting and Pyles Ford Roads. The lowest elevation, approximately 218 feet, occurs just below the Routes 100/92 Pond for an overall difference of 214 feet.

Existing Land Use

Meadows	± 468 ac.	48%	of total area
Woodlands and hedgerows	± 192 ac.	20%	
Golf course	± 150 ac.	16%	
Gardens, *incl. Pavilion Pine Grove*	± 52 ac.	5%	
Ponds	± 11 ac.	1%	
All other areas	± 93 ac.	10%	
Total	± 966 ac.		

Streams	28,000+ lf / 5.0+ miles
Railroad	3,500+ lf / 0.5+ miles
Roads	75,500+ lf / 14.0+ miles *(±80% are "improved")*

PROGRAMMATIC USES

Current Uses and Events

General admission to Winterthur includes access to the "Garden Area Proper." Maps are available for self-guided walking tours. Also included with the general admission is a 30–45 minute narrated tram ride through the garden and outlying areas of Winterthur. Topics covered include the history of the property and the story of Henry Francis du Pont, as well as aspects of nature, color, and seasonal interests. Guided garden walks are also offered.

Programs offered by the Garden Department have included garden lectures, horticultural and design symposiums featuring national and international experts and speakers, and the "Successful Gardener Series," a series of hands-on workshops for the home gardener.

Special events have included "Picnicking Under the Cherry Blossoms," "Easter in the Garden," a family event, a "Plant Extravaganza" with experts available to answer questions, talks, guided garden walks, and plants and books available for purchase, and the annual Point-to-Point Races and Craft Festival. The Point-to-Point Races are held on the first Sunday in May each year with 20,000 to 24,000 people attending typically. The Craft Festival, which will have its fourth year in 1999, is a 2-day event over the Labor Day weekend with 180 juried craftsmen that attracts over 20,000 people.

Future Uses and Events

Gardens, Programs, and Special Events

The following recommendations for additional or expanded programmatic uses related to environmental issues and concerns have been generated as a result of this study and from internal work sessions of the Winterthur staff.

~ Highlighting native plants throughout the garden

~ Special subject tours including “Birds in the Garden,” “Native Plants in the Garden,” “The Winterthur Estate/Farm,” and “Winterthur’s Natural Areas”

~ Lectures and/or walks on subjects such as birdwatching and fungi identification

~ Workshops on natural areas management and restoration techniques

~ Arbor Day events highlighting native species

~ Azalea Festival events highlighting native species

Trails

The opportunity exists to utilize the natural areas to greatly enhance the recreational and educational experience of Winterthur visitors. A well defined trail system with interpretive materials (brochures, signage) could be used to tell a more complete story of the property, inform visitors of proper management techniques, and provide inspirational views of meadow vistas and the large trees of the woodlands. A potential trail system, divided into three phases, has been proposed for the Winterthur property. The phasing is to allow Winterthur to experiment with increased public use of the natural areas and to evaluate the program throughout its implementation.

Research and Education

The natural areas at Winterthur offer a wide range of research and educational opportunities through which Winterthur, local natural resource managers, and local schools and universities can benefit. Winterthur staff and other resource managers will benefit by receiving information that can assist them in better understanding and managing their natural areas. The academic world gains by having access to relatively secure natural areas with diverse plant communities. In addition, supporting environmental education helps to educate the next generation to the importance of stewardship.

There are three resource management issues associated with research and education programs. The first is the concern for balancing public use policy with the need to protect research and interpretive sites from unintentional damage from property users (hikers) and vandals. Before promoting or increasing passive recreation, it must be ascertained how this will impact current or future research and education activities. The second concern is the potential impact on staff resources that would accompany these activities. While Winterthur has no plans to conduct research or educational projects itself at this point, there will be a need to coordinate and monitor the activities. Increases in staff demands could result in a reduced management level or lost research or educational opportunities. Finally, consideration should be given to possible conflicts with other existing programs such as agricultural leases and deer management.

Conservation Easements

A conservation easement is a legal agreement between a landowner and a conservation organization or government agency that protects land while leaving it in private ownership. The restrictions of the easement, tailored to suit the particular property and landowner's goals, permanently limit a property's uses in order to protect its conservation values. The easement binds all present and future owners of the eased land. A landowner generally donates the easement to a qualified conservation organization or government agency, which in turn ensures that the conditions of the easement are met over time.

Conveying a conservation easement is a way of making a tangible commitment to the preservation of the natural resources, cultural heritage, scenic beauty, and open spaces of a property, and the community in which it lies, for present and future generations. Winterthur is a significant property not only for its size, almost 1,000 acres of which 90% is open, but also for the diversity and health of the natural habitats that occur there. Over time, these lands will become more and more important as development pressures increase and open space and natural areas are lost. The property could also provide valuable information to local resource professionals trying to understand current ecological problems and to prepare for future ones.

The Board of Trustees for Winterthur has already begun to address these issues. The *Policy and Guidelines for the Gardens and Grounds,* May 1987, states that "Winterthur is committed to conserving the former estate and residence of Henry Francis du Pont." The Board also authorized this Study, which has a goal of developing and implementing a stewardship plan to assure that future management, events, and site development will be conducted in an environmentally responsible manner. The logical next step in ensuring this commitment into the future would be for the Winterthur Board of Trustees to consider conveying a conservation easement.

Future Site Development

The first step in identifying suitable areas for future site development is to identify areas which should not be developed. These "preservation areas" contain critical constraining natural features such as wetlands, hydric soils, and steep slopes which make them unbuildable. The next step is to identify "conservation areas" where development could occur, but in a limited manner; areas with fewer development constraints but important natural features. These include features that are still environmentally sensitive, such as soils with a seasonally high water table, moderate slopes, woodlands, and scenic viewsheds, but vary in importance, vulnerability, or fragility. What remains are the areas most suited for development, the "potential development areas."

The Future Site Development plan shows such an analysis of Winterthur. What this mapping does not include though, is scenic viewsheds. The determination of these are very site specific and involve many factors such as historical and cultural significance, botanical interest, and garden design which are outside the scope of this Study. Winterthur staff will need to overlay this information during the planning process for any future site development.

LAND STEWARDSHIP

Winterthur's natural landscape offers an excellent representation of regional physiographic characteristics. Its balance of woodland, meadow, and stream habitats supports a diverse assortment of plant and wildlife species and beautifully compliments the formal horticultural areas. Like the Garden, these natural areas offer a unique menu of management challenges and opportunities. Successfully addressing the challenges and opportunities within such an important natural areas will require a serious, on-going commitment to stewardship based upon a long-term perspective of protecting and enhancing the natural communities and their environmental and ecological benefits.

All stewardship programs should be based upon the conservation priorities of the site. Conservation priorities can be ecological, recreational, historical, or programmatic depending on the context of the site within the local landscape, legal restrictions, the historical use of the property, and the goals of the landowner. Based upon Winterthur's goals and the existing natural resources within and around Winterthur, we recommend establishing the following conservation priorities to guide the management of the natural areas:

ECOLOGICAL:	Water resources of the Clenny/Wilson Run watershed
	Habitat for local wildlife
	Rare and endangered species
HISTORICAL:	Open landscape resulting from the design intent of Henry Francis du Pont
	Landscape design, including scenic views from the Garden
PROGRAMMATIC:	Environmental education for visitors
RECREATIONAL:	Natural environment for visitors and staff
BUDGETARY:	Human resources
	Financial resources

Once conservation priorities are established, a stewardship plan is developed to minimize the internal and external threats to these priorities with the further goal of enhancement.

This chapter provides guidelines on which to develop a detailed stewardship plan. It includes sections on woodlands and hedgerows, meadows, and aquatic resources that outline general recommendations for resource types, give specific recommendations for management units, and provide stewardship guidelines for achieving the recommendations. The stewardship guidelines include sections on vegetation management/restoration, wildlife management, stormwater management, and aesthetics/ hazards. These are based upon the current health of each resource, a review of current management practices, and the goal to protect and enhance the conservation priorities listed above. There are also sections on trail design and maintenance, staffing and equipment, and priorities.

The recommendations offered within this report are based upon current information and technology and land management experience within other natural areas. These recommendations should not be implemented with blind faith in perpetuity. Because of the uniqueness of every property and the fact that we are dealing with evolving natural systems, the management regime should similarly evolve over time as new "bad actors" are identified, land management knowledge and technology change,

and Winterthur's goals are modified. Land stewards need to be aware of both the ubiquitous and site-specific natural processes involved and the potential of existing management techniques, but creative in applying each technique to (and developing new ones for) individual natural areas.

Woodlands and Hedgerows

The woodlands at Winterthur were actively managed until the mid-1950s to produce lumber for in-house use. The current management goal is to maintain them in as natural a state as possible. Aesthetics and hazards are the main concerns, particularly in the areas that receive more public use or scrutiny. Management in all other areas is largely done on an as-needed basis to remove down or hazardous trees and any obstructions to the internal roads. The control of invasive vegetation has not been a management priority.

Given the conservation priorities and the current goals of Winterthur, there needs to be a significant increase in management of the woodland resources. Because of their many environmental, ecological, and human benefits every attempt should be made to sustain the woodlands on the property. Today there are serious threats to that goal. Addressing those issues and facilitating additional public use will require an increased commitment of staff resources.

The perpetuation of any woodland community depends upon the ongoing establishment of tree and shrub regeneration that are sufficient in number to occupy the gaps that are created by natural or human disturbance to the various structural layers (canopy, understory, shrub) within these plant communities. Throughout the woodlands and hedgerows of Winterthur there is a clear deficiency of native tree and shrub regeneration. Given the age of the canopy trees and their increased susceptibility to windthrow, this lack of regeneration raises concerns for the perpetuation of all the existing woodlands and the loss of the genetic material that created these impressive communities. The presence of invasive vegetation further decreases the probability that the future wooded areas of Winterthur will come close to resembling the current woodlands.

The lack of tree and shrub regeneration results principally from competition with invasive vegetation for growing space and an overabundance of white-tailed deer. In order to perpetuate the existing woodlands it will be necessary to aggressively address these problems as soon as possible. If allowed to reach a crisis level, the task of restoration will become formidable. More importantly, valuable ecological and human benefits will be lost for many decades.

General Recommendations

~ Control invasive vegetation through physical removal, chemical application, and the reduction of forest edge.

~ Expand woodland areas to protect water resources, reduce edge, and create wildlife corridors between woodland parcels by releasing designated meadow areas to succession.

~ Eliminate/minimize the practice of removing dead and dying trees.

~ Reduce deer impact through increased harvest levels and protective devices (fencing, tree shelters).

~ Establish 10 x 10 meter exclosures in several woodlands for monitoring and interpreting the deer impact on woodland vegetation.

~ Improve aesthetics/eliminate hazards by cleaning up scattered trash, removing obsolete structures (with no historical, interpretive, or functional value) and materials, and consolidating needed materials (woodchips, soil) in least conspicuous area(s).

~ Address stormwater erosion areas through maintenance and modification of man-made structures and stabilization of terrain and natural streams.

Meadows

Historically, meadows occurred as breaks in the eastern deciduous forest resulting from human and natural disturbances such as clearing for agriculture by native Americans, fire, periodic flooding, insect infestation, and soil conditions (saturated, serpentine) that restricted growth of woody plants. Most meadows, therefore, existed as temporary ecosystems. Without further human or natural disturbance, natural succession would return a meadow to native woodland conditions within 50 to 100 years.

The meadows at Winterthur, like those throughout the East, are the result of the rise and fall of agriculture following European settlement. During the next three centuries all but the most restrictive (wet, steep) lands were cleared to raise crops for the growing eastern cities. As the agricultural center of the country moved south and west during the 20th century, and, more recently, development pressure has increased, much open land (particularly that on marginal soils) has reverted to woodlands or has been converted to housing developments.

The historic agricultural landscape remains at Winterthur by maintaining the open areas as meadows. Indeed, meadows currently make up almost 50% of the property and total almost 470 acres. This unusually large meadow resource provides not only beautiful vistas from the Gardens but significant ecological benefits. Currently the meadows are maintained through a lease agreement with a local farmer who takes two cuttings of mushroom hay each year. Modifying the current management regime could significantly increase the ecological benefits without impacting the Garden vistas.

In general, the meadows are in very good condition compared to most meadows in this region. They are relatively free of invasives and are dominated by native warm-season grasses, particularly broomsedge. Warm-season grasses are desirable because they are preferred as nesting and feeding sites for native animals, including grassland nesting birds. Many of these birds, such as bobolink, Eastern meadowlark, grasshopper sparrow, savannah sparrow, upland sandpiper and bobwhite quail, have declined drastically in recent years due to the loss of habitat from development and changes in farming practices, including earlier mowing times and the extensive use of non-native cool-season grasses for turf and hay.

General Recommendations

~ Delay the timing of haying from early June to the beginning of July to improve habitat for grassland nesting birds (e.g. Eastern Meadow Lark, Grasshopper Sparrow, Field Sparrow, and possibly Bobolink) by allowing adequate time for successful nesting and rearing of young.

~ Harvest only one crop of hay per year instead of two or harvest hay in designated fields on a rotating schedule, cutting each field every other year. This will create tall grass areas in winter that provide winter habitat for grassland birds.

~ Create successional habitats by removing designated meadows from mowing to favor old field dependent species.

~ Install artificial bird nest boxes for species such as Eastern Bluebird and American Kestrel.

~ Develop and maintain a trail system through the upland fields and the restoration areas to allow for routine maintenance, nature study, and passive recreation.

~ Gradually increase the diversity of meadows by planting plugs or overseeding several additional native species including Indian grass, switchgrass, big bluestem and little bluestem.

Aquatic Resources

According to the Delaware Department of Natural Resources and Environmental Control (DNREC), water quality concerns in Clenny/Wilson Run on the Winterthur grounds include periodic algal blooms that occur in the many ponds and which are often transported downstream during storms. In addition, the large and increasing number of Canada geese using the ponds and mowed fields contributes significant nutrient and fecal coliform loading to the aquatic system resulting in eutrophic conditions in the ponds and periodic release of nutrient-rich waters to the Brandywine system. Other concerns noted by DNREC include the lack of riparian buffer or natural edge around the Winterthur ponds and creek edge.

It is clear that although still relatively healthy, the aquatic resources (ponds and stream complex) through the Winterthur portion of the watershed are being stressed and are in danger of becoming permanently degraded if measures are not taken to better manage the lands surrounding them.

General Recommendations

~ Provide more riparian buffers. Establish at least tall grass meadow buffers (preferably shrub and/or tree buffers where appropriate) along all streams and ponds. Establish or expand woodland buffers where they do not impact important viewsheds.

~ Address stormwater erosion areas through maintenance and modification of manmade structures and stabilization of terrain and natural streams.

~ Control invasive vegetation (particularly exotic vines) which prevents natural regeneration or planted trees and shrubs from becoming established. Monitor and control invasives (phragmites, knotweed) which displace native wetland species.

~ Install nest boxes for Wood Ducks and Eastern Screech Owls and basking logs for turtles. Establishing riparian buffers should discourage Canada Geese.

~ Remove cement lining from stream areas and re-establish a more natural, meandering stream channel using bioengineering techniques.

Trail Design and Maintenance

This section provides guidelines for new and existing trails that fall into three types: recreation enhancement, environmental protection, and public use and safety. Specific guidelines and recommendations are provided for trail construction, trail marking, and trail signage.

Staffing and Equipment

Staffing

The natural areas encompass over 70% of the land area at Winterthur, yet there is no personnel dedicated exclusively to their management. Currently, management within these areas is done on an as-needed basis by members of the Horticultural Department as part of their job responsibilities that focus on maintenance of the hardscape (roads, bridges, garden structures) within the Garden and setting up for the Point-to-Point and Craft Fair. While this has served to handle urgent maintenance needs, such as removal of hazardous trees, it has fallen far short in protecting these areas from natural and human degradation. To seriously address existing problems and to realize potential opportunities highlighted within this plan, a greater commitment of staff time will be needed for the management of Winterthur's natural areas.

It is recommended that Winterthur dedicate one staff member to focus exclusively on the management of the natural areas. This person should have an educational background and hands-on experience in natural resource management and environmental education. Responsibilities would include (1) to prioritize and organize restoration and enhancement projects, (2) to coordinate with other staff for time and equipment, (3) to monitor ongoing projects, and (4) to develop and implement an environmental education program to compliment the tours of the formal gardens. This person would also provide a natural resource perspective to review activities proposed by other departments that might impact the natural areas.

Equipment

The staff at Winterthur appears to be well-equipped to effectively handle management needs within the natural areas. Most maintenance and restoration work within the woodlands can be accomplished with small hand tools, a small chainsaw, and a handheld or backpack herbicide applicator. The only specialized equipment would be that needed for meadow restoration and maintenance.

Priorities

This report offers numerous recommendations for the restoration and management of the extensive natural areas of Winterthur. Given the many other on-site priorities of the management staff there is currently insufficient time to address all of these recommendations. Therefore, ***the first priority Winterthur should consider is the dedication of one staff member (or equivalent) to focus exclusively on the management of the natural areas.*** This person would oversee and coordinate the necessary restoration and enhancement projects, monitor ongoing projects, and oversee and coordinate public use and research and environmental education programs.

To assist Winterthur in making the most efficient and effective use of the time and resources available, we are providing a list of overall priorities for work within the natural areas. Initiating these will have the greatest environmental and ecological benefits with the least investment of staff resources. These priorities are based upon current conditions and should be reviewed on a periodic basis as conditions and internal priorities change.

~ *Reduce the local deer population*
Continue efforts to lower the population to encourage native tree and shrub regeneration and protect woodland wildflowers.

~ *Modify the meadow mowing schedule*
Mow only once per year after July 15th and consider mowing only half of the meadows each year to provide better habitat for grassland dependent fauna, particularly birds.

~ *Cut invasive vines on canopy trees*
Protect the existing canopy to help shade invasives and provide a native seed source.

~ *Address stormwater runoff*
Reducing the rate of flow from the main parking lot and from the golf courses will protect on-site soil resources and water resources within and outside of Winterthur.

~ *Reduce ornamental groundcovers*
Eradicate or at least control patches of invasive exotic groundcovers in order to maintain and/or restore the native herbaceous vegetation.

~ *Cut understory invasive trees and shrubs*
Removing these trees will allow more light to penetrate to the forest floor and encourage tree regeneration. It will also reduce the invasive seed source.

~ *Riparian buffer*
Establish at least tall grass meadow riparian buffers (preferably shrub and/or tree buffers where appropriate) along all streams and ponds to improve water quality.

~ *Promote research and education*
Contact local schools and universities and offer the site for appropriate research and education projects. Students and researchers will benefit by having diverse and relatively secure sites and property managers will benefit with an increased understanding of the on-site resources.

~ *Establish public trail system*
Creating an interpretive trail system (starting with Phase I) will provide visitors a contrasting experience to the formal gardens and perhaps garner support for needed management.

Environmental Management Study for

WINTERTHUR

Museum, Garden & Library

New Castle County, Delaware

NATURAL
LANDS
TRUST

with

Patricia Ann Quigley, Inc.

and

Hyla Associates

February 2000

Acknowledgements

This project was funded by the Delaware Department of Natural Resources and Environmental Control, *Project Manager:* Stephen N. Williams, P.G., Whole Basin Coordinator

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1.0 Introduction

1.1 PURPOSE AND GOALS

Winterthur Museum, Garden and Library is committed to being a good steward of the land and to fostering a greater understanding and appreciation of our environment. As a result of that commitment, in October 1996, Natural Lands Trust, along with Patricia Ann Quigley, Inc. and Hyla Associates, was engaged to prepare an Environmental Management Study for the more than 900 acres that make up Winterthur. The purpose of the study is to develop and implement a stewardship plan which will assure that future management, events, and site development will be conducted in an environmentally responsible manner. Winterthur's short term goal for the study is to inventory the environmental resources and review current management practices. The long term goals include using the study as an educational tool, as a baseline for future measurement of the health and quality of the environment, and as a guide for future site development.

1.2 PROJECT BACKGROUND AND SCOPE

Natural Lands Trust's approach to the study was to gain a thorough understanding of the site, its potential, and current management practices, capabilities, and problems, and then develop a stewardship plan that will serve as a long term guide to the future use and management of Winterthur. NLT, along with Patricia Ann Quigley, Inc. and Hyla Associates, conducted an inventory of the biological and physical resources of the property from the fall of 1997 through fall of 1998. Interviews and site visits were held with key personnel to review current management practices and to obtain their input. Work sessions were also held with various staff to discuss existing and potential programmatic uses of Winterthur.

1.3 SITE DESCRIPTION

Winterthur, the former country estate of Henry Francis du Pont (1880–1969), is a ±966 acre property located approximately five miles northwest of the city of Wilmington in New Castle County, Delaware (see Figures 1 and 2). The property features a museum filled with du Pont's collection of American decorative arts made or used in America between 1640 and 1860; a 60-acre naturalistic garden, considered one of the world's finest, that represents the artistic vision of it's creator, H. F. du Pont; and a research library for the study of American art and material culture.

Meadows, woodlands, hedgerows, and ponds and streams comprise almost 70% of the Winterthur property. The steeply rolling topography is covered with native grass meadows and primarily native hardwood forests, many of which can be classified as old growth (>150 years old). Clenny/Wilson Run flows eastward through the property to the Brandywine Creek and creates the primary feature of the property, a stream valley with steep sides and a series of six ponds. The diversity of wildlife inhabiting Winterthur is relatively high including a number of species of special concern, those that are rare or uncommon and/or threatened within the state.

FIGURE 1: Location Map

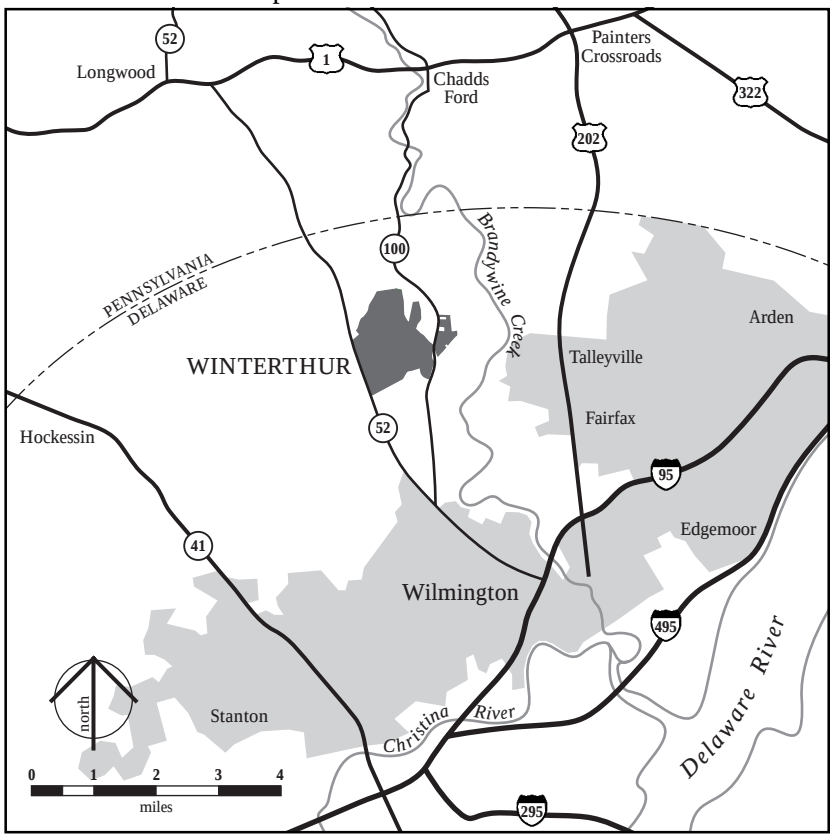
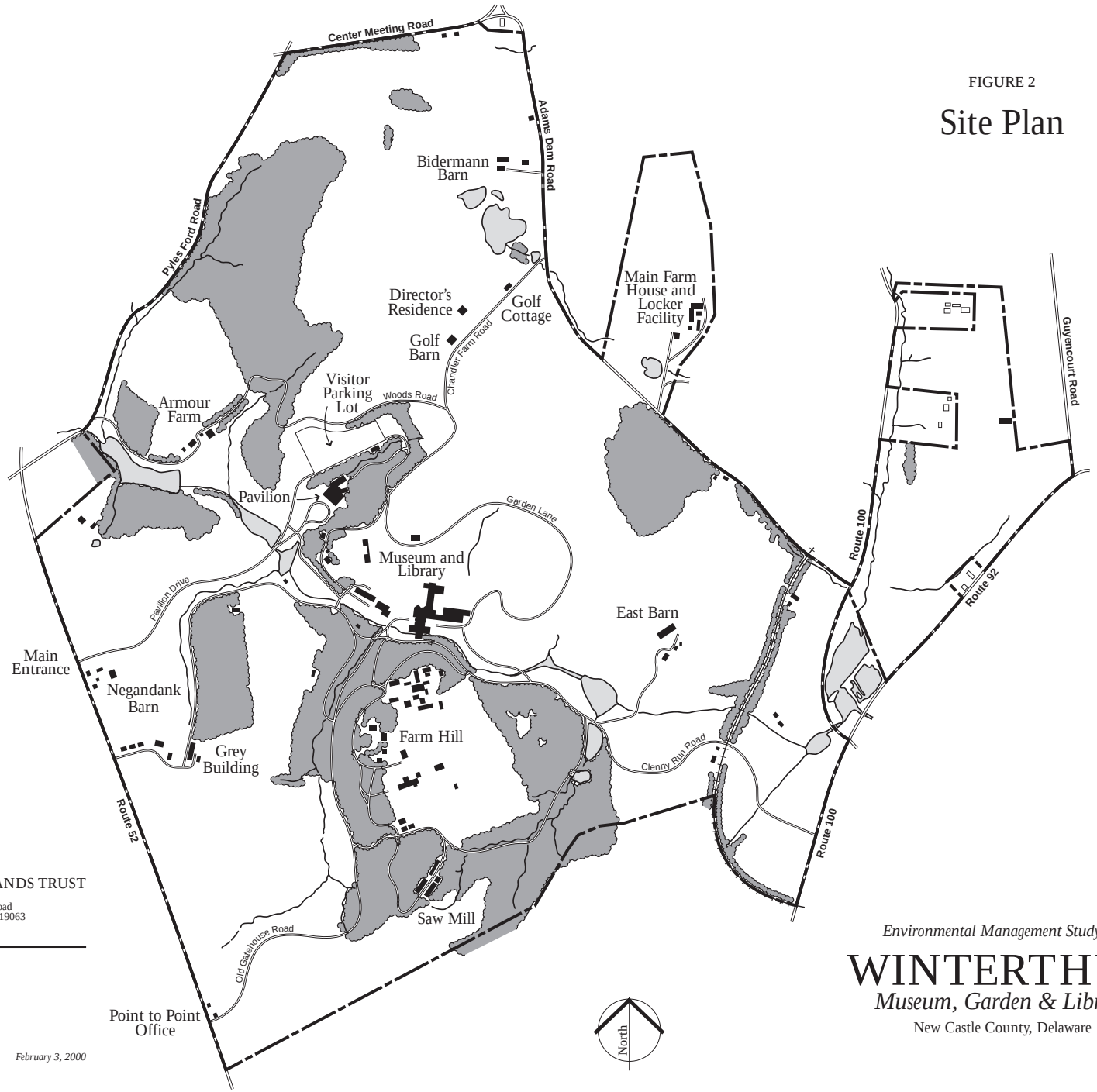


FIGURE 2

Site Plan



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February 3, 2000

Environmental Management Study for

WINTERTHUR
Museum, Garden & Library
New Castle County, Delaware

2.0 Inventory and Analysis

2.1 BIOLOGICAL RESOURCES

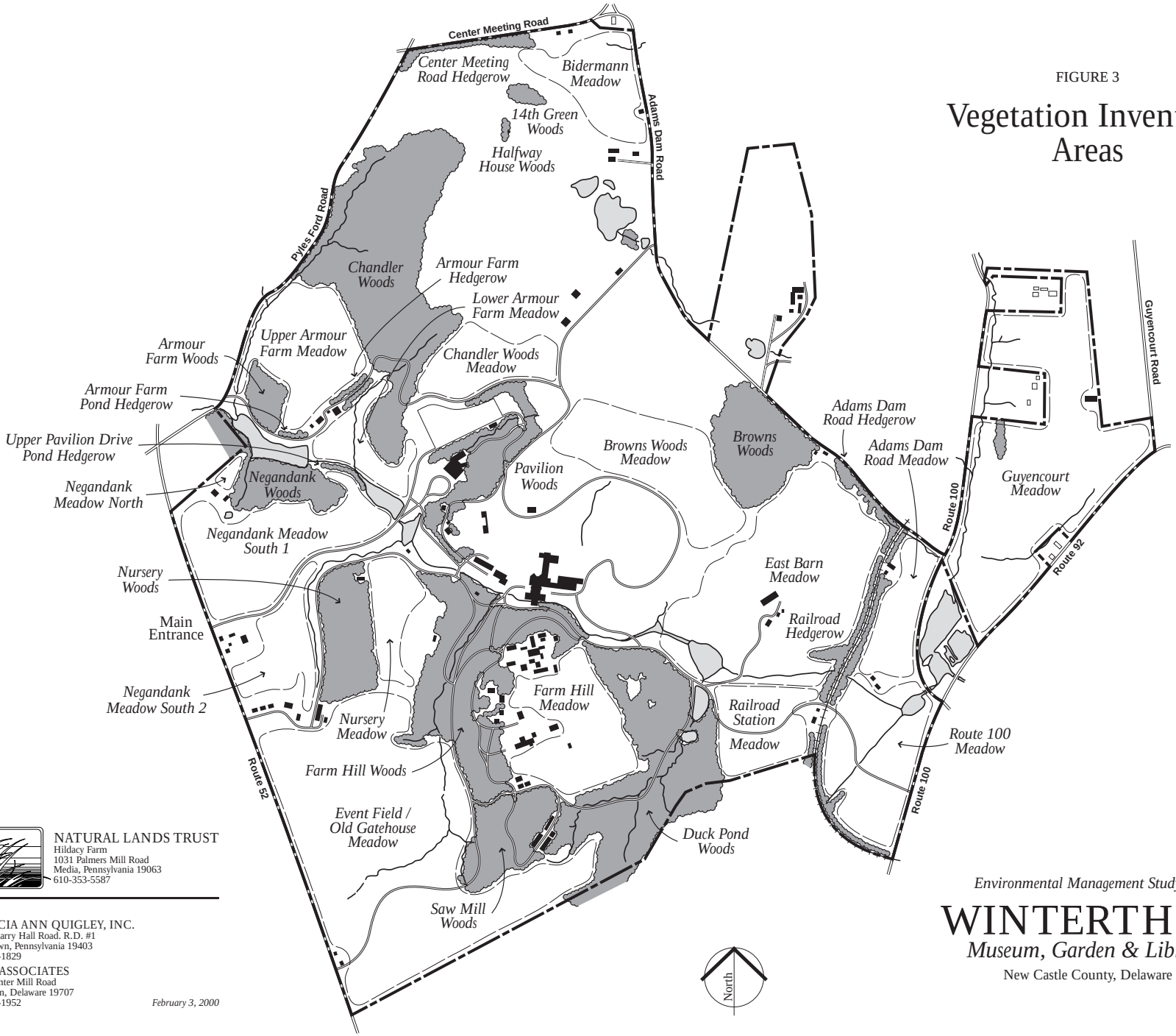
2.1.1 Terrestrial Resources

FLORA

Site visits to Winterthur were made by Natural Lands Trust staff between October 1997 and October 1998 to inventory the vegetation. See Figure 3 for the vegetation inventory areas. The vegetation was categorized into three general types: woodlands, hedgerows, and meadows (including wet/riparian areas) and the detailed inventories are included as Appendix A.

FIGURE 3

Vegetation Inventory Areas



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Woodland Flora

The woodland areas at Winterthur are dominated by hardwood forests, many of which can be classified as old growth (>150 years old). Like most of the mature forests in this area the woodlands occupy those sites that were inappropriate (too steep or wet) for agriculture. Unlike most of the region's forests, the woodlands at Winterthur did not suffer major disturbance (clearcutting, hurricane) over the last one and a half centuries. The result was the creation of a magnificent canopy of large oak, tuliptree, and beech.

The canopy of the woodlands is dominated by native species: oak *(Quercus* spp.*),* American beech *(Fagus grandifolia),* and tuliptree *(Liriodendron tulipifera).* Native species, primarily American beech and some black gum *(Nyssa sylvatica),* red maple *(Acer rubrum),* and hickory *(Carya* spp.*),* also dominate the understory. Norway maple *(Acer platanoides),* an introduced invasive species, is becoming established in the understory of most forested areas and is now the dominant understory species in Browns Woods. The shrub layer is generally sparse and dominated by viburnums *(Viburnum* spp.*),* both native and introduced. Jetbead *(Rhodotypos scandens),* another introduced invasive species, is becoming established in the shrub layer. The herbaceous layer throughout most of the woodlands is sparse.

These woodlands show signs of the degradation which plagues this region's forests. Invasive vegetation, including species from the formal gardens, are well established in the understory. Regeneration of native tree, shrub and herbaceous species are spotty at best, a result of both competition from exotic vegetation and consumption by white-tailed deer. This raises serious concern for the perpetuation of the existing woodlands.

14th Green and Halfway House Woods

± 1.0 acres and ± 0.3 acres

Dominant Vegetation

CANOPY: Oak
UNDERSTORY: Dogwood
SHRUB: No shrub layer

Woodland Health

INVASIVE VEGETATION IMPACT: Low
REGENERATION: None

Chandler Woods

± 48.5 acres

Dominant Vegetation

CANOPY: Oak, beech, tuliptree
UNDERSTORY: Black gum, beech, Norway maple, red maple, hickory
SHRUB: Viburnums and spicebush

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate
REGENERATION: Occurring in woodland gaps

Armour Farm Woods

± 4.0 acres

Dominant Vegetation

CANOPY: Oak, beech
UNDERSTORY: Beech
SHRUB: Sparse

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate on edges, low in interior
REGENERATION: Sparse, except for beech

Negandank Woods

± 8.0 acres

Dominant Vegetation

CANOPY: Eastern half tuliptree, ash, oak; western half tuliptree, beech, oak
UNDERSTORY: Eastern half hornbeam and cherry; western half open, beech
SHRUB: Eastern half euonymus and viburnum; western half no shrub layer

Woodland Health

INVASIVE VEGETATION IMPACT: Eastern half - moderate to heavy on edges, moderate in interior; western half - moderate on edges, moderate to low in interior
REGENERATION: Sparse

Pavilion Woods

± 10.0 acres

Dominant Vegetation

CANOPY: Oak, tuliptree, beech
UNDERSTORY: Tuliptree, beech, red maple
SHRUB: Sparse, primarily planted rhododendrons; northern portion - dense cover of southern arrow-wood and maple-leaved viburnums

Woodland Health

INVASIVE VEGETATION IMPACT: Low to moderate
REGENERATION: Sparse

Browns Woods

± 14.5 acres

Dominant Vegetation

CANOPY: Oak and tuliptree. Young tuliptree (±15 years) in northern corner.
UNDERSTORY: Norway maple with sparse pignut and mockernut hickory, some beech
SHRUB: Viburnum, jetbead, euonymus

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate to heavy
REGENERATION: Sparse

Nursery Woods

± 12.5 acres

Dominant Vegetation

CANOPY: Oak, tuliptree
UNDERSTORY: Sparse understory of beech
SHRUB: Maple-leaved viburnum, brambles

Woodland Health

INVASIVE VEGETATION IMPACT: Low to moderate
REGENERATION: Sparse

Farm Hill/Saw Mill/Duck Pond Woods

± 81.5 acres

Dominant Vegetation

CANOPY: Tuliptree, beech, and oak with some hickory (minor component)
UNDERSTORY: Beech with some hickory, red maple
SHRUB: More spicebush than in other woodlands

Woodland Health

INVASIVE VEGETATION IMPACT: Farm Hill and Saw Mill Woods - moderate to heavy for groundcovers and shrubs, low for canopy and vines; Duck Pond Woods - low to moderate for vines, moderate for shrubs, groundcover, and canopy

REGENERATION: Sparse

Woodland Species of Special Concern

The woodlands at Winterthur contain a number of plant species identified as rare and uncommon by the Delaware Natural Heritage Program. The species are ranked for both their rarity within Delaware and throughout the world. These ranks are used to prioritize conservation and protection efforts. See Appendix B for an explanation of the global and state ranks.

Species of concern identified within the woodlands are:

Acer saccharum	sugar maple	S3, G5	
Quercus marilandica	blackjack oak	S3, G5	
Castanea dentata	American chestnut	SU, G4	
Cercis canadensis	redbud	SH, G5	
Actaea pachypoda	white baneberry	S1, G5	
Agrimonia striata	roadside agrimony	S1, G5	
Caltha palustris	cowslip	S1, G5	**
Galium asprellum	rough bedstraw	S1, G5	
Geum vernum	spring avens	S1, G5	**
Geum virginianum	cream-colored avens	S1, G5	
Sanicula marilandica	black snake-root	S1.1, G5	
Thalictrum dioicum	early meadow-rue	S1, G5	**
Allium tricoccum	ramps	S2, G5	
Aralia racemosa	spikenard	S2, G5	*
Galium lanceolatum	wild licorice	S2, G5	
Orobanche uniflora	broom-rape	S2, G5	
Osmorhiza claytoni	sweet-cicely	S2, G5	
Mertensia virginica	Virginia bluebells	S3, G5	
Viola affinis	LeConte's violet	SU, G5	

* observed by Janet Ebert, 1990
** observed by Janet Ebert, 1991

Hedgerow Flora

Hedgerows function as corridors for wildlife to move between woodland patches. Unfortunately, with the introduction of invasive plants, they have become ideal edge habitat for the proliferation of these species. Invasive vines such as Japanese honeysuckle, Oriental bittersweet, and grape thrive along hedgerows and woodland edges where they receive direct sunlight and physical support from the trees. Invasive shrubs such as the shrub honeysuckles and multiflora rose often join these vines.

The hedgerows at Winterthur are chiefly along roads and the railroad and the impact from invasive vegetation is moderate to heavy throughout. While the canopy trees are mostly native, they are experiencing the same lack of native tree, shrub and herbaceous species regeneration as the woodlands.

The following hedgerows were inventoried: Center Meeting Road Hedgerow, Armour Farm Hedgerow, Armour Farm Pond Hedgerow, Upper Pavilion Drive Pond Hedgerow, Adams Dam Road Hedgerow, and Railroad Hedgerow.

Hedgerow Species of Special Concern

The hedgerows at Winterthur contain the following plant species identified as rare and uncommon:

Taxodium distichum	bald cypress	S2, G5
Juglans cinerea	butternut	S3, G3G4
Arabis lyrata	lyre-leaved rock-cress	S1, G5
Tradescantia virginiana	spiderwort	S2, G5

Meadow Flora

Meadows (including wet/riparian areas) are the dominant vegetation type at Winterthur. The dominant species in the meadows is the native grass broom-sedge (Andropogon virginicus). Most of the meadows contain a high degree of native herbaceous vegetation, due primarily to the regular mowing schedule. The upland meadows are presently in hay production, with either one or two cuttings each year, and the wet meadows are not hayed but are rotary mowed annually. Some areas, especially those now being allowed to succeed to woodlands, are moderately to severely impacted with invasive species.

Bidermann Meadow

± 14.5 acres

INVASIVE VEGETATION IMPACT: Low to moderate

Armour Farm Meadow

± 23.0 acres

INVASIVE VEGETATION IMPACT: Low on the top of the ridge and the south facing slope, heavy on the lower north facing steep slope

Lower Armour Farm Meadow

± 9.5 acres

INVASIVE VEGETATION IMPACT: Moderate to heavy

Chandler Woods Meadow

± 12.5 acres

INVASIVE VEGETATION IMPACT: Low

Negandank Meadow North

± 1.0 acres

INVASIVE VEGETATION IMPACT: Moderate to heavy

Negandank Meadow South 1

± 29.5 acres

INVASIVE VEGETATION IMPACT: Low, except for small, heavily impacted areas along Route 52, along edges, and patches throughout

Negandank Meadow South 2

± 11.0 acres

INVASIVE VEGETATION IMPACT: Low

Nursery Meadow

± 9.0 acres

INVASIVE VEGETATION IMPACT: Moderate, primarily along edges

Event Field/Old Gatehouse Meadow

± 100.0 acres

INVASIVE VEGETATION IMPACT: Low

Farm Hill Meadow
± 22.0 acres
INVASIVE VEGETATION IMPACT: Low to moderate

Browns Woods Meadow
± 25.0 acres
INVASIVE VEGETATION IMPACT: Low

East Barn Meadow
± 58.0 acres
INVASIVE VEGETATION IMPACT: Low in general, riparian area moderate

Railroad Station Meadow
± 14.0 acres
INVASIVE VEGETATION IMPACT: Low

Route 100 Meadow
± 26.0 acres
INVASIVE VEGETATION IMPACT: Low, except on steep slopes

Adams Dam Road Meadow
± 11.5 acres
INVASIVE VEGETATION IMPACT: Low

Guyencourt Meadow
± 101.5 acres
INVASIVE VEGETATION IMPACT: Low in general, riparian area moderate

Meadow Species of Special Concern

The meadows at Winterthur also contain a number of plant species identified as rare and uncommon:

Rubus odoratus	purple-flowering raspberry	S1, G5
Apocynum androsaemifolium	pink dogbane	S1, G5
Arabis lyrata	lyre-leaved rock-cress	S1, G5
Calamagrostis canadensis	Canada bluejoint	S1, G5
Campanula aparinoides	marsh bellflower	S2, G5
Lobelia spicata	spiked lobelia	S2, G5 *
Rhynchospora glomerata	beak-rush	S2, G5
Spiranthes lacera var. *gracilis*	southern slender ladies'-tresses	S2, G5T4T5
Tradescantia virginiana	spiderwort	S2, G5
Carex caroliniana	sedge	S3, G5 **
Polygonum scandens var. *scandens*	climbing false-buckwheat	SU,G5T5
Asclepias incarnata ssp. *incarnata*	swamp milkweed	SH, G5T5
Pycnanthemum clinopodioides	mountain-mint	SH, G2

* observed by Janet Ebert, 1992
** observed by Janet Ebert, 1993

FAUNA

Field surveys of amphibians, reptiles, birds, mammals, butterflies, dragonflies, and damselflies were conducted by Jim White of Hyla Associates between September 14, 1997 and October 4, 1998. The surveys were conducted on foot, aided by the use of binoculars and spotting scope. Species were identified by visual observation, sound (e.g., frog and bird calls), and signs (e.g., tracks). In addition, live traps (have-a heart and Sherman) were used to capture small mammals and hand nets were used to capture dragonflies.

Tables 2–6 in Appendix C present lists of species that were observed and may occur at Winterthur by habitat type. Tables 8–10 are "short lists" of the species of special concern for amphibians and reptiles, birds, and mammals designated by the Delaware Natural Heritage Program as "S1", "S2" or "S3" species, which indicates that they are of 1st, 2nd, or 3rd priority ranking for protection, respectively, out of 5 ranking categories.

Included in both tables are species that are believed by Hyla Associates to be "probable" or "possible" on the property, based on past field experience in similar habitats, although they were not observed during this field survey. "Probable" species are those that should occur within the identified habitats on the site and were missed during the survey. "Possible" species are those that generally do not utilize the identified habitats, but may occur under special circumstances or may occur for very brief periods of time. Management practices within identified habitats should include consideration of the biological needs of "probable" species, but in general, need not consider those of "possible" species.

For purposes of summarizing the survey findings, the various areas at Winterthur have been classified into nine general "habitat" types: woodland, field, edge, pond, stream, spring, vernal pool, gardens area, and golf course.

Woodland Fauna

The diversity of fauna in the woodlands appears relatively high. Amphibian species observed include American Toad, Wood Frog, Red-backed Salamander, and Northern Spring Peeper. Several other amphibian species probably utilize the woodlands for foraging, including Northern Dusky Salamander, Northern Two-lined Salamander, Long-tail Salamander, Red-spotted Newt, and Northern Red Salamander. While the Eastern Box Turtle was the only reptile species observed, it is very probable that Northern Black Racer, Black Rat Snake, Ring-necked Snake, Eastern Milk Snake and Eastern Garter Snake also occur in these woodlands.

Woodland nesting birds are well represented within Chandler Woods, Browns Woods, and the Farm Hill/Saw Mill/Duck Pond Woods. Species confirmed to have nested in these woodlands include Wood Thrush, Ovenbird, Veery, Scarlet Tanager, Hairy Woodpecker, Eastern Screech Owl, Great Horned Owl, and Red-tailed Hawk.

While no rare mammal species were found, most of the mammal species expected to occur in the woodlands were observed, including Opossum, Northern Short-tailed Shrew, Little Brown Myotis, Big Brown Bat, Red Bat, Eastern Gray Squirrel, Eastern Chipmunk, Red Squirrel, Woodchuck, Raccoon, Red Fox and White-tailed Deer. Mammals that probably occur but were not observed in these woodlands include Eastern Pipistrelle, Southern Flying Squirrel, Meadow Vole, Long-tailed Weasel, and Striped Skunk.

Lepidoptera observed in the woodlands included Question Mark, Eastern Comma, Mourning Cloak, Red-spotted Purple, and Appalachian Brown, and several other species are likely to occur there, as listed in Table 6. No Odonata species were observed in the woodlands.

Woodland Species of Special Concern

The woodlands at Winterthur provide habitat for numerous species of special concern. Although no amphibians or reptiles of special concern were observed in the woodlands during this survey, it is probable that the Longtail Salamander, Northern Red Salamander, and Eastern Milk Snake occur there, and others may be possible (see Table 8). Bird species of special concern that were observed in the woodlands include Black Vulture, Bald Eagle, Cooper's Hawk, Broad-winged Hawk, Hairy Woodpecker, Pileated Woodpecker, White-breasted Nuthatch, Brown Creeper, Veery, Warbling Vireo, American Redstart, Northern Parula, Chestnut-sided Warbler, Black-and-white Warbler, Kentucky Warbler, and Hooded Warbler. Other bird species of special concern that were not observed but are considered likely to utilize the woodlands, such as the Black-billed Cuckoo, are listed in Table 9. Mammal species of special concern observed in the woodlands include Red Bat and Red Squirrel (see Table 10).

Upland Field and Wet Meadow Fauna

Bird species that depend on upland field habitats that were observed during the surveys include Canada Goose, Black Vulture, Turkey Vulture, Northern Harrier, Red-tailed Hawk, American Kestrel, Mourning Dove, Northern Bobwhite, Ruby-throated Hummingbird, Northern Flicker, Olive-sided Flycatcher, Eastern Kingbird, Tree Swallow, Northern Rough-winged Swallow, Indigo Bunting, Field Sparrow, American Gold Finch, Eastern Meadowlark, Eastern Bluebird, and Killdeer. Mammal species observed include Opossum, Eastern Mole, Northern Short-tailed Shrew, Little Brown Myotis, Big Brown Bat, Eastern Cottontail, Woodchuck, Meadow Vole, Raccoon, Red Fox, and White-tailed Deer. No amphibian or reptile species were observed in the upland fields.

The upland fields are utilized by numerous species of Lepidoptera, many of which were observed during the field surveys, as listed in Table 6. Many Odonata species were also observed in the fields, as indicated in Table 5.

The wet meadows support a higher diversity of plant species, and therefore a higher diversity of animal species, than do the upland fields. In addition to supporting the vast majority of vertebrate species found in the upland fields, the wet meadows also are likely to support Eastern American Toad, Pickerel Frog, Eastern Box Turtle, Black Rat Snake, Eastern Garter Snake, and Meadow Jumping Mouse. Because of the abundance of flowering plants, Lepidoptera are especially abundant in the wet meadows. Odonata species are also attracted to the wet meadows because of the abundance of prey insect species.

Upland Field and Wet Meadow Species of Special Concern

No amphibian, reptile, or mammal species of special concern were observed in the fields, nor are they considered likely to utilize the field habitat, with the exception of the Bog Turtle which can sometimes be found in very wet meadows. Although the wet meadows surveyed provide only marginal habitat for the Bog

Turtle, it is possible that Bog Turtle may use the wet meadows in transition between more suitable habitat, or that a change in hydrology could make the current wet meadows more suitable.

Bird species of special concern that were observed utilizing the fields include Black Vulture, Northern Harrier, Cooper's Hawk, Broad-winged Hawk, American Kestrel, Common Nighthawk, Chipping Sparrow, and Eastern Meadowlark. Great Blue Heron, Great Egret, and Herring Gull were also observed in the fields, but are not considered to be dependent on them. Additional bird species, such as Bobolink, may occur in the fields, although they were not observed (see Table 9).

Edge Habitat Fauna

The transitional areas between woodlands and fields are important to many of our common animals. Edge habitat is generally not very supportive of amphibian species, and the only species found during the survey was Northern Spring Peeper. Although no reptiles were found in the edge areas during the field surveys, several species, including Black Rat Snake, probably utilize these areas. Many bird species that are typical of edge habitat were observed in the edge areas including Northern Cardinal, Mockingbird, Carolina Wren, Gray Catbird, Carolina Chickadee, Tufted Titmouse, Cedar Waxwings and several hawk species. Many mammal species were also observed, including Eastern Cottontail, which is particularly adapted to this habitat.

Edge Species of Special Concern

No amphibian or reptile species of special concern were observed in Winterthur's edge areas, although it is considered likely that the Eastern Milk Snake occurs there. Bird species of special concern that were observed utilizing edge habitat included Cooper's Hawk, American Kestrel, White-breasted Nuthatch, Warbling Vireo, Northern Parula, Chestnut-sided Warbler, Black-and-white Warbler, American Redstart, Yellow-breasted Chat, and Chipping Sparrow. The only mammal species of special concern observed in the edge areas was Red Squirrel. For additional species of special concern that may utilize the edge areas, see Tables 8, 9, and 10.

Pond Fauna

Amphibians found around the ponds include Bullfrog, Green Frog, and Pickerel Frog and reptiles include Common Snapping Turtle, Eastern Painted Turtle, Redbelly Turtle, Common Musk Turtle, and Northern Water Snake. Many species of birds were found to utilize the ponds including Great Blue Heron, Great Egret, Green Heron, Canada Goose, Wood Duck, American Black Duck, Mallard, Ruddy Duck, Osprey, Solitary Sandpiper, Belted Kingfisher, and Tree, Rough-winged and Barn Swallows. The only mammals found using the ponds were Little Brown Myotis, Big Brown Bat (feeding on insects over pond), Raccoon, Opossum, and Muskrat. Several species of Odonata were also observed using the ponds.

Pond Species of Special Concern

Vertebrate species of special concern that were observed at Winterthur ponds included Great Blue Heron, Great Egret, and Osprey. For a listing of other vertebrate species of special concern that may utilize the ponds but were not observed (such as Bald Eagle and Red Bat) see Tables 7, 8, 9, and 10.

Stream Fauna

Clenny/Wilson Run and, to a greater extent, its tributaries provide important salamander habitat. Species found include Northern Dusky Salamander, Northern Two-lined Salamander, Northern Red Salamander. Although not found during the survey, the Longtail Salamander probably exists in or near the Duck Pond Woods stream. Reptiles that were found in the streams included Northern Watersnake and Eastern Garter Snake. Although not found during the survey, the Queen Snake occurs on Wilson's Run, just downstream of Winterthur and may occur along Clenny/Wilson Run west of East Barn Pond. Marginal Bog Turtle habitat also exists along the upper portions on Event Field/Old Gatehouse Meadow stream.

Many birds utilize the streams on the property but only a few species rely on them for much of their food, including the following species observed during the survey: Belted Kingfisher, Great Blue Heron, Great Egret, Green Heron, Wood Duck, and Northern Rough-winged Swallow. Other bird species, such as the Louisiana Waterthrush, Northern Waterthrush, and Spotted Sandpiper, although not found during the surveys, are also dependent on the streams and probably occur there.

Many mammal species were observed utilizing the streams on the property, including the Raccoon and Muskrat which are particularly dependent on the streams for their existence.

The streams on the property are also important to several species of Odonata; however, few species were observed during the survey.

Stream Species of Special Concern

Vertebrate species of special concern that were observed in Winterthur streams included Northern Red Salamander, Queen Snake, Great Blue Heron, and Great Egret. Several other species of special concern that were not observed but are considered likely to utilize the streams include Swallowtail Shiner, Longtail Salamander, Spotted Sandpiper, and Louisiana Waterthrush (see Tables 7, 8, 9, and 10).

Spring Habitat Fauna

The spring located on the west bank of Upper Duck Pond is the best example of a wooded spring and it creates a cool wet boggy area that is particularly good salamander habitat. Amphibian species found include Northern Two-lined Salamander, Northern Dusky Salamander, and Pickerel Frog. Although not found during the survey, Longtail Salamander, Northern Red Salamander, and Four-toed Salamander may also occur in wooded springs of this type. Other vertebrate species may utilize springs but only the Opossum, Raccoon, and Louisiana Waterthrush are likely to be regular visitors to these areas.

The non-wooded springs that are found in more open, disturbed areas may be interesting botanically but provide only marginal faunal habitat.

Spring Habitat Species of Special Concern

Longtail Salamander and Northern Red Salamander are the only two vertebrate species of special concern that are considered likely to utilize the springs/spring seeps at Winterthur.

Vernal Pool Fauna

Vernal pools are small to medium sized, closed system wetlands that have standing water at least part of the year but only occasionally year round. Because of their perennial dry periods, these pools are usually fishless, and therefore, provide very valuable wildlife habitat and breeding sites for aquatic invertebrates and amphibians. Water levels are generally influenced by rainwater runoff and/or groundwater levels and are at their highest in winter and spring. Dry down generally occurs in mid to late summer. Vernal pools are rare on the Winterthur property.

Although only the Northern Spring Peeper and Green Frog were found at a vernal pool at Winterthur during the survey period, other amphibian species including Four-toed Salamander, Spotted Salamander, Eastern American Toad, Wood Frog, and Pickerel Frog are known vernal pool breeders. In addition, reptiles such as Spotted Turtle, Northern Water Snake, and Ribbon Snake may also be found at these pools. Although there are no bird or mammal species that depend on vernal pools, several species may visit these areas in search of food. Various Odonata species also utilize vernal pools, although not observed there during the field surveys.

Vernal Pool Species of Special Concern

No species of special concern were observed at the vernal pool during the survey period; however, several species, including Spotted Salamander, Four-toed Salamander, Northern Red Salamander, Spotted Turtle, Bog Turtle, and Eastern Ribbon Snake, may possibly occur there.

Garden Area Fauna

A few common amphibian species, including Redback Salamander, American Toad, Northern Spring Peeper, and Green Frog were observed in the Gardens Area. The only reptile that was observed in the Gardens Area was the Ringneck Snake. Other amphibian and reptile species that probably are found there include Pickerel Frog, Black Rat Snake, Eastern Milk Snake, and Eastern Garter Snake.

Birds of many species are found commonly in the Gardens Area. Woodland songbirds such as Tufted Titmouse, Carolina Chickadee, Brown Creeper, Red-breasted and White-breasted Nuthatch, Carolina Wren, Scarlet Tanager, Downy Woodpecker, and Hairy Woodpecker were observed in the gardens. The gardens were also used by spring and fall migrating songbirds. Birds of prey including Sharp-shinned Hawk, Cooper's Hawk, Red-tailed Hawk and American Kestrel were also observed hunting in the gardens. The evergreen trees within the Gardens Area appear to offer very good resting areas for Great Horned Owls, Eastern Screech Owls and possibly the uncommon Northern Saw-whet Owl and Long-eared Owl although no owls were observed there during the survey.

Numerous common mammals were also observed in the Gardens Area, as listed in Table 4.

Insects are abundant in the Gardens Area with the many flowers attracting many species of butterflies including Black Swallowtail, Eastern Tiger Swallowtail, Spicebush Swallowtail, Eastern Tailed Blue, Gray Hairstreak, Spring Azure, Variegated, Meadow and Great Spangled Fritillary, Pearl Crescent, Question Mark, Eastern Comma, Common Buckeye, Painted Lady, Red Admiral, Mourning Cloak, Viceroy, and Monarch. One uncommon species,

the Appalachian Azure, was found to be fairly common in the Azalea Woods portion of the Gardens Area. This species has only been found in one other location in Delaware. Several Appalachian Azure larvae were found on their host plant, Black Cohosh.

Garden Area Species of Special Concern

Although no amphibian, reptile, or mammal species of special concern were observed in the Gardens Area during the survey, it is likely that Eastern Milk Snake, Red Bat, and Red Squirrel utilize the Gardens Area (see Tables 8 and 10). Bird species of special concern observed in the Gardens Area included Cooper's Hawk, American Kestrel, Hairy Woodpecker, White-breasted Nuthatch, Brown Creeper, and Chipping Sparrow and it is likely that Black Vulture and several species of warblers also utilize the Gardens Area, although they were not observed there (see Table 9).

As mentioned above, the Appalachian Azure was also found to be fairly common in the Azalea Woods portion of the Gardens Area. Although not listed by the Delaware Natural Heritage Program as a species of special concern, this butterfly has only been found in one other location in Delaware.

Golf Course Fauna

No amphibians or reptiles were observed in the golf course area except in and around the ponds (as discussed above). Numerous common species of birds were observed in the golf course area, as indicated in Table 3. Mammals observed on the golf course were Little Brown Myotis, Eastern Cottontail, Eastern Gray Squirrel, Woodchuck, Raccoon, Red Fox, and White-tailed Deer. Although a few butterflies were observed flying over the golf course grounds, in general there is little suitable habitat for them there.

Golf Course Species of Special Concern

As mentioned above, the grounds of the golf course area provide only marginal wildlife habitat. The only species of special concern observed in the golf course area were Black Vulture, Sharp-shinned Hawk, Cooper's Hawk, and American Kestrel.

2.1.2 Aquatic Resources

Aquatic resources within the ±966-acre Winterthur property consist of streams, ponds, and wetlands. The property almost fully includes Clenny/Wilson Run, a first to second order tributary of the Brandywine Creek. The segment of the stream that flows through the Winterthur grounds (northwest of Routes 92 and 100) is designated by the State of Delaware Surface Water Quality Standards (February 26, 1993) as "ERES" or waters of exceptional recreational or ecological significance. The watershed is part of the highly valued Brandywine Creek system and is largely undeveloped except for the Winterthur property, several golf courses and low density residential development.

The original hydrology within the property has been altered through dam and stream channel construction, the capping or diversion of natural seeps and springs, the deposition of landscaping waste and rubble into wetlands, and the mowing of stream buffers. The latter has created ideal habitat for Canada geese which further degrade water quality.

Clenny/Wilson Run within the project area was most recently sampled by the Delaware Department of Natural Resources and Environmental Control (DNREC) in the Fall of 1993. Sampled parameters included flow, pH, dissolved oxygen, conductivity, temperature, macroinvertebrates, and habitat. Findings indicate a loading of nutrients and oxygen demand associated with the ponds, resulting in a pollution tolerant benthic macroinvertebrate community in downstream areas.

The sampling of the unvegetated components of the inventory (stream and pond) was guided by the methodologies currently in use by DNREC Division of Water Resources. For this project DNREC required on-site sampling at established sampling stations. Their method of biological assessment of non-tidal streams in the Piedmont Region relies on a modified version of the "EPA Rapid Bioassessment Protocols for Use in Streams and Rivers" (EPA 1989). The Rapid Bioassessment Protocols (RBP) utilize an integrated assessment procedure that compares physical habitat and biological measures at sites of interest with regional "reference sites" that represent the optimum or least disturbed condition. However, the DNREC data base for reference streams in the northern Delaware Piedmont had very little data on only a few streams and these were not at all comparable in land use or geology to Clenny Run and therefore not directly applicable. Therefore, the results of the stream sampling are summarized based on other biological indicators of stream quality, such as aquatic organism diversity, especially of those species known to be pollution sensitive such as those of the taxa Ephemeroptera, Plecoptera, and Trichoptera.

STREAMS

The evaluation procedures provided by DNREC for this study call for two 1-meter square kicknet samples to be obtained in a riffle zone according to RBP Protocol Level II 1/2 methodology (with the exception that a Course Particulate Matter sample is not required). RBP metrics to be assessed include: total taxa, EPT (Ephemeroptera, Plecoptera, Trichoptera) index, % EPT, % dominant, % Chironomid, and Hilsenhoff diversity index. In addition to the biological data collection, stream habitat is also to be characterized at each station using RBP. Habitat parameters include bottom substrate, available cover, embeddedness, riffle quality and frequency, channel modification, sediment deposition, velocity, water depth, bank condition (shading and stability), and width of riparian zone. Water quality parameters to be sampled include the following: flow, pH, conductivity, and temperature.

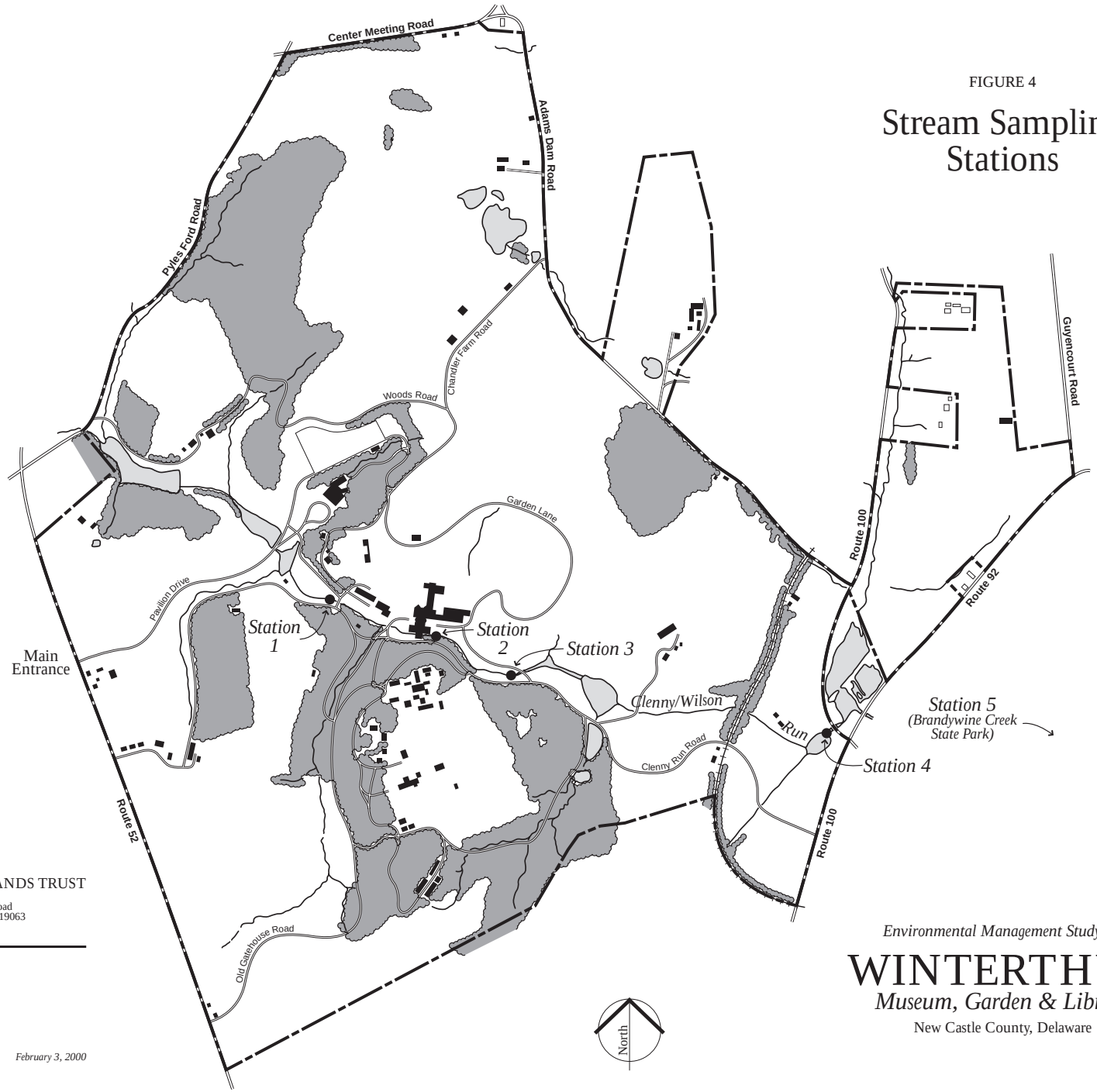
On October 23, 1997, kick net samples of macroinvertebrates were obtained by Patricia Ann Quigley, Inc. at five locations along Clenny/Wilson Run (see Figure 4 and Table 1). Four samples were obtained within Winterthur and one sample was obtained within the Brandywine Creek State Park. Stations 1, 2, and 5 correspond with the established DNREC water quality sampling stations.

Sampling Station Descriptions

Station 1 (DNREC Site #NC185) is upstream of the Clenny Run Road stream crossing near the Winterthur Museum building. This represents man-made stream habitat modified for bridge construction, with a stone and mortar creek bed and banks to the north, and a more natural but manicured bank to the south. Substrate consists primarily of mortar and cobble with gravel and

FIGURE 4

Stream Sampling Stations



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Environmental Management Study for

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Table 1: Stream Sample Results

CLASS/ORDER	FAMILY	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Oligochaeta		3	5?	1		
Crustacea	Gammaridae				6	6
	Aselius			2	3	3
Insecta/Coleoptera	Elmidae			Stenelmis larva - 5 Stenelmis adult - 5		Stenelmis adult - 1
Diptera	Tipulidae	1		7		14
	Chironomidae				2+	89
Ephemeroptera	Heptageniidae					
	Ephemerellidae	1				6
	Leptophlebiidae	1			1	
Odonata	Corydalidae			3		6
	Lestidae	10		7		
	Gomphidae	1		1		2
	Coenagrionidae	1				
Plecoptera	Perlidae					1
Tricoptera	Hydropsychidae	3		41	200+	35+
Gastropoda	Physidae	1		2		1
Total Taxa		9	1	9	5	9
Total Individuals		22	5	74	212	173
EPT Index		3	0	1	2	4
% EPT		0.23	0	0.55	0.95	0.76
% Dominant		0.45	100.0	0.55	0.94	0.51
% Chironomid		0	0	0	0.01	0
Hilsenhoff Diversity Index		7.50 Very Poor	10.0 Very Poor	5.42 Fair	5.08 Fair	1.01 Excellent

sand. The stream averages 4′ wide with a 3″ to 5″ deep perennial flow. Filamentous green algae covers most of the rocks and lush beds of true-forget-me-not *(Myosotis scorpioides)* grow along the edges. Large specimen trees provide partial shade and the water temperature was 45° F. The general macroinvertebrate habitat is poor because the substrate is primarily flat, slime covered, and armored with very few loose rocks.

Station 2 (DNREC Site #NC186) is located next to the Winterthur Museum building. It represents poorer man-made habitat than Station 1. For this reason DNREC did not sample this station during their last campaign. The stream is completely lined with large flat rocks that are closely pieced together. Substrate consists of slime covered sections of stone approximately 4′ square. The stream averages 20′ wide with a 1″ deep perennial flow which meanders over the stone. A few large specimen trees provide partial shade and the water temperature was 36° F.

Station 3 is located approximately 100′ upstream of the Museum Road crossing and about 30′ downstream of the Museum's sewage treatment plant effluent outfalls. It is the most natural habitat sampled on the property. The natural substrate is composed primarily of cobble and gravel with some sand deposits. The stream averages 6′ wide with a 4″ deep fairly turbulent flow which oxygenates the water below. Although vegetation grows along the stream edges, it is regularly mowed and there is very little overhead shading of the stream. The water temperature was 42° F.

Station 4 is located toward the southeastern corner of the property, below the Routes 100/92 Pond. It represents man-made habitat at the spillway of the small dam. The stream averages 6′ wide with a 6″ deep flow over the dam. The rough texture of the dam base provides good macroinvertebrate habitat and the waterfall serves to oxygenate the downstream waters. Shrubs provide a small amount of overhead shading of the stream. The water temperature was 45° F.

Station 5 (DNREC Site #NC191) is located downstream of the Brandywine Creek State Park entrance on Adams Dam Road. It represents good macroinvertebrate habitat and this portion of Clenny/Wilson Run is stocked with trout by DNREC. Substrate consists of boulder, cobble, gravel, and sand. The stream averages 4′ to 7′ wide and between 8″ and 14″ deep. Small amounts of filamentous green algae cover some rocks. Large trees provide partial shade and the water temperature was 49° F.

Total Taxa (Taxa Richness) roughly approximates diversity through a measurement of the variety of taxa (families). This is expected to increase with improving water quality. Total Individuals is a reflection of biomass and productivity. The EPT Index also increases with improving water quality. It is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. These are typically pollution sensitive organisms and are usually absent from degraded waters. The % EPT would also increase with improving water quality. The % Chironomid values increase with decreasing water quality because Chironomid typically thrive in low quality, poorly oxygenated waters. The Hilsenhoff Diversity Index (HDI) assigns tolerance values from 0 to 10, increasing as water quality decreases.

Station 1 displayed fair species diversity with low numbers of individuals per sample. Total taxa values were fairly high and the HDI indicated very poor water quality. Two blacknose dace (Rhinichthys atratulus) were collected at Station 1. These minnow provide a good forage base for largemouth bass (Micropterus salmoides) and bluegills (Lepomis macrochirus) that were seen in deeper portions of the creek and likely reside in all the ponds at Winterthur.

Station 2 yielded a sample of only five Oligochaete worms. Two tadpoles were also obtained in this sample. Poor habitat and water quality likely minimizes macroinvertebrate colonization. The HDI indicated very poor water quality.

Conditions improved at Station 3 even though this zone received effluent from the Museum's sewage treatment plant. Diversity and number of individuals were good as was habitat. The HDI indicated fair water quality.

Station 4 provided somewhat limited diversity, however very high numbers of caddisflies were collected. This yielded a high % EPT and % dominant values. The HDI indicated fair water quality.

Station 5 probably indicated the most favorable water quality of all samples because both diversity and numbers of individuals were high and the HDI calculations indicated excellent water quality.

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PONDS

The methodologies used for evaluation of the ponds at Winterthur correspond to those used by the DNREC Division of Water Resources. Water chemistry parameters obtained include: dissolved oxygen and temperature profiles, secchi transparency, total phosphorus, total suspended solids, chlorophyll a, and pH. Algae and rooted macrophytes were sampled, identified and estimated for % cover. This information is used, along with dissolved oxygen profiles, to infer overall habitat and pond water quality. Pond morphometry, including shoreline features and bathymetry is desired in an effort to gauge lake volume in the event that chemical treatment or aeration is recommended. A general investigation of land use within the watershed is included and obvious problems identified during background or field investigations are noted.

Sampling Station Descriptions

On October 21, 1997, grab samples of pond water were obtained by Patricia Ann Quigley, Inc. at the outflow structures at a total of six ponds along Clenny/Wilson Run within Winterthur (see Figure 5 and Table 2). The ponds are in series along the creeks and represent approximately 7,000 linear feet of stream length. The uppermost pond, Armour Farm Pond, is situated near the northwestern property boundary at Pyles Ford Road. The last pond, the Routes 100/92 Pond, is located near the eastern property boundary near the intersection of Routes 100 and 92. Samples were collected from 10:30 to 14:00 hr., maintained on ice and relinquished to the laboratory at 15:20 hr.

Total Suspended Solids (TSS) were below the 10 mg/l detection limit in all ponds except East Barn Pond which displayed 12.0 mg/l TSS. TSS relates directly to turbidity, and to some extent, silt loading. The State of Delaware, Surface Water Quality Standards, as amended February 26, 1993, recommends a turbidity level of 10 or less for Clenny/Wilson Run's watershed. Excessive TSS can reduce the amount of light entering the water, reducing plant and algae growth. The gills of juvenile fish, invertebrates, and mussels and clams can become clogged by excessive TSS. Benthic

FIGURE 5

Ponds

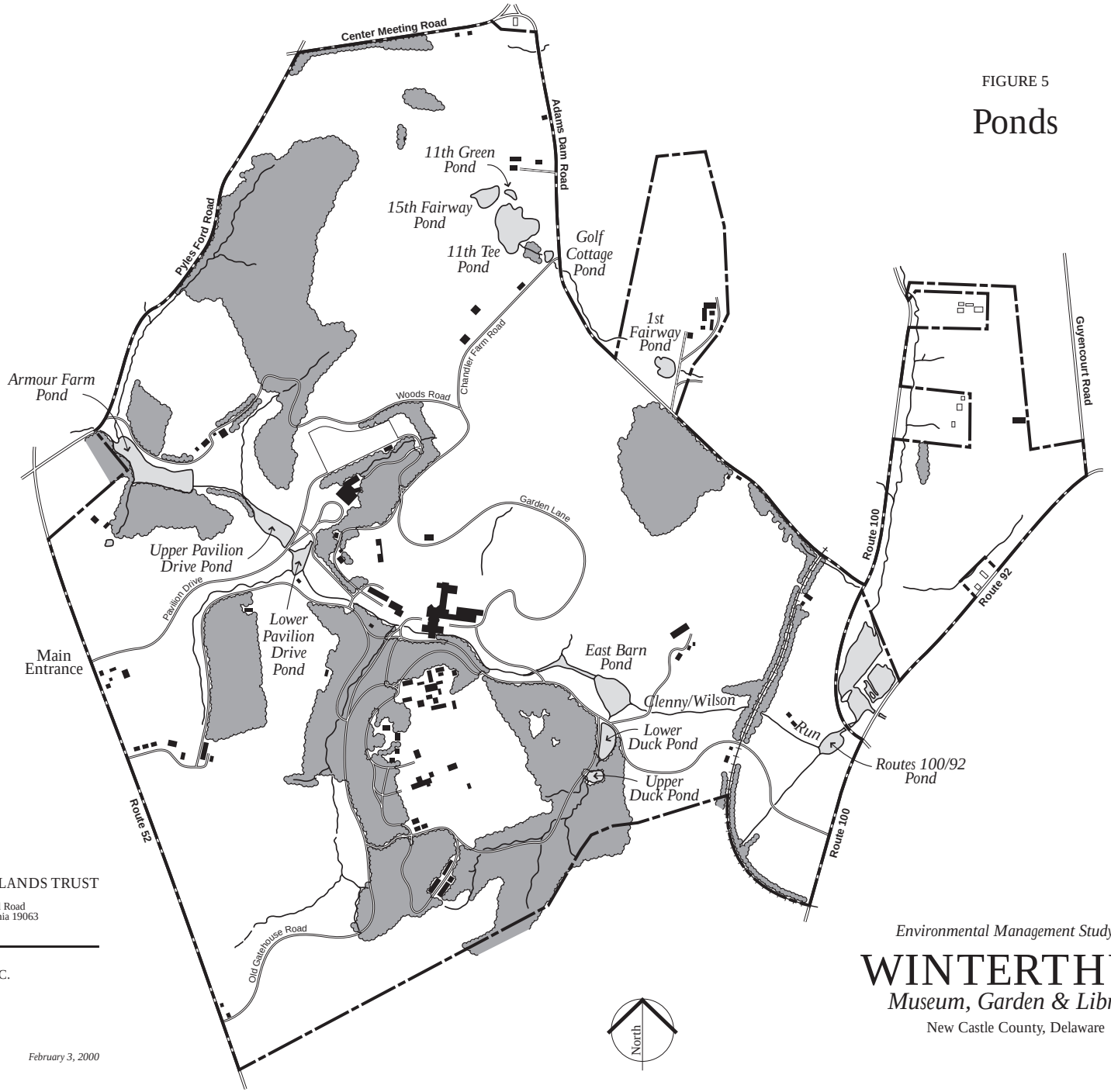

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Table 2: Pond Sample Results

	ARMOUR FARM POND	11TH TEE POND	UPPER PAVILION DRIVE POND	LOWER DUCK POND	EAST BARN POND	ROUTES 100/92 POND
Total Suspended Solids (mg/l)	N.D.	N.D.	N.D.	N.D.	***12.0***	N.D.
Dissolved Oxygen (mg/l)	***4.7***	11.0	9.3	9.0	8.5	15.0
pH	6.73	***8.81***	7.2	7.32	7.3	***9.24***
Total Phosphorus (mg/l)	***0.099***	N.D.	N.D.	N.D.	***1.3***	N.D.
Total Coliform (CFU/100 ml)	***>1,600***	9	8	***140***	***170***	***90***
Chlorophyll a (mg/l)	2.4	***16.0***	7.5	4.2	1.9	1.9

**** Bold-italicized values indicate levels outside of mandated or recommended parameters***

macroinvertebrate habitat is degraded and sometimes eliminated by siltation (Hynes, 1979). Much of the TSS within Clenny/ Wilson Run is removed by the ponds, which allow suspended items to settle out. Armour Farm Pond is currently being dredged. This will reduce the amount of sediment and nutrient loading to downstream reaches.

Dissolved Oxygen (DO) is a measure of the amount of oxygen dissolved in the water. DO levels were generally favorable except for Armour Farm Pond. DO values ranged from 4.7 to 15.0 mg/l. DO is necessary for aquatic life, which absorb oxygen through gills. DO levels below 4.0 are typically stressful to most forms of aquatic life. The Surface Water Quality Standards mandates a minimum dissolved oxygen level of 4.0 mg/l and an average for the June–September period of no less than 5.5 mg/l for Clenny/ Wilson Run's watershed. The ponds did not exceed these criteria for any of the water samples.

pH is a measure of aqueous acidity and basicity, ranging from zero (most acidic) to fourteen (most basic) with seven being neutral. pH levels were generally favorable except for the 11th Tee Pond and Routes 100/92 Pond which had elevated pH values. pH values ranged from 6.73 to 9.24 standard units. The Surface Water Quality Standards mandates a pH range of 6.5–8.5 for Clenny/ Wilson Run's watershed. These criteria were exceeded in the 11th Tee Pond, which had a pH of 8.81, and the Routes 100/92 Pond,

which had a pH of 9.24. Most lakes have a pH of 6 to 9, and a pH of 10 may indicate eutrophic soda lakes or marl (Goldman and Horne, 1983).

Total Phosphorus (TP) is an important nutrient for plant growth and excessive phosphorus can cause increased algal or macrophyte growth leading to pond eutrophication. TP concentrations of nonpolluted waters are usually less than 0.1 mg/l (Lind, 1985). However, because phosphorus is often a limiting nutrient, a small phosphorus increase can lead to a marked rise in plant growth because nitrogen and carbon are usually present in excess. TP levels were favorable except for East Barn Pond which slightly exceeded the recommended value at 1.3 mg/l. The Surface Water Quality Standards do not provide guidance for phosphorus. Phosphorus is primarily found within pond sediments and by dredging Armour Farm Pond inputs of phosphorus should decrease downstream.

Total Coliform (TC) is a measure of certain bacteria which are associated with sewage. The bacteria are derived from the digestive tracts of mammals, and measuring total coliform does not distinguish between human or animal origin. Certain levels of these bacteria are always present in healthy aquatic systems. TC values ranged from 8 to >1,600 colonies/100 ml. The highest TC values occurred within Armour Farm Pond, Lower Duck Pond, East Barn Pond, and the Routes 100/92 Pond. Coliform inputs to the ponds do occur naturally and wide variation in TC values is common. However, excessive loadings are occurring through the droppings of resident Canada Geese and probably from off-site septic systems.

Chlorophyll a is a plant pigment which converts light energy to chemical energy during photosynthesis. This indirectly measures growth, primary productivity, and algal abundance or standing crop. Surface Water Quality Standards does not provide guidance for this parameter, however a healthy non-eutrophic lake or pond should have chlorophyll a levels below 10 mg/l (Hynes, 1979). Only the 11th Tee Pond exceeded this value at 16.0 mg/l.

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WETLANDS

Due to the large study area, a full-scale point-to-point survey of all regulatory wetlands on the Winterthur grounds was not recommended. To meet the goals of an overall land stewardship plan, it is essential though to have preliminary boundary identification, based on field observations, with detailed observations recorded of the wetland type, dominant species, rare or endangered species, and degree of disturbance. Full-scale surveying of wetland boundaries should be reserved for key areas where potential future facilities development or expansion is considered which may encroach on regulated wetlands.

A diversity of wetland types — swamps, marshes, and ponds — are found at Winterthur and were examined by Patricia Ann Quigley, Inc. on various field visits between September 1997 and October 1998 (see Hydrology map). These wetlands occur in association with seeps, streams, and impoundments located in the watershed of Clenny/Wilson Run which drains eastward to Brandywine Creek. Forested wetlands occur where a canopy has

remained and wet meadows occur in areas that are periodically mowed. Extensive manipulation of the ground and surface water resources at Winterthur have effected the wetlands. Piping has depleted water from some areas causing wetlands to diminish in area over time while elsewhere, wetter circumstances have been created. Winterthur as a whole has an abundance of water which supports an array of relatively natural wetlands as well as the many lovely, yet unnatural, ponds.

Wetlands and some adjacent non-wetland areas are described below in the order that they occur moving downstream from headwater areas and from north to south and west to east across the property. Also refer to Appendix D for a master species list of plants occurring in sampled wetlands.

Wet area in Bidermann Meadow

An area of wet meadow grading into scrub/shrub wetland occurs in Bidermann Meadow. Springs and seeps support the wetland. Young red maples *(Acer rubrum)* dominate the scrub/shrub zone on the northern side of the wetland. The southern portion supports a diversity of herbaceous species including soft rush *(Juncus effusus),* sensitive fern *(Onoclea sensibilis),* fowl manna grass *(Glyceria striata),* grass-leaved goldenrod *(Euthamia graminifolia),* deer-tongue grass *(Panicum clandestinum),* purple-stemmed aster *(Aster puniceus),* swamp milkweed *(Asclepias incarnata),* and New York ironweed *(Vernonia noveboracensis).* A raspberry species *(Rubus* sp.*)* and multiflora rose *(Rosa multiflora)* are interspersed among the herbaceous plants. A dogbane species *(Apocynum* sp.*)* and Japanese honeysuckle *(Lonicera japonica)* grow in drier areas at the edge of the wetland. Little bluestem *(Andropogon scoparius)* dominates the surrounding non-wetland meadow. An intermittent stream that drains the wet meadow flows eastward under Adams Dam Road.

Forested wetlands in Chandler Woods

Downgradient along a generally dry swale southeast of a golf green along Pyles Ford Road, the swale gathers more water and becomes a headwater stream of Clenny/Wilson Run that parallels and runs east of the road. In an open area of wetland where there is a break in the surrounding upland forest canopy, one observes 40' sour gum *(Nyssa sylvatica),* a shrub layer dominated by spicebush *(Lindera benzoin)* with some wineberry *(Rubus phoenicolasius),* and an herbaceous layer dominated by clearweed *(Pilea pumila)* with smartweed *(Polygonum* sp.*),* stiltgrass *(Microstegium vimineum),* bulrush *(Scirpus* sp.*),* garlic mustard *(Alliaria petiolata),* skunk cabbage *(Symplocarpus foetidus),* curly dock *(Rumex crispus),* and Indian strawberry *(Duchesnea indica).* Grape *(Vitis* sp.*)* is the dominant vine. The soil has a silty clay loam texture and from the surface to 8" has a 5Y 3/1 matrix with 10YR 3/6 and 10YR 4/6 mottles indicating hydric conditions.

Further downstream a finger of forested wetland fed by seeps joins the Clenny/Wilson Run tributary from the east. The forested wetland has an 80' canopy of tulip tree *(Liriodendron tulipifera)* on slightly higher ground, a 20' subcanopy of black ash *(Fraxinus nigra),* beech *(Fagus grandifolia),* and sour gum *(Nyssa sylvatica),* a shrub layer dominated by spicebush *(Lindera benzoin)* with some elderberry *(Sambucus canadensis)* and arrowwood *(Viburnum dentatum),* and a diverse herbaceous layer dominated by skunk cabbage *(Symplocarpus foetidus)* and golden saxifrage *(Chrysosplenium americanum)* with turtlehead *(Chelone glabra),* spotted touch-me-not *(Impatiens capensis),* primrose *(Primula* sp.*),*

sedge *(Carex* sp.*)*, cinnamon fern *(Osmunda cinnamomea)*, false nettle *(Boehmeria cylindrica)*, clearweed *(Pilea pumila)*, jack-in-the-pulpit *(Arisaema triphyllum)*, and violet *(Viola* sp.*)*. The herbaceous cover is sparse in the shade and lush in open areas near a dirt road that passes nearby. Between the surface and 8" the saturated soil has a color of 5Y 2.5/1 indicating that it is hydric. Frogs and toads were observed in the area on 10/10/97.

Wet area in Armour Farm Meadow

Continuing downstream along the Clenny/Wilson Run tributary that parallels Pyles Ford Road, the forest cover opens into wet meadow. Soft rush *(Juncus effusus)* and arrow-leaved tearthumb *(Polygonum sagittatum)* dominate the wet meadow with numerous other species present in lesser amounts including purple-stemmed aster *(Aster puniceus)*, lurid sedge *(Carex lurida)*, dogbane *(Apocynum* sp.*)*, multiflora rose *(Rosa multiflora)*, deer-tongue grass *(Panicum clandestinum)*, goldenrod *(Solidago* sp.*)*, sensitive fern *(Onoclea sensibilis)*, rough-leaved goldenrod *(Solidago patula)*, spotted touch-me-not *(Impatiens capensis)*, smartweed *(Polygonum* sp.*)*, bedstraw *(Galium* sp.*)*, New York ironweed *(Vernonia noveboracensis)*, umbrella sedge *(Cyperus* sp.*)*, mountain mint *(Pycnanthemum* sp.*)*, and purple-leaved willow herb *(Epilobium coloratum)*. Between the surface and 8" the soil matrix is 10YR 3/2 with 7.5YR 3/4 mottles indicating hydric conditions. The wet meadow extends along the eastern side of the stream down to where an access road from Pyles Ford Road crosses the drainage. From the access road downstream to where the tributary flows into Armour Farm Pond, disturbance in the form of filling, regrading, planting, and mowing has obscured natural wetland boundaries. Soft rush *(Juncus effusus)* grows here in the closely-cropped lawn.

Armour Farm Pond

At the upstream end of Armour Farm Pond where the previously described Clenny/Wilson Run tributary enters the pond and a second Clenny/Wilson Run tributary which enters the Winterthur property from the west also flows into the pond, spikerush *(Eleocharis* sp.*)* and mud plantain *(Heteranthera reniformis)* grow. Due to inputs of sediment from upstream, the pond is less than 1 foot deep in this area.

Forested wetlands in Negandank Woods

A northward-flowing spring-fed stream drains into the southern side of Armour Farm Pond and supports forested wetland with some emergent patches along its length. At the upper end of this system is a pond, supporting burreed *(Sparganium* sp.*)* and common reed *(Phragmites australis)*, that is connected to the creek corridor by underground pipes. In a seepy wet meadow along the creek one finds clearweed *(Pilea pumila)*, a tussock-forming sedge *(Carex* sp.*)*, false nettle *(Boehmeria cylindrica)*, spotted touch-me-not *(Impatiens capensis)*, fowl manna grass *(Glyceria striata)*, stiltgrass *(Microstegium vimineum)*, common arrowhead *(Sagittaria latifolia)*, tussock sedge *(Carex stricta)*, violet *(Viola* sp.*)*, jumpseed *(Polygonum virginianum)*, long-bristled smartweed *(Polygonum cespitosum)*, arrow-leaved smartweed *(Polygonum sagittatum)*, and mild water-pepper *(Polygonum hydropiperoides)*. Spicebush *(Lindera benzoin)* edges the wet meadow. The combination of mucky substrate, flowing water, and tussocks makes the area potential bog turtle habitat. From the surface to refusal at 5", the inundated and saturated soil has a color of 2.5Y 2.5/1 indicating hydric conditions.

Wet area in Lower Armour Farm Meadow

Downstream of Armour Farm Pond there is a disturbed wet meadow on the north side of Clenny/Wilson Run. Mowing of the area has set back desirable wetland plant species and damaged wildlife as evidenced by a large mowed snapping turtle shell on 10/10/97. A diverse mix of species includes sweetflag *(Acorus calamus),* soft rush *(Juncus effusus),* purple-stemmed aster *(Aster puniceus),* lurid sedge *(Carex lurida),* black bulrush *(Scirpus atrovirens),* reed canary grass *(Phalaris arundinacea),* dogbane *(Apocynum* sp.*),* a white-flowering smartweed *(Polygonum* sp.*),* barnyard grass *(Echinochloa crusgalli),* umbrella sedge *(Cyperus* sp.*),* a white aster *(Aster* sp.*),* thistle *(Cirsium* sp.*),* Canada goldenrod *(Solidago canadensis),* wild mint *(Mentha arvensis),* yellow foxtail grass *(Setaria glauca),* and water purslane *(Ludwigia palustris).*

Forested wetland in Chandler Woods and wet area in Lower Armour Farm Meadow

Another Clenny/Wilson Run tributary flowing from northeast to southwest joins Clenny/Wilson Run at the upper end of Upper Pavilion Drive Pond. The upper most segment of this tributary above Woods Road was dry on 10/10/97 and lacked hydric soils therefore precluding it from qualifying as wetland. A wetland fringe along the tributary extends from a small waterfall below Woods Road downstream to Upper Pavilion Drive Pond. A seepy emergent wetland dominated by turtlehead *(Chelone glabra)* and elderberry *(Sambucus canadensis)* occurs on the eastern side of the tributary below Woods Road. Capped cisterns indicate past use of the area for spring water collection. Downstream of a second lower crossing of the tributary by Woods Road, wet meadow extends along the tributary. A representative sample point next to a spring house on the western side of the creek in an area where many cut logs have been placed supports a diverse mix of emergents including arrow-leaved tearthumb *(Polygonum sagittatum),* spotted touch-me-not *(Impatiens capensis),* purple-stemmed aster *(Aster puniceus),* and bulrush *(Scirpus* sp.*)* as dominants and curly dock *(Rumex crispus),* Canada goldenrod *(Solidago canadensis),* soft rush *(Juncus effusus),* purple-leaved willow herb *(Epilobium coloratum),* rice cutgrass *(Leersia oryzoides),* grass-leaved goldenrod *(Euthamia graminifolia),* sensitive fern *(Onoclea sensibilis),* and umbrella sedge *(Cyperus* sp.*)* in lesser amounts.

Upper Pavilion Drive Pond

In walking around Upper Pavilion Drive Pond, one sees “dwarfed” awl aster *(Aster pilosus)* in repeatedly mowed drier areas. Cup plant *(Silphium perfoliatum),* swamp milkweed *(Asclepias incarnata),* purple-stemmed aster *(Aster puniceus),* multiflora rose *(Rosa multiflora),* and alder *(Alnus* sp.*)* fringe the pond. Mud plantain *(Heteranthera reniformis)* and water purslane *(Ludwigia palustris)* grow in shallow water at the pond’s edge.

Waters with marshy pockets in Pavilion Woods

Drainageways that feed into Clenny/Wilson Run in the vicinity of the Picnic House and Pavilion have been manipulated. One such drainageway has some broader fringing areas of emergent vegetation and in many places has steep-sided banks that would qualify it as waters. At its upper end, grey hydric soils occur in an area supporting beggarticks *(Bidens* sp.*),* sensitive fern *(Onoclea sensibilis),* stiltgrass *(Microstegium vimineum),* and spotted touch-me-not *(Impatiens capensis).* Continuing downstream, one finds

drainage pipes along the western side of the drainageway that direct stormwater runoff from the nearby Visitor Parking Lot into the small stream. One also finds a series of breached walls crossing the drainageway that once impounded sections to create small pools. Wetland emergents including skunk cabbage *(Symplocarpus foetidus),* stiltgrass *(Microstegium vimineum),* New York fern *(Thelypteris noveboracensis),* clearweed *(Pilea pumila),* and aster *(Aster* sp.*)* grow on benches adjacent to the small stream. At its lower end, the drainageway is piped underground.

Lower Pavilion Drive Pond

Vegetation fringes Lower Pavilion Drive Pond. Upper Pavilion Drive Pond flows into this pond from the northwest, the previously described drainageway flows into the pond from the northeast, and another Clenny/Wilson Run tributary flows into the pond from the southwest. Numerous Canada geese utilize the lawn surrounding the pond and the pond itself. Fringing vegetation includes yellow iris *(Iris pseudacorus),* swamp milkweed *(Asclepias incarnata),* purple-stemmed aster *(Aster puniceus),* smartweed *(Polygonum* sp.*),* arrow-leaved tearthumb *(Polygonum sagittatum),* true forget-me-not *(Myosotis scorpioides),* false nettle *(Boehmeria cylindrica),* rose-mallow *(Hibiscus moscheutos),* willow *(Salix* sp.*),* beggarticks *(Bidens* sp.*),* soft rush *(Juncus effusus),* sedge *(Carex* sp.*),* curly dock *(Rumex crispus),* umbrella sedge *(Cyperus* sp.*),* mud plantain *(Heteranthera reniformis),* spotted touch-me-not *(Impatiens capensis),* halberd-leaved tearthumb *(Polygonum arifolium),* sensitive fern *(Onoclea sensibilis),* and primrose *(Primula* sp.*).*

Wet area in Negandank Meadow South 2 and forested wetland fringe north of Nursery Woods and Meadow

The Clenny/Wilson Run tributary that drains into Lower Pavilion Drive Pond begins in Negandank Meadow South 2 and has a manhole cover at its uppermost end. Seeps feed the tributary along its length and support a band of wet meadow. At its uppermost end, sensitive fern *(Onoclea sensibilis),* spotted touch-me-not *(Impatiens capensis),* and Canada thistle *(Cirsium arvense)* grow. Continuing downstream one find stiltgrass *(Microstegium vimineum)* and halberd-leaved tearthumb *(Polygonum arifolium)* in soils that were saturated on 8/6/98. Where the wetland band broadens, umbrella sedge *(Cyperus* sp.*),* common cattail *(Typha latifolia),* curly dock *(Rumex crispus),* true forget-me-not *(Myosotis scorpioides),* common arrowhead *(Sagittaria latifolia),* stiltgrass *(Microstegium vimineum),* aster *(Aster* sp.*),* and grass grow. On 8/6/98, the wetland band had been mowed across. Continuing downstream, one sees sprinkler heads along the tributary. Cardinal flower *(Lobelia cardinalis)* and primrose *(Primula* sp.*)* are dominant here. The wetland band along the tributary narrows moving downstream toward Lower Pavilion Drive Pond as the banks steepen. The stream in this stretch is generally shallow with a rocky to gravelly substrate, abundant leaf litter, and an average width of four feet. Common privet *(Ligustrum vulgare),* multiflora rose *(Rosa multiflora),* spotted touch-me-not *(Impatiens capensis),* and poison ivy *(Toxicodendron radicans)* dominate the narrow wetland band that extends along the stream here. White oak *(Quercus alba),* red maple *(Acer rubrum),* and sour gum *(Nyssa sylvatica)* are dominant trees in the adjacent upland forest fringe along the tributary. Flowering dogwood *(Cornus florida)* is present as well as common privet *(Ligustrum vulgare),* multiflora rose *(Rosa*

multiflora), and wineberry *(Rubus phoenicolasius).* Upland herbaceous layer and vine species include white ash *(Fraxinus americana)* seedlings, New York fern *(Thelypteris noveboracensis),* Asiatic bittersweet *(Celastrus orbiculatus),* and grape *(Vitis* sp.*).*

Marsh along Clenny/Wilson Run from Lower Pavilion Drive Pond to bridge at H.F. du Pont House

A band of marsh vegetation extends along the main channel that flows from Lower Pavilion Drive Pond. A diverse mix includes true forget-me-not *(Myosotis scorpioides),* sensitive fern *(Onoclea sensibilis),* moneywort *(Lysimachia nummularia),* English ivy *(Hedera helix),* poison ivy *(Toxicodendron radicans),* curly dock *(Rumex crispus),* Japanese honeysuckle *(Lonicera japonica),* multiflora rose *(Rosa multiflora),* aster *(Aster* sp.*),* spotted touch-me-not *(Impatiens capensis),* stiltgrass *(Microstegium vimineum),* mud plantain *(Heteranthera reniformis),* false nettle *(Boehmeria cylindrica),* iris *(Iris* sp.*),* cup plant *(Silphium perfoliatum),* primrose *(Primula* sp.*),* purple-stemmed aster *(Aster puniceus),* turtlehead *(Chelone glabra),* soft rush *(Juncus effusus),* and arrow-leaved tearthumb *(Polygonum sagittatum).*

On the south side of the main channel there is an abandoned quarry with natural seeps that feed a fern garden.

Wet area in Event Field/Old Gatehouse Meadow and forested wetland in Farm Hill Woods

A northward-flowing tributary joins the main channel a short distance beyond the quarry. The southwest arm of the tributary is lined with soft rush *(Juncus effusus)* in its uppermost stretch. Below a gravel crossing, a wet meadow band broadens and includes both soft rush *(Juncus effusus)* and sensitive fern *(Onoclea sensibilis).* Moving downstream, the channel meanders with sluggish flow. The stream suffers from Canada geese use and lack of shade. Continuing downstream along this southwest arm, the southern side becomes steeply banked and a shallow rivulet with good flow issues into the stream. Dense sweetflag *(Acorus calamus),* spotted touch-me-not *(Impatiens capensis),* and arrow-leaved tearthumb *(Polygonum sagittatum)* grow here. Numerous red-winged blackbirds were observed in this area. The southeast arm of the tributary has seeps at its uppermost end supporting spotted touch-me-not *(Impatiens capensis)* and garlic mustard *(Alliaria petiolata).* Moving downstream, the tributary qualifies as waters where it flows through a beech *(Fagus grandifolia)* and tulip tree *(Liriodendron tulipifera)* forest. Downstream of the confluence of the southwest and southeast arms of the tributary, it flows through open meadow and is flanked by emergent wetland. A drainage joins the tributary from the west. Below a road crossing the tributary flows through forest and is flanked by forested wetland. Seeps feed into the tributary along its length. Dominant herbaceous plants in the forested wetland include spotted touch-me-not *(Impatiens capensis),* fowl manna grass *(Glyceria striata),* and wood nettle *(Laportea canadensis).* Spicebush *(Lindera benzoin)* is dominant in the creek valley with non-native viburnums *(Viburnum* sp.*).* Near the confluence of the northward-

flowing tributary and the main channel, one find numerous alien shrub and groundcover species along the tributary.

Marsh along main channel from bridge at H.F. du Pont House to below Museum Road

Downstream of the confluence of the northward-flowing tributary and the main channel there is a shallow section of the main channel near a stone crossing and just upstream of where it flows under the Museum and Library. Here, one finds a great diversity of herbaceous plants along the channel including true forget-me-not *(Myosotis scorpioides)*, mud plantain *(Heteranthera reniformis)*, rice cutgrass *(Leersia oryzoides)*, lady's thumb *(Polygonum persicaria)*, beggarticks *(Bidens* sp.*)*, arrowleaved tearthumb *(Polygonum persicaria)*, beggarticks *(Bidens* sp.*)*, arrow-leaved tearthumb *(Polygonum sagittatum)*, umbrella sedge *(Cyperus* sp.*)*, spotted touch-me-not *(Impatiens capensis)*, yellow iris *(Iris pseudacorus)*, watercress *(Nasturtium officinale)*, stiltgrass *(Microstegium vimineum)*, burreed *(Sparganium* sp.*)*, smartweed *(Polygonum* sp.*)*, and halberd-leaved tearthumb *(Polygonum arifolium)*. Beyond where the main channel flows under the building, Japanese knotweed *(Polygonum cuspidatum)* fringes the southern edge of the creek.

Below the Museum and Library, a diverse mix of emergents continues to thrive in a fringe along the main channel. These species include curly dock *(Rumex crispus)*, true forget-me-not *(Myosotis scorpioides)*, clearweed *(Pilea pumila)*, stiltgrass *(Microstegium vimineum)*, spotted touch-me-not *(Impatiens capensis)*, lady's thumb *(Polygonum persicaria)*, water pepper *(Polygonum hydropiper)*, Japanese knotweed *(Polygonum cuspidatum)*, false nettle *(Boehmeria cylindrica)*, Canada goldenrod *(Solidago canadensis)*, reed canary grass *(Phalaris arundinacea)*, cup plant *(Silphium perfoliatum)*, hosta, dodder *(Cuscuta* sp.*)*, mint *(Mentha* sp.*)*, beggarticks *(Bidens* sp.*)*, halberd-leaved tearthumb *(Polygonum arifolium)*, and purple-stemmed aster *(Aster puniceus)*.

Downstream of Museum Road, the main channel broadens as it flows into a small triangular pond also fed by a tributary draining the rock garden. The channel above this small pond has Japanese knotweed *(Polygonum cuspidatum)*, cup plant *(Silphium perfoliatum)*, true forget-me-not *(Myosotis scorpioides)*, umbrella sedge *(Cyperus* sp.*)*, and willow *(Salix* sp.*)* along its length. Banded killifish live in this stretch of the channel as well.

Marsh in Quarry Garden

The Quarry Garden drains into the small triangular pond. At the upper end of the Quarry Garden one discovers that seeps feeding the lovely feature derive, at least in part, from the upslope pump house. In late summer, cardinal flower *(Lobelia cardinalis)* of multiple hues and great blue lobelia *(Lobelia siphilitica)* fill the garden. Below the garden, a flowing stream traces a curving path downslope with periodic low walls impounding small ponds. At the bottom of the slope a seep feeds into the stream from the northwest.

Triangular Pond

Mud plantain *(Heteranthera reniformis)* and water purslane *(Ludwigia palustris)* grow in mats in shallow areas. At the edge, one finds a fringe of spotted touch-me-not *(Impatiens capensis)*, false nettle *(Boehmeria cylindrica)*, water pepper *(Polygonum hydropiper)*, sensitive fern *(Onoclea sensibilis)*, true forget-me-not *(Myosotis scorpioides)*, swamp milkweed *(Asclepias incarnata)*, bugleweed

(Lycopus sp.*),* sweetflag *(Acorus calamus),* purple-stemmed aster *(Aster puniceus),* common water plantain *(Alisma subcordatum),* St. Johnswort *(Hypericum* sp.*),* mint *(Mentha* sp.*),* and curly dock *(Rumex crispus).*

East Barn Pond

East Barn Pond occurs downstream of the triangular pond. Cup plant *(Silphium perfoliatum)* and creeping water primrose *(Ludwigia peploides)* grow along the southwestern edge. The northern edge has a steep, abrupt, and eroded silty loam bank. Asiatic bittersweet *(Celastrus orbiculatus),* true forget-me-not *(Myosotis scorpioides),* spotted touch-me-not *(Impatiens capensis),* small white aster *(Aster* sp.*),* English plantain *(Plantago lanceolata),* Queen Anne's lace *(Daucus carota),* swamp milkweed *(Asclepias incarnata),* cup plant *(Silphium perfoliatum),* dogbane *(Apocynum* sp.*),* dodder *(Cuscuta* sp.*),* St. Johnswort *(Hypericum* sp.*),* multiflora rose *(Rosa multiflora),* and speckled alder *(Alnus incana)* grow along the northern edge. Seeps feed into the pond along its northern edge at the break in slope. The pond has submerged aquatic plants that swans feed upon. A great blue heron was observed here, too.

Forested wetland in Duck Pond Woods

A northward-flowing tributary feeds into the southern side of East Barn Pond. A southwestern arm of the tributary has a channel that was dry on 11/1/98 at its upper end. A seep-fed scrub-shrub area dominated by spicebush *(Lindera benzoin)* and spotted touch-me-not *(Impatiens capensis)* occurs downslope. Above the first road crossing, the small creek was flowing on 11/1/98. A wetland band of arrowwood *(Viburnum dentatum),* spicebush *(Lindera benzoin),* and garlic mustard *(Alliaria petiolata)* extends along the creek in this area. Below the road crossing, a narrow wetland band extends along the creek as it flows through beech *(Fagus grandifolia)* forest. A southeastern arm of the tributary also had a dry channel as of 11/1/98 at its upper end. Debris is strewn in this channel. Downslope, seeps feed a small wetland dominated by Japanese knotweed *(Polygonum cuspidatum),* multiflora rose *(Rosa multiflora),* and spicebush *(Lindera benzoin).* An old road crosses the lower end of this small wetland. A pipe under the old road disgorges water from the wetland into a narrow, steep-sided channel that would qualify as waters. Downstream seeps feed into the channel creating a relatively broad wetland area with spicebush *(Lindera benzoin)* and spotted touch-me-not *(Impatiens capensis)* dominant. Below the first existing road crossing the southwest and southeast arms join. Continuing downstream, a dry (on 11/1/98) steep-sided channel with abundant debris along its sides joins the tributary from the east. A broad band of forested wetland fed by numerous seeps issuing from the slope east of the tributary occurs below the second road crossing. The wetland supports spicebush *(Lindera benzoin),* skunk cabbage *(Symplocarpus foetidus),* clearweed *(Pilea pumila),* jack-in-the-pulpit *(Arisaema triphyllum).* Although some winged euonymus *(Euonymus alatus)* and Asiatic bittersweet *(Celastrus orbiculatus)* are present, the forested wetland is relatively natural. Downstream there are two ponds. At the eastern edge of the southern pond, Upper Duck Pond, one finds stiltgrass *(Microstegium vimineum),* halberd-leaved tearthumb *(Polygonum arifolium),* sedge *(Carex* sp.*),* spotted touch-me-not *(Impatiens capensis),* skunk cabbage *(Symplocarpus foetidus),* and beggarticks *(Bidens* sp.*).* Seeps feed into the southern end of the northern pond, Lower Duck Pond, to support wood nettle *(Laportea canadensis),* spotted touch-me-not *(Impatiens capensis),* hosta, and skunk cabbage *(Symplocarpus foetidus).* A steep bank extends along parts of the western and northern edges of the pond.

At the northern end, one finds a narrow wetland band of beggarticks *(Bidens* sp.*)*, water purslane *(Ludwigia palustris)*, and yerba-de-tajo *(Eclipta alba)*.

Wet area in East Barn Meadow and Route 100 Meadow

Downstream of East Barn Pond wet meadow grading to scrub/shrub wetland extends along the main channel. Upstream of the railroad embankment, one finds a diversity of herbaceous species including spotted touch-me-not *(Impatiens capensis)*, purple-leaved willow herb *(Epilobium coloratum)*, sensitive fern *(Onoclea sensibilis)*, sweetflag *(Acorus calamus)*, Canada goldenrod *(Solidago canadensis)*, trumpetweed *(Eupatorium fistulosum)*, swamp goldenrod *(Solidago uliginosa)*, and soft rush *(Juncus effusus)*. Multiflora rose *(Rosa multiflora)* and speckled alder *(Alnus incana)* are present here along with black cherry *(Prunus serotina)* seedlings, Japanese honeysuckle *(Lonicera japonica)*, and Asiatic bittersweet *(Celastrus orbiculatus)*. Downstream of the railroad embankment, one finds wet meadow extending along the main channel that is dominated by reed canary grass *(Phalaris arundinacea)* and New York ironweed *(Vernonia noveboracensis)* with an admixture of soft rush *(Juncus effusus)*, umbrella sedge *(Cyperus* sp.*)*, purple-stemmed aster *(Aster puniceus)*, moneywort *(Lysimachia nummularia)*, dwarf St. Johnswort *(Hypericum mutilum)*, dogbane *(Apocynum* sp.*)*, and poison-hemlock *(Conium maculatum)*. The main channel drains into Routes 100/92 Pond which has clumps of rose-mallow *(Hibiscus moscheutos)* around its edge.

Route 100 Meadow has a patchwork of upland areas dominated by broom sedge *(Andropogon virginicus)* with some New York ironweed *(Vernonia noveboracensis)*, aster *(Aster* sp.*)*, and Queen Anne's lace *(Daucus carota)* and wetland areas. A typical wetland patch supports soft rush *(Juncus effusus)*, New York ironweed *(Vernonia noveboracensis)*, beggarticks *(Bidens* sp.*)*, multiflora rose *(Rosa multiflora)*, dwarf St. Johnswort *(Hypericum mutilum)*, Queen Anne's lace *(Daucus carota)*, goldenrod *(Solidago* sp.*)*, sedge *(Carex* sp.*)*, moneywort *(Lysimachia nummularia)*, violet *(Viola* sp.*)*, broom sedge *(Andropogon virginicus)*, and a grass *(Paspalum* sp.*)*.

A straight ditch extending northeast across the broad meadow to Routes 100/92 Pond is fringed by wetland dominated by reed canary grass *(Phalaris arundinacea)* and New York ironweed *(Vernonia noveboracensis)*. Watercress *(Nasturtium officinale)* grows in standing water in the channel.

Ponds and forested wetland south of Bidermann Barn

A series of ponds occurs south of Bidermann Barn and west of Adams Dam Road. On 11/15/98, the area surrounding the uppermost pond, 15th Fairway Pond, appeared to have been recently reseeded and was devoid of vegetation.

The largest pond in the series, 11th Tee Pond, has a fringe of vegetation in some areas and has been mowed to the edge in other areas. Much of the southern edge of the pond lacks a vegetative fringe. The northern edge has some large patches of common reed *(Phragmites australis)* which is an aggressive species that should be controlled. Red maple *(Acer rubrum)* trees grow along part of the western pond edge south of a pumphouse. A narrow fringe of willow *(Salix* sp.*)* and common cattail *(Typha latifolia)* extends along the southwestern edge of the pond.

The stream draining from 11th Tee Pond flows through a concrete-lined channel for a short distance and then through a low broad area supporting forested wetland. White ash *(Fraxinus americana)* and silver maple *(Acer saccharinum)* dominate the canopy while black cherry *(Prunus serotina)* is a dominant sapling. An exotic shrubby honeysuckle *(Lonicera* sp.*)* and multiflora rose *(Rosa multiflora)* are common shrubs and spotted touch-me-not *(Impatiens capensis)* is a dominant herbaceous species.

Below the forested wetland, the stream is impounded to form a small pond, Golf Cottage Pond, surrounded by a narrow fringe of rose-mallow *(Hibiscus moscheutos)*, stiltgrass *(Microstegium vimineum)*, a smartweed species *(Polygonum* sp.*)*, and a sedge species *(Carex* sp.*)*. Below this small pond the stream, bordered along much of its length by a fringe of wetland, continues southeast and flows under Adams Dam Road.

Wet area along Adams Dam Road Hedgerow and Meadow

Wet meadow and forested wetland fed by seeps and a stream occur along the south side of Adams Dam Road west of Route 100. The first segment of wetland to be described occurs upstream of the railroad embankment, along Adams Dam Road Hedgerow. At the upper end of this wetland segment, an upland forest of tulip tree *(Liriodendron tulipifera)* and beech *(Fagus grandifolia)*, including one notably large specimen, grows on relatively steeply-sloping ground. Wetland begins at the break in slope. Forested wetland extends along a creek that crosses from the north to the south side of Adams Dam Road in this area. Sycamore *(Platanus occidentalis)* and black willow *(Salix nigra)* dominate the canopy while musclewood *(Carpinus caroliniana)*, American elm *(Ulmus americana)*, spicebush *(Lindera benzoin)*, multiflora rose *(Rosa multiflora)*, and Japanese barberry *(Berberis thunbergii)* are present in the understory. Pachysandra and spotted touch-me-not *(Impatiens capensis)* are dominant herbaceous species while Japanese honeysuckle *(Lonicera japonica)* is a common vine. A broad zone of wet meadow fed by seeps lies adjacent to the forested wetland. Reed canary grass *(Phalaris arundinacea)* dominates the herbaceous layer. Additional species include purple-stemmed aster *(Aster puniceus)*, lurid sedge *(Carex lurida)*, soft rush *(Juncus effusus)*, daylily *(Hemerocallis* sp.*)*, and goldenrod *(Solidago* sp.*)*.

From the downstream side of the railroad embankment to Route 100 is a second segment of wetland along the northern edge of Adams Dam Road Meadow. Reed canary grass *(Phalaris arundinacea)* dominates with sensitive fern *(Onoclea sensibilis)*, a smartweed species *(Polygonum* sp.*)*, spotted touch-me-not *(Impatiens capensis)*, common cattail *(Typha latifolia)*, climbing nightshade *(Solanum dulcamara)*, purple-leaved willow herb *(Epilobium coloratum)*, soft rush *(Juncus effusus)* also present. On 11/1/98, this segment of wetland had standing water present. At its lower end, the wetland drains under Route 100.

Wet area in Guyencourt Meadow

Wet meadow extends along the length of an unnamed tributary to Clenny/Wilson Run that flows south along the east side of Route 100 from Guyencourt to the ponds at the intersection of Routes 100 and 92. At the northern end, there is a relatively broad swath of wetland including a loop that extends eastward that is fed by seeps and supports at its upper end purple-leaved willow herb *(Epilobium coloratum)*, soft rush *(Juncus effusus)*, lurid sedge *(Carex lurida)*, monkeyflower *(Mimulus ringens)*, and purple-stemmed

aster *(Aster puniceus).* In the area north of a residential driveway crossing, the wetland plant assemblage is fairly typical and includes stiltgrass *(Microstegium vimineum),* purple-stemmed aster *(Aster puniceus),* purple-leaved willow herb *(Epilobium coloratum),* reed canary grass *(Phalaris arundinacea),* soft rush *(Juncus effusus),* blue vervain *(Verbena hastata),* sensitive fern *(Onoclea sensibilis),* swamp milkweed *(Asclepias incarnata),* seedbox *(Ludwigia alternifolia),* skunk cabbage *(Symplocarpus foetidus),* umbrella sedge *(Cyperus* sp.*),* and bugleweed *(Lycopus* sp.*).*

A significant spring-fed tributary to the aforementioned unnamed Clenny/Wilson Run tributary extends from east to west from Route 92. Wet meadow fills the swale. At its upper end, the wetland supports swamp milkweed *(Asclepias incarnata),* purple-stemmed aster *(Aster puniceus),* sedge *(Carex* sp.*),* reed canary grass *(Phalaris arundinacea),* New York ironweed *(Vernonia noveboracensis),* common cattail *(Typha latifolia),* soft rush *(Juncus effusus),* umbrella sedge *(Cyperus* sp.*),* purple-leaved willow herb *(Epilobium coloratum),* and sensitive fern *(Onoclea sensibilis).* Moving downstream, there is a recent fill pad placed across the swale with a culvert permitting continued flow. A similar species mix occurs downstream of the fill pad.

FISH

Field surveys were conducted by Jim White of Hyla Associates between September 14, 1997 and October 4, 1998. Seines, hand nets and small traps were used to capture fish. Table 1 in Appendix C presents a list of fish that may occur at Winterthur by habitat type. Table 7 is a "short list" of the species of special concern for fish designated by the Delaware Natural Heritage Program as "S1", "S2" or "S3" species, which indicates that they are of 1st, 2nd, or 3rd priority ranking for protection, respectively, out of 5 ranking categories. Included in both tables are species that are believed by Hyla Associates to be "probable" or "possible" on the property, based on past field experience in similar habitats, although they were not observed during this field survey.

All of the twelve relatively small ponds at Winterthur maintain populations of fish including American Eel, Common Carp, Brown Bullhead, Pumpkinseed, Bluegill Sunfish, Large Mouth Bass, and White Crappie. Clenny/Wilson Run supports a moderate diversity of piedmont stream fish, including Common Shiner, Black-nosed Dace, Creek Chub, White Sucker, and Tessellated Darter, whereas only Black-nosed Dace and Tessellated Darter were found in the smaller tributaries.

2.2 PHYSICAL RESOURCES AND FEATURES

2.2.1 Geology

Refer to Geology map.

Excerpted from Piedmont Basin Preliminary Assessment Report, *Delaware Department of Natural Resources and Environmental Control, www.dnrec.state.de.us, October 27, 1998.*

[Winterthur] lies within the Piedmont Province in Delaware. This geologic province, whose name literally means lying at the base or the foot of the mountains, occupies the northernmost, 6% of the state and is commonly referred to as "Delaware's hard rock country."

The geology of the Piedmont Province consists predominantly of a thick mass of highly deformed metamorphic and igneous rocks estimated to be more than 500 million years old, likely ranging from Proterozoic to early Paleozoic in age (Woodruff and Plank, 1995). These rocks are highly faulted, folded, jointed, and foliated in some areas. Gneisses and schists form the major rock types. Igneous intrusive rocks, including coarse varieties of granite called pegmatites, are also present in some areas. This crystalline mass is overlain with saprolite (weathered rock material) and in some isolated areas is capped with much younger fluvial sedimentary deposits. Recent work by Woodruff and Plank (1995) categorizes the Piedmont crystalline rock complex into five units. [Table 3] below provides their names, ages, and lithologies.

The Baltimore Gneiss forms the base upon which the younger Piedmont sediments were deposited. In Proterozoic time, the area was under water, and the Baltimore Gneiss formed the ocean floor. The Setters, Cockeysville, and Wissahickon formations were originally deposited as sedimentary cover over the Baltimore Gneiss (Woodruff and Plank, 1995).

The Cockeysville Formation resulted from shallow-water deposition of carbonates on a continental margin, while the Wissahickon Formation formed as a result of deep-water sedimentation and turbidity-current deposits. During Paleozoic time, a mountain-building event — the Taconic Orogeny (480 to 435 million years ago) — caused extreme deformation and metamorphism of the sedimentary deposits. This is when the majority of the Wilmington Complex rocks are believed to have formed (Woodruff and Plank, 1995).

Beginning in the Devonian Period (345 to 405 million years ago), much of the Piedmont Province emerged from the ocean and remained emerged until Cretaceous time. During this period, thousands of feet of crystalline rock were removed from the area by extensive erosion (Woodruff and Thompson, 1975). Delaware's Piedmont Province continues to undergo this weathering and erosion.

Due to the extensive saprolite mantle — in excess of 80 feet thick in some areas — fresh, unaltered exposures of the aforementioned rock units are not common. The saprolite's thickness in Delaware's Piedmont Province averages approximately 20 to 50 feet (Christopher and Woodruff, 1982).

Of the formations described, the Wilmington Complex and the Wissahickon Formation are by far the most widespread surficial units of the Piedmont Province. In contrast, the Baltimore Gneiss, Setters Formation, and Cockeysville Formation have been mapped only in the northwestern portion of the basin in small, isolated locations.

[Winterthur lies almost completely within the Wissahickon Formation with two small areas on the far eastern boundary, along Routes 92 and 100, within the Wilmington Complex.]

The Wissahickon Formation

The Wissahickon Formation forms the dominant rock type in the northwestern Piedmont Province and may be greater than 8,000 feet thick (Woodruff and Plank, 1995). This formation is less resistant to chemical and physical weathering than the Wilmington Complex. Thus, deeply incised stream valleys and steep slopes characterize this portion of the basin. Amphibolites and gneisses of the Wissahickon support ridges while mica schists erode to form deep-sided valleys (Christopher and Woodruff, 1982). The formation has considerably more secondary porosity than the Wilmington Complex and therefore has more capacity to store and transmit groundwater. Although high densities of joints and faults exist in some locations and may be able to support initial groundwater yields of 300 to 400 gallons per minute, groundwater typically yields 10 gallons per minute (Woodruff, 1981).

The Wilmington Complex

The Wilmington Complex represents the dominant rock type in the eastern Piedmont Province. This formation is more resistant to chemical and physical weathering than the Wissahickon Formation; for this reason, the eastern Piedmont Province is characterized by relatively gentle slopes and less deeply incised valleys than found in its western portions (Christopher and Woodruff, 1982).

Table 3: Rocks of the Piedmont Basin
(Adapted from Woodruff and Plank, 1995)

ROCK UNIT NAME	AGE (millions of years)	GENERAL LITHOLOGICAL DESCRIPTION
Wilmington Complex	340 Early Paleozoic Period	• Mafic and felsic gneisses and intrusive igneous rock including gabbroic and dioritic plutons and amphibolites
Glenarm Series Wissahickon Formation		• Gneisses and schists derived from sandstones and mudstones, amphibolites, and serpentinite
Cockeysville Formation Setters Formation	>570 Proterozoic Period	• Calcareous schists and dolomitic marble • Impure quartzite
Baltimore Gneiss	>570 Proterozoic Period	• Gneisses of varying lithologies and amphibolites

Wilmington Complex rocks are generally massive and do not exhibit significant secondary porosity (faults and joints). These rocks do not readily transmit or store groundwater and do not make good aquifers. An average domestic well in the Wilmington Complex typically yields one gallon per minute or less (Woodruff, 1981). Small quantities of groundwater of questionable quality do exists where the saprolite is of sufficient thickness.

Joints and other fractures in the bedrock, through which groundwater flows, are moderately abundant in metamorphic and igneous rock. Areas above jointed rock, usually evidenced by drainage swales, ephemeral streams, and spring-fed rills and brooks, will generally have greater infiltration rates and recharge capacities, and therefore, can be particularly good locations for stormwater impoundments that can also function as groundwater recharge basins. Because of these same characteristics, they can just as equally be sources of contamination to the groundwater.

2.2.2 Soils

The Soil Survey for New Castle County, Delaware (Natural Resources Conservation Service, formerly the Soil Conservation Service, 1965), divides the county into soil associations. A soil association is “a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.”

Winterthur lies with the Glenelg–Manor–Chester association (see Soils map). The Survey describes the association as follows:

This association is in one large area in the northern and northwestern parts of the county. It consists mainly of gently sloping to moderately sloping soils. On the bottomlands and crests, however, the soils are nearly level, and in some areas above streams they are steep. This association occupies about 15% of the county. Glenelg soils make up about 43% of the association; Manor soils about 28%; Chester soils about 14%; and minor soils the remaining 15%.

The major soils in this association are deep, well drained, and micaceous. The Glenelg soils have a subsoil of silt loam and silty clay loam that generally extends to a depth of not more than 36". The Chester soils have a subsoil of clay loam and silt loam that generally extends to a depth of more than 36". The Glenelg and Chester soils are more micaceous in their underlying material than in the material above it. The Manor soils are highly micaceous. They generally are fairly uniform loam throughout the profile; the subsoil is not finer textured than the surface layer.

The most important minor soils in this association are in the Glenville, Codorus, and Hatboro series. The Glenville soils occur mainly around the head of drainageways and at the base of slopes. They contain a brittle fragipan and are moderately well drained to somewhat poorly drained. The Codorus soils are moderately well drained, and the Hatboro soils are poorly drained. Both kinds of soils occur mainly on floodplains and are susceptible to flooding. Some areas are on foot slopes.

The major soils of this association provide good building sites, though slope is a limitation in places. In most places excavation is not difficult and is not limited by wetness. The soils generally have only slight to moderate limitations to use for sewage disposal by septic tanks. Care should be taken, however, not to place filter fields on steep soils or on wet soils of the floodplains.

2.2.3 Topography and Slopes

Winterthur's topography is very typical of the character of the underlying Wissahickon Formation — deeply incised stream valleys with steep slopes (see 2.2.1 Geology). The primary feature is the main Clenny/Wilson Run valley running roughly west to east. The ridges to the north and south of the stream have gentle, 0–8%, slopes on their tops with the side walls typically over 15% with large areas over 25% (see Slopes map). The highest elevation is approximately 432 feet, occurring in the northwestern corner of Bidermann Golf Course near the intersection of Center Meeting and Pyles Ford Roads. The lowest elevation, approximately 218 feet, occurs just below the Routes 100/92 Pond for an overall difference of 214 feet.

2.2.4 Existing Land Use

Meadows	± 468 ac.	48%	of total area
Woodlands and hedgerows	± 192 ac.	20%	
Golf course	± 150 ac.	16%	
Gardens, incl. Pinetum	± 52 ac.	5%	
Ponds	± 11 ac.	1%	
All other areas	± 93 ac.	10%	
Total	± 966 ac.		

Streams	28,000+ lf / 5.0+ miles
Railroad	3,500+ lf / 0.5+ miles
Roads	75,500+ lf / 14.0+ miles

(±80% are "improved")

3.0 Programmatic Uses

3.1 CURRENT USES AND EVENTS

3.1.1 Gardens

General admission to Winterthur includes access to the “Garden Area Proper” which is open from 9:00 A.M. to dusk year round except Thanksgiving, Christmas, and New Year’s Day. Maps are available for self-guided walking tours. Also included with the general admission is a 30–45 minute narrated tram ride through the garden and outlying areas of Winterthur. Topics covered include the history of the property and the story of Henry Francis du Pont, as well as aspects of nature, color, and seasonal interests. Guided garden walks, available for an additional $5.00, are offered on Saturdays and Sundays from late March through mid-June (except Easter and the first Sunday in May) and mid-September through late October.

3.1.2 Programs

Programs offered by the Garden Department have included garden lectures, horticultural and design symposiums featuring national and international experts and speakers, and the "Successful Gardener Series," a series of hands-on workshops for the home gardener.

3.1.3 Special Events

Special events have included "Picnicking Under the Cherry Blossoms," "Easter in the Garden," a family event, a "Plant Extravaganza" with experts available to answer questions, talks, guided garden walks, and plants and books available for purchase, and the annual Point-to-Point Races and Craft Festival. The Point-to-Point Races are held on the first Sunday in May each year with 20,000 to 24,000 people attending typically. The Craft Festival, which will have its fourth year in 1999, is a 2-day event over the Labor Day weekend with 180 juried craftsmen that attracts over 20,000 people.

3.2 FUTURE USES AND EVENTS

The following recommendations for additional or expanded programmatic uses related to environmental issues and concerns have been generated as a result of this study and from internal work sessions of the Winterthur staff.

3.2.1 Gardens

~ Highlighting native plants throughout the garden. A pamphlet or brochure could be developed that points out native plants throughout the garden and explains how they can be used in the residential landscape and the various benefits to wildlife and the environment.

~ Special subject tours, guided and/or self-guided, could include:

"*Birds in the Garden*," including ideas on how to attract them (in partnership with Delaware Audubon Society)

"*Native Plants in the Garden*" could complement and expand on the brochure mentioned above.

"*The Winterthur Estate/Farm*" could expand (both in content and route) on the current tour, but would probably require some road improvements

"*Winterthur's Natural Areas*" could highlight the woodlands, meadows, and wetlands and explain management and restoration techniques

3.2.2 Programs

~ Lectures and/or walks:

Birdwatching or nature walks combined with a breakfast (in partnership with Delaware Audubon Society)

Fungi identification combined with a dinner

~ Workshops:

Natural areas management and restoration techniques (in partnership with Delaware Nature Society, Mt. Cuba Center for the Study of Piedmont Flora)

3.2.3 Special Events

~ Arbor Day events could highlight native species as well as offer native trees for sale

~ Azalea Festival events could highlight native species as well as offer them for sale

3.2.4 Trails

The opportunity exists to utilize the natural areas to greatly enhance the recreational and educational experience of Winterthur visitors. A well defined trail system with interpretive materials (brochures, signage) could be used to tell a more complete story of the property, inform visitors of proper management techniques, and provide inspirational views of meadow vistas and the large trees of the woodlands. Figure 6 and the Management Recommendations plan show a potential trail system for the Winterthur property.

Figure 6 shows the proposed trail system in three phases. This is to allow Winterthur to experiment with increased public use of the natural areas and to evaluate the program throughout its implementation. Phase 1 uses the existing road network in Chandler Woods, which was previously an interpretive trail, and then creates new trails to incorporate Upper Armour Farm Meadow, Armour Farm Woods, and Negandank Meadow South 1. This network would highlight the healthiest woodlands on the property and introduce users to the meadow habitats as well as restoration measures such as afforestation, wetlands enhancement, and riparian buffers.

Phase 2, which includes the existing trails along Clenny/Wilson Run between East Barn Road and the railroad, adds a new trail along the north side of East Barn Pond, as well as a new trail through Browns Woods Meadow and Browns Woods, accessed from the Garden Lane. These trails would highlight aquatic habitat and riparian buffers and woodlands restoration.

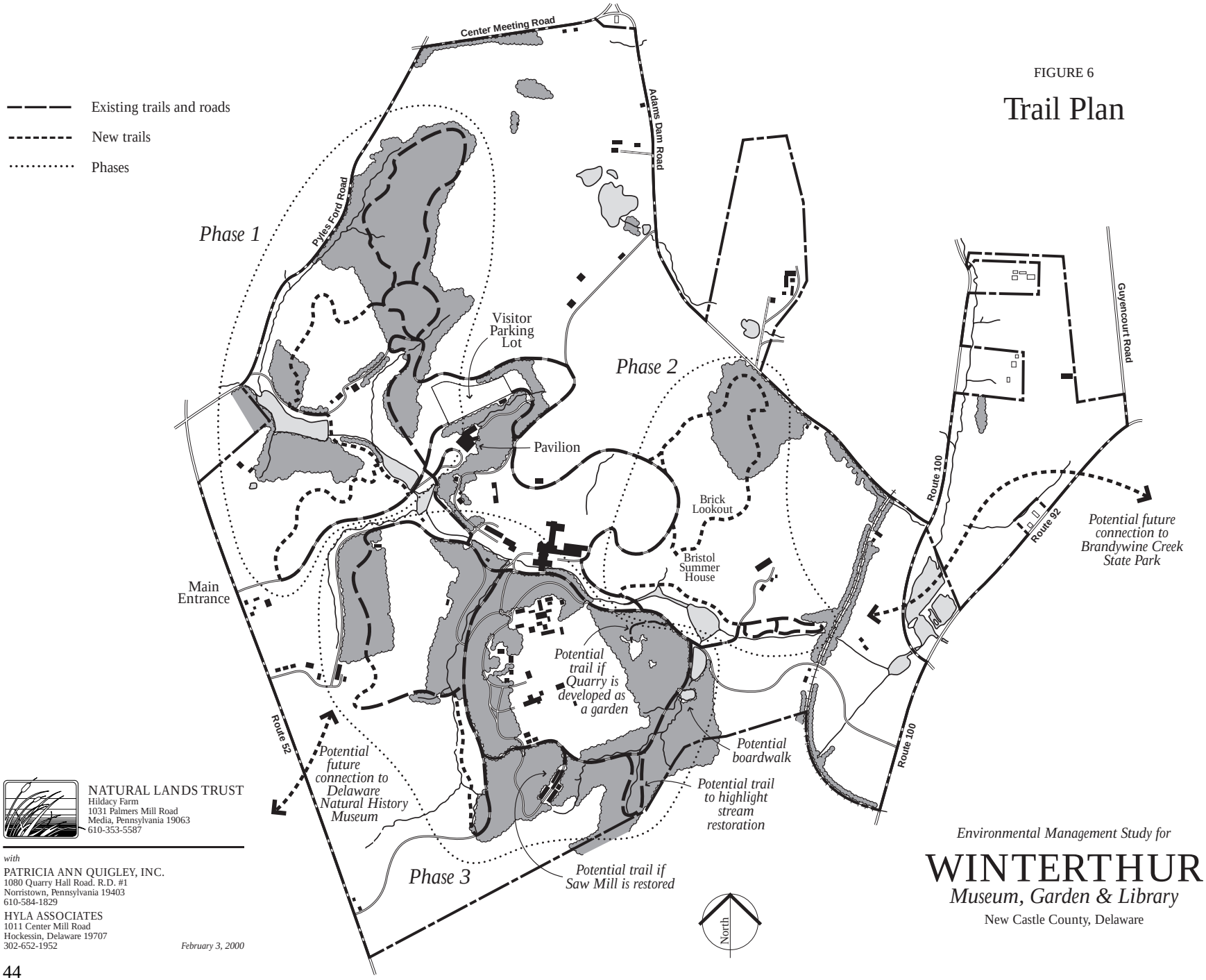
Phase 3 is indicated as the final phase because although its trails highlight interesting areas of Winterthur, they also take users through working areas of the property and more environmentally sensitive areas. A new trail is shown along the stream in the Event Field/Old Gatehouse Meadow that has been recommended as an afforestation and/or riparian buffer restoration area. Another trail, utilizing an old road, could highlight stream restoration measures. And there is a unique opportunity to construct a boardwalk through the exceptional wetlands associated with the Upper and Lower Duck Ponds.

3.2.5 Research and Education

The natural areas at Winterthur offer a wide range of research and educational opportunities through which Winterthur, local natural resource managers, and local schools and universities can benefit. Winterthur staff and other resource managers will benefit by receiving information that can assist them in better understanding and managing their natural areas. The academic world gains by

FIGURE 6

Trail Plan



Environmental Management Study for

WINTERTHUR

Museum, Garden & Library

New Castle County, Delaware

NATURAL LANDS TRUST
Hildacy Farm
1031 Palmers Mill Road
Media, Pennsylvania 19063
610-353-5587

with

PATRICIA ANN QUIGLEY, INC.
1080 Quarry Hall Road. R.D. #1
Norristown, Pennsylvania 19403
610-584-1829

HYLA ASSOCIATES
1011 Center Mill Road
Hockessin, Delaware 19707
302-652-1952

February 3, 2000

having access to relatively secure natural areas with diverse plant communities. In addition, supporting environmental education helps to educate the next generation to the importance of stewardship. Winterthur has already been approached by the Delaware Natural History Museum, the Delaware Audubon Society, and other organizations about use of the property. Other institutions that may be interested are the Academy of Natural Sciences in Philadelphia, Widener University, and the University of Delaware.

As an example, research projects and educational activities that are currently being conducted at Natural Lands Trust preserves include:

- ~ The simplification of structure and composition in southeastern Pennsylvania woodlands as a result of a complex of forces of human origin with adverse consequences for wildlife and plant diversity.
- ~ Exclosures and the effects of heavy deer browse on plant communities.
- ~ Reestablishing the American chestnut to the Eastern forest by breeding hybrids resistant to the chestnut blight.
- ~ If and how different management practices affect breeding bird populations.
- ~ The effects of prescribed fire on meadow plant communities.
- ~ Informal research to determine the most practical way to convert open land to forest in light of invasive vegetation and high deer populations. Treatments include plantations protected by tree shelters, natural regeneration, and natural regeneration protected with tree shelters.
- ~ Over the past several years the Trust has hosted two week-long teacher workshops at our Stroud Preserve focused on current resource management issues. These workshops are funded by the Pennsylvania Department of Conservation and Natural Resources and designed to disseminate knowledge of regional forest resources and what human activities are doing to these forests; the target audience was school teachers and their students in Chester County and nearby. The first program was entitled “People, Deer, and the Land” which ran from 1994-1995; the current program is called “Human Impact on Forests in Southeastern Pennsylvania.” One past participant in the program, an environmental science and ecology teacher, continues to bring a class to Stroud Preserve every fall and spring, to study the deer exclosure experiment set up there as a part of “People, Deer, and the Land.”

There are three resource management issues associated with research and education programs. The first is the concern for balancing public use policy with the need to protect research and interpretive sites from unintentional damage from property users (hikers) and vandals. Before promoting or increasing passive recreation, it must be ascertained how this will impact current or future research and education activities. The second concern is the potential impact on staff resources that would accompany these activities. While Winterthur has no plans to conduct research or educational projects itself at this point, there will be a need to coordinate and monitor the activities. Increases in staff demands could result in a reduced management level or lost research or educational opportunities. Finally, consideration should be given to possible conflicts with other existing programs such as agricultural leases and deer management.

3.2.6 Conservation Easements

A conservation easement is a legal agreement between a landowner and a conservation organization or government agency that protects land while leaving it in private ownership. The restrictions of the easement, tailored to suit the particular property and landowner's goals, permanently limit a property's uses in order to protect its conservation values. The easement binds all present and future owners of the eased land. A landowner generally donates the easement to a qualified conservation organization or government agency, which in turn ensures that the conditions of the easement are met over time.

Conveying a conservation easement is a way of making a tangible commitment to the preservation of the natural resources, cultural heritage, scenic beauty, and open spaces of a property, and the community in which it lies, for present and future generations. Winterthur is a significant property not only for its size, almost 1,000 acres of which 90% is open, but also for the diversity and health of the natural habitats that occur there. Over time, these lands will become more and more important as development pressures increase and open space and natural areas are lost. The property could also provide valuable information to local resource professionals trying to understand current ecological problems and to prepare for future ones.

Winterthur staff within the Garden Department have had discussions regarding whether to place a conservation easement on all or part of the property. Their recommended process for making a decision on the issue is to first have an understanding of what is to be accomplished and then making a commitment to proceed. This process would begin with the Garden Committee presenting a recommendation to the Executive Committee and then to the Board of Trustees. Once a commitment by Winterthur has been made, a qualified conservation organization or government agency would be selected and the necessary documentation prepared. The results of this Study will provide most of the information needed for baseline documentation of existing conditions.

The Board of Trustees for Winterthur has already begun to address these issues. The *Policy and Guidelines for the Gardens and Grounds,* May 1987, states that "Winterthur is committed to conserving the former estate and residence of Henry Francis du Pont." The Board also authorized this Study, which has a goal of developing and implementing a stewardship plan to assure that future management, events, and site development will be conducted in an environmentally responsible manner. The logical next step in ensuring this commitment into the future would be for the Winterthur Board of Trustees to consider conveying a conservation easement.

3.2.7 Future Site Development

The first step in identifying suitable areas for future site development is to identify areas which should not be developed. These "preservation areas" contain critical constraining natural features such as wetlands, hydric soils, and steep slopes which make them unbuildable. The next step is to identify "conservation areas" where development could occur, but in a limited manner; areas with fewer development constraints but important natural features. These include features that are still environmentally sensitive, such as soils with a seasonally high water table, moderate slopes, woodlands, and scenic viewsheds, but vary in importance, vulnerability, or fragility. Within each type of resource there are examples of greater and lesser significance—large and/or mature

stands of woodlands versus younger woodlands or those severely impacted by invasive vines. What remains are the areas most suited for development, the “potential development areas.”

The Future Site Development plan shows such an analysis of Winterthur. What this mapping does not include though, is scenic viewsheds. The determination of these are very site specific and involve many factors such as historical and cultural significance, botanical interest, and garden design which are outside the scope of this Study. Winterthur staff will need to overlay this information during the planning process for any future site development.

4.0 Land Stewardship

Winterthur's natural landscape offers an excellent representation of regional physiographic characteristics. Its balance of woodland, meadow, and stream habitats supports a diverse assortment of plant and wildlife species and beautifully compliments the formal horticultural areas. Like the Garden, these natural areas offer a unique menu of management challenges and opportunities. Successfully addressing the challenges and opportunities within such an important natural areas will require a serious, on-going commitment to stewardship based upon a long-term perspective of protecting and enhancing the natural communities and their environmental and ecological benefits.

All stewardship programs should be based upon the conservation priorities of the site. Conservation priorities can be ecological, recreational, historical, or programmatic depending on the context of the site within the local landscape, legal restrictions, the historical use of the property, and the goals of the landowner. Based upon Winterthur's goals and the existing natural resources within and around Winterthur, we recommend establishing the following conservation priorities to guide the management of the natural areas:

ECOLOGICAL:	Water resources of the Clenny/Wilson Run watershed
	Habitat for local wildlife
	Rare and endangered species
HISTORICAL:	Open landscape resulting from the design intent of Henry Francis du Pont
	Landscape design, including scenic views from the Garden
PROGRAMMATIC:	Environmental education for visitors
RECREATIONAL:	Natural environment for visitors and staff
BUDGETARY:	Human resources
	Financial resources

Once conservation priorities are established, a stewardship plan is developed to minimize the internal and external threats to these priorities with the further goal of enhancement. This chapter provides guidelines on which to develop a detailed stewardship plan. What follows are sections on woodlands and hedgerows, meadows, and aquatic resources that outline general recommendations for resource types, give specific recommendations for management units, and provide stewardship guidelines for achieving the recommendations. These are based upon the current health of each resource, a review of current management practices, and the goal to protect and enhance the conservation priorities listed above. There are also sections on trail design and maintenance, staffing and equipment, and priorities.

The recommendations offered within this report are based upon current information and technology and land management experience within other natural areas. These recommendations should not be implemented with blind faith in perpetuity. Because of the uniqueness of every property and the fact that we are dealing with evolving natural systems, the management regime should similarly evolve over time as new “bad actors” are identified, land management knowledge and technology change, and Winterthur’s goals are modified. Land stewards need to be aware of both the ubiquitous and site-specific natural processes involved and the potential of existing management techniques, but creative in applying each technique to (and developing new ones for) individual natural areas.

4.1 WOODLANDS AND HEDGEROWS

The woodlands at Winterthur were actively managed until the mid-1950s to produce lumber for in-house use. Until recently the woodlands were kept clean of all woody debris including standing dead trees. There was also periodic removal of invasive, non-native trees. The current management goal is to maintain them in as natural a state as possible. Aesthetics and hazards are the main concerns, particularly in the areas that receive more public use or scrutiny. In these areas, such as surrounding the Point-to-Point field, the woodlands are kept clear of woody debris and shrubs. Management in all other areas is largely done on an as-needed basis to remove down or hazardous trees and any obstructions to the internal roads. This is performed by both in-house staff and,

for larger trees, a contractor. The control of invasive vegetation has not been a management priority.

Given the conservation priorities and the current goals of Winterthur, there needs to be a significant increase in management of the woodland resources. Because of their many environmental, ecological, and human benefits every attempt should be made to sustain the woodlands on the property. Today there are serious threats to that goal. Addressing those issues and facilitating additional public use will require an increased commitment of staff resources (see 4.6 Staffing and Equipment).

The perpetuation of any woodland community depends upon the ongoing establishment of tree and shrub regeneration (seedlings and saplings) that are sufficient in number to occupy the gaps that are created by natural or human disturbance to the various structural layers (canopy, understory, shrub) within these plant communities. Throughout the woodlands and hedgerows of Winterthur there is a clear deficiency of native tree and shrub regeneration. Given the age of the canopy trees and their increased susceptibility to windthrow (as seen in the damage during 1998's summer storms), this lack of regeneration raises concerns for the perpetuation of all the existing woodlands and the loss of the genetic material that created these impressive communities. The presence of invasive vegetation further decreases the probability that the future wooded areas of Winterthur will come close to resembling the current woodlands.

The lack of tree and shrub regeneration results principally from competition with invasive vegetation for growing space and an overabundance of white-tailed deer. In order to perpetuate the existing woodlands it will be necessary to aggressively address these problems as soon as possible. If allowed to reach a crisis level (probably within the next two decades or after the next high wind event), the task of restoration will become formidable. More importantly, valuable ecological and human benefits will be lost for many decades.

4.1.1 General Recommendations

The primary management recommendations for the woodlands and hedgerows at Winterthur are:

- Control invasive vegetation through physical removal, chemical application, and the reduction of forest edge.
- Expand woodland areas to protect water resources, reduce edge, and create wildlife corridors between woodland parcels by releasing designated meadow areas to succession.
- Eliminate/minimize the practice of removing dead and dying trees.
- Reduce deer impact through increased harvest levels and protective devices (fencing, tree shelters).
- Establish 10 x 10 meter exclosures in several woodlands for monitoring and interpreting the deer impact on woodland vegetation.
- Improve aesthetics/eliminate hazards by cleaning up scattered trash, removing obsolete structures (with no historical, interpretive, or functional value) and materials, and consolidating needed materials (woodchips, soil) in least conspicuous area(s).
- Address stormwater erosion areas through maintenance and modification of man-made structures and stabilization of terrain and natural streams.

4.1.2 Woodland and Hedgerow Management Units

Refer to Figure 7 and the Management Recommendations plan.

14th Green/Halfway House Woods ± 1.0 / 0.3 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Low

REGENERATION: None

Vegetation Management / Restoration

- Plant native understory and shrub species.

Trails

Miscellaneous

Chandler Woods ± 48.5 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate

Norway maple and ailanthus invading edges and openings. Norway maple also invading interior. Vines and multiflora rose heavy along edges and within section bordering stream in southeast corner.

REGENERATION: Occurring in some woodland gaps

Vegetation Management / Restoration

- Remove invasive vines from interior, moving out to edges.
- Cut or girdle invasive trees and shrubs to encourage natural regeneration. Initial focus should be on Norway maple to increase sunlight to forest floor and encourage natural regeneration.
- Cut vines out of trees along stream in southeast section.
- Install exclosure to demonstrate impact of high deer population.
- Long term: replace non-native viburnums with natives.
- See Armour Farm Meadow for recommendations on creating a connection with Armour Farm Woods.
- See Lower Armour Farm Meadow for recommendations on afforesting area between Chandler Woods and Armour Farm Hedgerow.

Trails

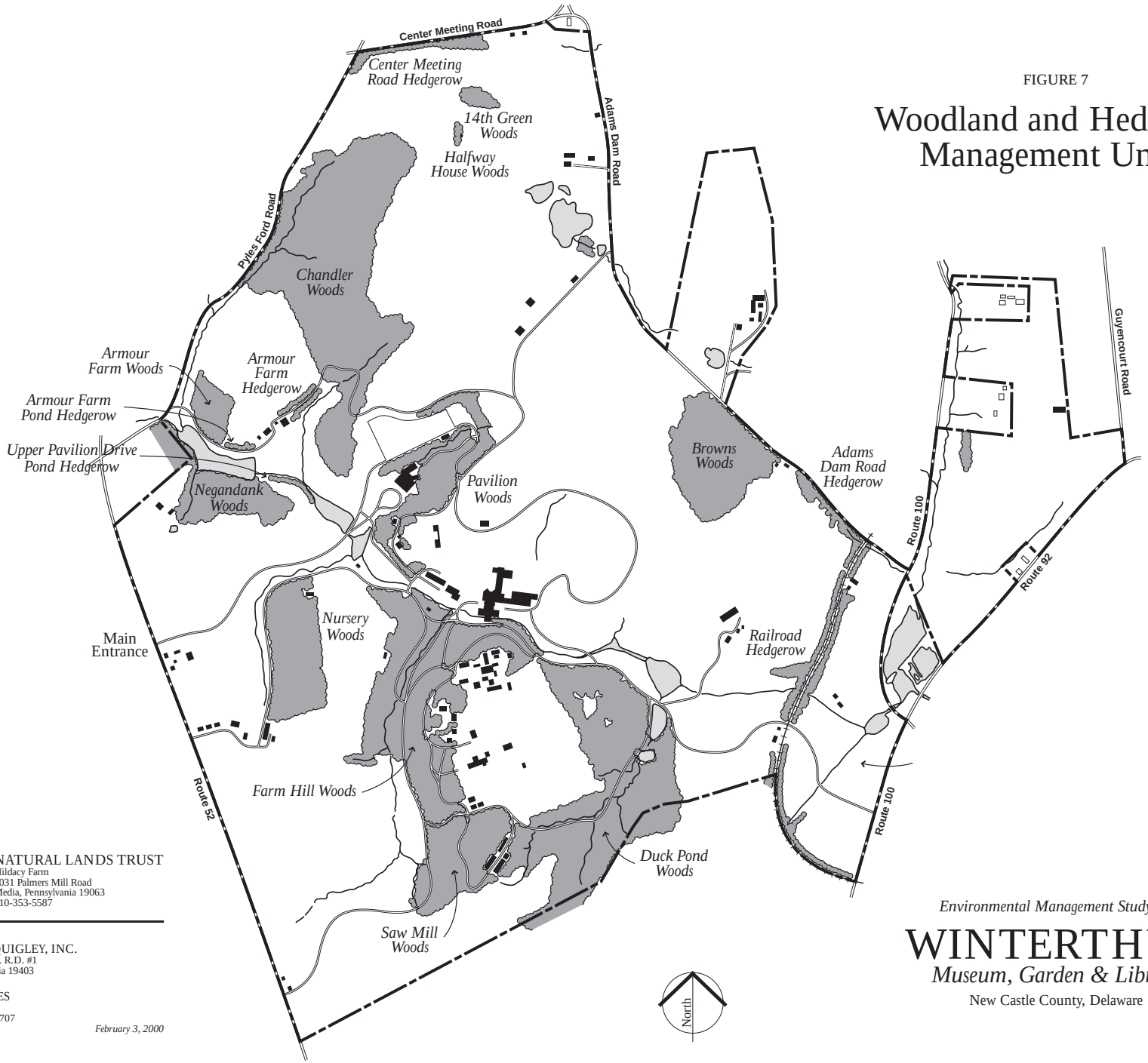
- Use existing old road network for trail system (see 3.2.4 Trails). Install restoration measures such as waterbars (see 4.5 Trail Design and Maintenance).

Miscellaneous

- Leaf and stump dumping occurring along northern edge with golf course. They are unsightly and

FIGURE 7

Woodland and Hedgerow Management Units



NATURAL LANDS TRUST
Hildacy Farm
1031 Palmers Mill Road
Media, Pennsylvania 19063
610-353-5587

with

PATRICIA ANN QUIGLEY, INC.
1080 Quarry Hall Road. R.D. #1
Norristown, Pennsylvania 19403
610-584-1829

HYLA ASSOCIATES
1011 Center Mill Road
Hockessin, Delaware 19707
302-652-1952

February 3, 2000

Environmental Management Study for

WINTERTHUR
Museum, Garden & Library
New Castle County, Delaware

encourage invasive vegetation. Remove existing piles, plant, and maintain area as meadow.

- Repair or remove pavilion along western portion of loop trail.
- Runoff from Bidermann Golf Course causing scouring/gullying at headwaters of stream in northwest section of woodlands (see 4.3 Aquatic Resources for recommendations).

Armour Farm Woods
± 4.0 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate on edges, low in interior

REGENERATION: Sparse, except for beech

Deer browse prominent. Sparse herbaceous layer.

Vegetation Management / Restoration

- Remove invasive vines from interior, moving out to edges.
- Cut or girdle invasive trees and shrubs to encourage natural regeneration. Initial focus should be on Norway maple to increase sunlight to forest floor and encourage natural regeneration.
- Install exclosure to demonstrate impact of high deer population.
- See Armour Farm Meadow for recommendations on creating a connection with Chandler Woods.
- Afforest area between Armour Farm Woods and Gate 6 along upper end of Armour Farm Pond.

Trails

- Create new trail (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).

Miscellaneous

- Remove scattered trash.

Negandank Woods
± 8.0 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Eastern half - moderate to heavy on edges, moderate in interior; western half - moderate on edges, moderate to low in interior

Japanese honeysuckle and privet throughout.

REGENERATION: Sparse

Understory trees fairly dense in eastern half, but sparse regeneration of natives. Deer browse prominent in western half. Sparse herbaceous layer.

Vegetation Management / Restoration

- Remove invasive vines from interior, moving out to edges.

- Cut or girdle invasive trees and shrubs to encourage natural regeneration. Initial focus should be on Norway maple to increase sunlight to forest floor and encourage natural regeneration.
- Install exclosure to demonstrate impact of high deer population.
- See Negandank Meadow South 1 for recommendations on afforesting area between Negandank Woods and Upper Pavilion Drive Pond Hedgerow.

Trails

Miscellaneous

- Remove old fencing, except along stream (it's acting as a silt fence).
- Remove scattered trash in western half.
- Runoff problem at southwest corner (see 4.3 Aquatic Resources for recommendations).

Pavilion Woods
± 10.0 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Low to moderate

REGENERATION: Sparse

Horticultural in nature.

Vegetation Management / Restoration

- Plant native understory and shrub species.
- Reduce areas of pachysandra, etc., by reusing in garden areas or selling to growers, and replace with native groundcovers.
- Plant ferns, rhododendrons, etc. in pine grove north of Visitor Parking Lot in order to eliminate need for spraying with herbicides.

Trails

Miscellaneous

- Some road runoff problems (see 4.3 Aquatic Resources for recommendations).
- Stream along Visitor Parking Lot: (1) stormwater outlet just up from Picnic House has significant erosion, (2) rebuild last dam to allow regular flow and slow storm flow, remove other dams (see 4.3 Aquatic Resources for recommendations).

Browns Woods
± 14.5 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate to heavy

REGENERATION: Sparse

Concern about advancing age of old growth (>150 years) canopy, windthrows opening up gaps. Problems primarily in understory and shrub layers.

Vegetation Management / Restoration

- Remove invasive vines from interior, moving out to edges.
- Cut or girdle invasive trees and shrubs to encourage natural regeneration. Initial focus should be on Norway maple to increase sunlight to forest floor and encourage natural regeneration.
- Install exclosure to demonstrate impact of high deer population.

Trails

- Trail potential (see 3.2.4 Trails and 4.5 Trail Design and Maintenance), but not high priority (out of the way), interpretive opportunities (tuliptree patch, other issues mentioned above).

Miscellaneous

- Remove scattered trash.
- Signs/evidence of vegetation “poaching.”

Nursery Woods
± 12.5 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Low to moderate
Invasives heavier along eastern edge.

REGENERATION: Sparse

Vegetation Management / Restoration

- Remove invasive vines from interior, moving out to edges.
- Cut or girdle invasive trees and shrubs to encourage natural regeneration. Initial focus should be on Norway maple to increase sunlight to forest floor and encourage natural regeneration.
- Install exclosure to demonstrate impact of high deer population.
- Reduce areas of pachysandra, by reusing in garden areas or selling to growers, and replace with native groundcovers.

Trails

- Incorporate existing old road/trail into trail system (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).
- Interpretive opportunity (is there a historical significance to nursery)?

Miscellaneous

- Remove fencing in interior and along southern edge.
- Buildings: reconsider use/removal (including paving).

Farm Hill/Saw Mill/Duck Pond Woods ± 81.5 acres

Woodland Health

INVASIVE VEGETATION IMPACT: Farm Hill and Saw Mill Woods - moderate to heavy for groundcovers and shrubs, low for canopy and vines; Duck Pond Woods - low to moderate for vines, moderate for shrubs, groundcover, and canopy

REGENERATION: Sparse

Vegetation Management / Restoration

- Remove invasive vines from interior, moving out to edges.
- Cut or girdle invasive trees and shrubs to encourage natural regeneration. Initial focus should be on Norway maple to increase sunlight to forest floor and encourage natural regeneration.
- Remove large patch of Norway maple along Old Gatehouse Road near where road from Gate 2 joins in and replant with native species.
- Experiment with larger exclosures to allow regeneration, ±5 acres at a time, starting with worst areas (biggest gaps) first.

Trails

- Incorporate existing roads into trail system (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).
- Potential trail along old road/trail looping around stream in Duck Pond Woods (see 3.2.4 Trails and 4.5 Trail Design and Maintenance). Opportunity for interpretation of stream restoration.
- Potential boardwalk trail system through wetlands surrounding Upper Duck Pond (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).

Miscellaneous

- Consolidate gravel, fill, curbing, wood, woodchip, limb piles. Perhaps some can be stored in unused structures such as the sheds at the Saw Mill or area around East Barn or Main Dairy Barn.
- Woodchip area in the old quarry is an attractive site for invasives. Consider storing them elsewhere, ideally on a hard surface where they can be picked up by a frontend loader, such as around East Barn or Main Dairy Barn. If they are coming from cleanup work in natural areas, either chip or cut brush in place (see Wildlife Management under 4.1.3 Woodland and Hedgerow Stewardship Guidelines). If they are not used on a regular basis, only chip as much as needed or investigate places that will buy chips or firewood.
- Discontinue practice of dumping and/or storing soil and organic debris in headwaters of stream southeast of Saw Mill.
- Review role of unused structures, remove those not necessary for current management needs or of historical importance.

- Saw Mill building #76 - fix up or take down.
- Runoff from Wilmington Country Club parking lot causing scouring/gullying of stream in Duck Pond Woods. Recommend approaching them about ways to ameliorate the problem (see 4.3 Aquatic Resources).
- Scouring/gullying occurring along stream draining into Duck Pond Woods from Farm Hill Meadow (see 4.3 Aquatic Resources for recommendations).
- Some road runoff problems (see 4.3 Aquatic Resources for recommendations).
- Culvert under road from Gate 2 to Old Gatehouse Road has some problems (see 4.3 Aquatic Resources for recommendations).
- Old Quarry - does it have historical significance? If it does, potential interpretive opportunity. Also potential horticultural value for a specialized garden planting.
- Remove scattered trash.

Hedgerows

Woodland Health

INVASIVE VEGETATION IMPACT: Moderate to heavy

REGENERATION: Sparse

Vegetation Management / Restoration

- Cut vines off canopy trees.
- Long term - remove invasive trees and shrubs and plant natives or allow to fill in.

Miscellaneous

- Remove scattered trash.

4.1.3 Woodland and Hedgerow Stewardship Guidelines

VEGETATION MANAGEMENT / RESTORATION

Invasive Vegetation

One of the most serious problems encountered in the management of open space in the southeastern Pennsylvania/ northern Delaware region is the presence of invasive vegetation. Woodlands and hedgerows smothered by vines and fields invaded by shrubs may offer food and shelter for birds and other wildlife, but they eventually create an unsightly landscape and restrict human transit. Most importantly, if left unchecked, invasives can rapidly destroy the native integrity and ecological succession of natural areas. Through their displacement of native vegetation they homogenize the structural and food resources of a site, thereby reducing its habitat value for native fauna, particularly songbirds.

An historical land use dominated by agriculture and logging, coupled with recent development, has effectively disturbed native vegetation in the region and, through its division and clearing of land parcels, added countless miles of the edge condition that is highly favorable to the proliferation of invasives. The misguided promotion of several exotic species for erosion and livestock control, and nearby horticultural plantings have provided enough seed sources for regional dispersal of numerous invasive species.

The control of invasive plants will be a perpetual concern of land managers in this region. The extensive edge areas and seed sources and the prolific nature of these plants guarantee that even with complete eradication on a given property, invasives can quickly reestablish themselves as a serious management problem. A strategy for coexisting with these plants is needed — one which will minimize their effect on the aesthetics and ecological stability of a property, with a minimum of management effort. Listed below is a general description of the management options followed by a prioritization methodology and recommended procedures for controlling invasive plants at Winterthur.

Management Options

In natural areas management, the most efficient and effective strategy usually results from a thorough understanding of the environmental forces in the area and the management goals that work with and not against these forces. This is true in developing a strategy for minimizing the impact of invasive plants. Any attempt to alter the vegetation of a site will succeed or fail according to its effects on the major forces (light, water, inorganic nutrients, atmospheric gases, collectively known as the "growing space") that support plant growth in that area. Given that growing space in any area is finite, successful management will be those practices which make more growing space available to desirable species and less to non-desirable species — in this case, invasives.

PHYSICAL REMOVAL

The most effective practice is the selective removal of invasives without disturbing the surrounding desirable vegetation. The invasive plant is denied any growing space and the surrounding desirable vegetation is well-positioned to occupy the vacated growing space. This approach is preferable whenever possible, although it is limited as a practical alternative by the available manpower and equipment relative to the size, quantity, and type of invasive(s) present.

Relatively small quantities of invasives can be effectively removed through manual pulling, digging with hand tools (shovel or spade) or pulling with a heavy duty truck or tractor. One specialized hand tool that works well on small single-stemmed plants is called a *Weed Wrench*. It is designed to clamp to the base of a tree or shrub and leverage the entire plant out of the ground. A tractor-mounted front end loader is ideal for removing larger trees or shrubs by several methods. One method entails elevating the lower branches with the bucket while a chain (a logging slip chain is best) is attached to the base of the plant and then, by raising the bucket, the plant can be removed from the ground. A second, easier tractor method is to use a single fork attachment on the front end loader to pop the shrub out by positioning the fork under the crown (the swollen area from which the roots and stem emerge) and raising the bucket. The third, and most efficient, method requires replacing the loader bucket with a new tool called a *Brush Brute* — a 4′ to 6′ steel frame with 18″ "teeth". With this tool you simply drive into the unwanted shrub or small tree until the base of the plant is impaled between the teeth and then lift the entire plant out of the ground.

Regardless of which means is employed, it is generally desirable to remove as much of the root system as possible (to prevent resprouting), although removal of the crown is usually sufficient to prevent rapid reestablishment of the plant. The degree of success through this method will depend upon the thoroughness with which the plant is removed and the speed at which desirable vegetation can occupy newly available growing space.

CUTTING

Removing some or all of the photosynthetic (food producing) area of the plant without disturbing the surrounding vegetation is another way to redistribute the available growing space and control invasives. It is less effective, but also less labor intensive, than physical removal. Cutting the plant with a pruner, handsaw, or lightweight chainsaw reduces its above-ground growing space without disturbing surrounding vegetation. However, the entire root system and any uncut stems can resprout and reoccupy the growing space. For this reason, it is best to cut the plant as low as possible to the ground and to combine it with an herbicide application (refer to Herbicides section for further details on use).

This option is most appropriate for controlling invasives in wooded areas. In this situation, the surrounding vegetation (trees) is usually situated above the residual live plant material. Because the surrounding trees limit sunlight needed for food production, the cut plant is forced to rely on stored root reserves to feed the remaining plant material and for refoliation. Although invasives are usually able to survive, they are weakened sufficiently to prevent them from achieving problem status for an extended period.

Cutting is less effective in open areas. In this case, their prolific nature allows invasives to quickly resprout and occupy the available growing space. The problem is alleviated only temporarily — cutting will be required again within a few years. This is particularly true at edge sites (where open fields meet woodlands) and hedgerows. There the vines gain the added benefit of tree support which they can utilize to occupy greater growing space to the detriment of the trees.

Late fall and winter are the most efficient and least painful times to perform cutting operations. Problem areas are more easily traversed and cool weather clothing gives added protection to the work crew. Following initial treatment, an annual or biennial inspection and control schedule should be adopted to prevent initial conditions from recurring. Frequent treatments are more effective in preserving the native integrity and aesthetic quality of the site.

PLANTING

Another option to remove growing space from invasives is through the planting of desirable species of trees and shrubs to increase the density of wooded areas and shade out invasives. It is particularly important to minimize the amount of interior and exterior edge of a woodland (high light areas where invasives thrive) by eliminating woodland gaps and rounding off borders with open areas.

In areas where invasives are a significant component, it is helpful to plant trees and shrubs where invasives have been removed. Killing or removing the invasives often disturbs the area and opens up the growing space. Invasives will quickly reoccupy the available growing space unless they are suppressed by other plantings.

Planting should occur in early spring or fall to optimize plant survival. Because they must compete with invasives, only species highly adapted to a site's condition (particularly light and soil water availability) should be planted.

HERBICIDES

In most cases the exclusive use of herbicides is not an effective long-term solution for controlling invasives. Difficulties in delivering an adequate amount of the chemical only to the target plants at the correct time in their growth cycle, and the potential

health risks to workers and the environment are all legitimate drawbacks to their use. In addition, inherent in the sole reliance on herbicides is a “once and done” attitude that is not conducive to the long-term control of invasives. Used appropriately, however, herbicides can be an important tool for land managers in certain situations. Herbicides should only be applied by personnel properly trained in both the safe use of each herbicide and the identification of desirable verses undesirable species.

To safely administer herbicides to the target plant it is best to minimize the above-ground volume of the plant prior to herbicide application. To control small trees, shrubs, or vines, apply an herbicide with glyphosphate (such as *Roundup*) to the fresh sprouts two weeks after cutting. Larger plants can be most effectively controlled by applying *Garlon* or *Roundup* directly to the freshly cut stump. This second method works best in fall and winter when sap flow is into the roots.

FIRE

Fire has been a major influence in the evolution of the herbaceous flora of this area. Deliberate fires set by Native Americans and colonists, and accidental lightning fires gave a strong edge to fire tolerant species. The use of fire to control invasives by giving an advantage to desirable native species is an exciting new application for an old management tool. The difficulty in utilizing this tool is the obvious destructive power that can arise from its misuse. Local governments and fire companies are often not receptive to the use of fire. Some fire companies, however, use controlled burns as training exercises. In certain circumstances, the potential benefits for the control of invasives may be sufficient to face the bureaucratic challenge.

As with herbicides, only properly trained individuals should utilize fire as a management tool. To be effective and safe, weather and fuel conditions must meet narrow parameters. It is usually best to burn in early spring since invasives usually sprout before native species. Before undertaking a burn you should also acquire any necessary permits and notify neighbors, local authorities, and, of course, the local fire company. Natural Lands Trust developed an in-house fire team several years ago and would be more than willing to discuss the process with Winterthur’s staff.

SUMMARY

There are many techniques available for controlling invasive vegetation. These options are not mutually exclusive. Usually the control of invasives on any given site requires a combination of two or more methods. The exact mixture and timing will be unique to each site. What will be common to all sites is the fact that the prolific nature of invasive plants mandates periodic monitoring and control to prevent a major disruption to the aesthetics and ecology of the impacted site.

Prioritization

In general, the future rate of woodland degradation is inversely proportional to the current level of degradation. When a single tree within a healthy, closed canopy forest is toppled by invasive vines the resulting gap (loss of growing space to desirable species) has a major impact on the surrounding trees — providing ideal conditions for the rapid establishment and spread of invasives within the gap to adjacent trees. On the other hand, the loss of a single tree in a heavily degraded, open canopy area creates relatively little change in the amount of growing space controlled by invasives. The first goal of restoration should be to protect that

portion of the community that controls the most growing space, which, in the case of a woodland, is the canopy trees.

The focus of initial restoration efforts, therefore, should be to halt the degradation within the healthiest areas, moving then to the moderately impacted areas, and so on to the most degraded areas. Those areas that are severely impacted should, for now, be left for "dead." Since they essentially cannot degrade any further, their restoration (which will usually require significant resources, including heavy equipment and years of high maintenance) is best left until the healthier, less impacted sites are stabilized. This approach is also healthier, psychologically, for the personnel involved in restoration. Spending the initial phase of a project stabilizing the majority of a site is more rewarding than struggling through a highly impacted area that is only a small portion of the site.

Generally, the order of initial restoration work should be as follows:

1. Cutting vines in the relatively healthy woodlands with low to moderate impact by invasive vegetation. In most cases this can be accomplished with a minimal amount of staff resources, usually less than half an hour per acre.
2. Reforesting woodland gaps. This will allow the canopy to close quicker and deter the establishment of invasive vegetation. The options are: (1) installing deer fencing and relying on natural regeneration; (2) planting seedlings and protecting them from browse with deer fence or tree shelters; and (3) planting large-sized material that is above deer browse height.
3. Cutting (or girdling) and herbiciding understory invasive trees in low to moderately impacted areas. This will free up growing space for existing desirable vegetation (native tree seedlings and saplings, and shrubs) and for new seedlings to become established through natural regeneration or planting. The amount of time to accomplish this will vary by the level of invasion and size of trees, but in most cases will not be substantial, averaging one to two hours per acre.
4. Correcting miscellaneous problems (dumping, vandalism, erosion/stream degradation, trail erosion, encroachment) that may, if left uncorrected, lead to larger, more costly problems in the future.
5. Cutting vines in the moderately to heavily impacted woodlands. Unless they are severely impacted by invasive vines, canopy trees usually respond by putting out new growth to capture more of the growing space. This helps to deter the amount of subsequent resprouting and new establishment of invasives. These areas will require a more substantial amount of staff time — on average ranging from two hours to two days per acre.
6. Reducing ornamental groundcovers. Invasive exotic groundcovers such pachysandra, English ivy, and to some extent, Japanese honeysuckle, can spread steadily through even relatively old growth forests. These species can form dense evergreen mats that will overrun and out compete the native herbaceous vegetation. Many plant species including many of our prized spring ephemeral wildflowers cannot successfully compete with these aliens for the available space, sunlight and nutrients of the forest floor. The diversity on the forest floor can be seriously reduced if these groundcovers are allowed to continue to spread unchecked. It is strongly recommended that a control program be put in place that would work to eradicate or at least control the patches of pachysandra and English ivy that are growing in

the woodlands at Winterthur. If these plants are left to grow unchecked the magnificent woodlands and the biodiversity that they maintain will be seriously degraded.

Priorities may need to be modified for best short-term efficiency of labor and long-term results according to the time of year or availability of labor. For example, the cutting and herbiciding of understory invasive trees is best done during fall and early winter when sap is flowing into the roots, while the planting of seedlings is best done in the late winter and early spring. If labor is first available in the spring, then it would be best to plant seedlings in moderately to heavily impacted woodlands and wait till the fall to cut the invasive trees in low to moderately impacted areas.

Recommended Procedures

REMOVAL

- Groundcovers and Vines

INVASIVE AND/OR UNDESIRABLE SPECIES:

Ampelopsis brevipedunculata	porcelain-berry
Celastrus orbiculatus	Oriental bittersweet
Euonymus sp.	euonymus
Hedera helix	English ivy
Lonicera japonica	Japanese honeysuckle
Pachysandra terminalis	Japanese spurge
Toxicodendron radicans	poison-ivy
Vinca minor	common periwinkle
Vitis sp.	grape vine
Wisteria sp.	wisteria

EQUIPMENT: Pruners, pruning saws, loppers, blade weedwhips, chainsaws, herbicides

PROCEDURES: Groundcovers can be pulled on a regular basis or herbicides can be used to control or eliminate patches. A mixture of *Garlon* and diesel fuel has been used successfully at the Delaware Nature Society when sprayed on foliage in the winter. Care must be given to not spray non-target species.

Start by cutting larger vines on canopy trees and work down to saplings and shrubs. Cut woody vines at ground level and at least 5′ above ground level and remove from trees if it won't cause damage. Immediately following cutting, large stumps should be painted with a systemic herbicide such as *Roundup* or *Garlon.*

- Shrubs and Saplings

INVASIVE AND/OR UNDESIRABLE SPECIES:

Acer platanoides	Norway maple
Ailanthus altissima	tree of heaven
Berberis sp.	barberry
Berberis thunbergii	Japanese barberry
Elaeagnus angustifolia	Russian olive
Elaeagnus umbellata	autumn olive
Euonymus alatus	winged euonymus
Ligustrum sp.	privet
Ligustrum obtusifolium	privet
Ligustrum vulgare	common privet
Lonicera maackii	Amur honeysuckle
Lonicera tatarica	Tartarian honeysuckle
Lonicera xylosteum	European fly honeysuckle
Rhodotypos scandens	jetbead
Rosa multiflora	multiflora rose
Viburnum cultivars	viburnum
Viburnum dilatatum	linden viburnum

EQUIPMENT: Pruners, pruning saws, loppers, blade weedwhips, *Weed Wrench*, chainsaws, tractor-mounted brush hog, front-end loader, herbicides

PROCEDURES: Eliminate or control invasive and undesired shrubs and saplings by manually or mechanically pulling or by cutting. Stumps cut manually should be immediately painted with a systemic herbicide such as *Roundup* or *Garlon*. In areas that have been brush hogged, cleanly recut all saplings over 2″ in diameter and immediately paint with the systemic herbicide. Limbs and related debris can be flychipped on-site or removed if there are viable fruits.

- Trees

INVASIVE SPECIES:

Acer platanoides	Norway maple
Ailanthus altissima	ailanthus, tree of heaven

EQUIPMENT: Pruners, pruning saws, loppers, *Weed Wrench*, chainsaws, front-end loader, herbicides

PROCEDURES: In areas adjacent to trails and other high use locations, drop invasive and hazardous trees without damage to surrounding desirable trees and either let lay as is or section trunks to create brush piles for wildlife habitat (see below). Trunks and limbs of Norway maple (ailanthus will decay rapidly) that are large (>6″ diameter) and straight (>8′ sections) may be useful for trail stabilization and restoration. Stumps of trees felled should be cut flush to the ground and immediately treated with a systemic herbicide such as *Roundup* or *Garlon*. (Note: In many areas ailanthus will root sprout vigorously following cutting, even with herbicide treatment. If this occurs do not cut, but apply herbicide directly to the bark at the base of the tree using oil-based *Garlon* mixed with a basal oil). Smaller limbs and related debris should be left to rot (see Wildlife Management under 4.1.3 Woodland and Hedgerow Stewardship Guidelines) or fly-chipped on-site. In areas with limited public use, larger (>6″ diameter) trees can be girdled to create future snags for wildlife. All dead trees, snags, or branches that do not pose a safety hazard or a threat to the ecological health or stability of the woodlands should be left for wildlife benefit.

To create a brush pile, first build a base by placing four large logs, set 1′ apart and parallel to each other, and then placing four more logs of the same size, stacked perpendicular to the first logs. Add brush to the top and sides, starting with the larger limbs first, then adding smaller pieces until the pile is about 6′ high and 6′ wide.

PLANTING

As mentioned previously, it is particularly important to establish trees and shrubs in wooded areas where invasives have been removed. This can be done through natural or artificial (planting) regeneration. The former is the preferred method because new seedlings will be derived from a gene pool that has evolved under the environmental conditions of the property over centuries. Currently, this is not an option at Winterthur because of the overabundance of deer. If deer impact cannot be reduced through increased hunting pressure or fencing, or if natural regeneration is insufficient for other reasons (weather, insects, etc.), planting of woodland gaps will be necessary.

Only straight (no cultivars) native tree and shrub species appropriate to site conditions should be used. Selecting species

that are high in wildlife food and cover value increases the benefits. They should also be locally grown if possible. Ideally, they would be grown from on-site plants. Trees should be 4′ – 6′ tall at planting to assist in survival from invasives and so that most of their foliage is above deer browse line. The Delaware Nature Society has had good success planting container trees, both potted and trees in tree bands. They have found them easier to plant and the trees have a much greater survival rate than bare root trees, especially if soil conditions in the planting area become dry. Planting container trees also extends the planting season.

Woodland gaps should be planted with trees on roughly 10′ x 10′ spacings and protected from deer damage with fencing, tree shelters, flexible tree wraps, or rigid stakes. Fencing and tree shelters prevent deer from browsing leaves and buds. The tree wraps and stakes minimize damage to the bark and cambium layer (girdling) of young trees caused by deer antler rubbing. The wraps should cover the trunk from 1′ to 5′ above the ground. The stakes should be placed in the ground close to, and on opposite sides of, the trunks. They can be made of wood, metal, or other rigid materials (including bamboo) and should be at least 5′ tall (above ground). Shrubs should be a minimum of 18″ – 24″ tall at planting. Without deer control, only highly unpalatable species, such as spicebush, should be planted.

Planting design should be spaced to allow for control of competing vegetation, but close enough for the canopy to close quickly. It should also be naturalistic in form, i.e., fitting in with existing trees and undulating in outline.

Watering at the time of planting is recommended, especially if the plant is planted with foliage and not during optimal planting times. If water is easily accessible, water all plants at time of planting to help remove air pockets from backfilled soil. Monitor the plantings for at least the first summer, watering them if conditions become very dry. A little maintenance goes a long way. If available, put a layer of mulch 2″ – 3″ thick over the planting area, but no closer than 2″ to the trunk.

SCHEDULE

Invasive and undesired vegetation removal is best done in September through February when systemic herbicides are most effective (sap is flowing into the roots). Conduct removal when site conditions are appropriate, i.e., preferably when the ground is frozen, or otherwise, when the ground is dry.

Plant trees and shrubs in early spring before they leaf out or in early fall to allow for root growth before the ground freezes. If needed, install flexible tree guards in August and remove in January, until the tree is large enough (2″ in diameter) to withstand buck rubs.

ON-GOING MANAGEMENT

Following restoration, every effort should be made to minimize future disturbance to woodlands, both from natural and human sources. This includes removing any trash and monitoring annually for intrusion or regrowth by invasive and/or undesirable plants.

Control invasive trees and shrubs through spot spraying or wick application of an appropriate systemic herbicide or manual or mechanical pulling. Areas that are disturbed by removal should be replanted with native trees and shrubs and mulched with woodchips or on-site leaf litter. Any resprouting invasive and undesirable vines should be prevented from climbing into trees and shrubs by pruning at a minimum. They should eventually be eliminated through spot spraying or wick application of an

appropriate systemic herbicide or manual or mechanical pulling and replanting of the area with native trees and shrubs.

Until natural regeneration becomes adequate, the planting of trees and shrubs should continue on an as-needed basis to assure that sufficient regeneration is available to replace canopy trees as they die. Reduce vegetative competition through selective cutting or herbicide use around the base of trees during the growing season until the canopy has closed.

WILDLIFE MANAGEMENT

Wildlife management includes activities to both encourage desirable species and discourage pest species. Typically, wildlife management focuses on wildlife species that satisfy a human commodity (food, clothing, or trophy) or recreational need (birding). However, there are many wildlife populations (soil microorganisms, insects, small mammals) on which these target species ultimately depend that should also be considered when managing natural areas. Modifying management activities to support those unseen populations can have significant benefits to those species humans find desirable. The following excerpt from *The Once and Future Forest* by Leslie Sauer (Island Press, 1998) provides a good perspective on how nutrients and energy flow through natural woodlands and how management activities can enhance restoration in general along with local wildlife populations that are desirable by humans.

Restoration of woodlands should include looking not only at the processes going on aboveground, but the ones occurring underground, within the soil, as well. In time, the organic litter on the forest floor will create humus, an organic soil horizon. Within it, most of the life of the soil occurs. As organic matter is continually broken down into humus, it becomes incorporated into the mineral layers of the ground surface to build topsoil.

Plants are the primary producers of organic matter in the forest soil system. Ants and other invertebrates initiate the breakdown of ground-layer litter. Soil microorganisms including fungi, bacteria, protozoa, and actinomycetes continue this process of converting organic matter into soil minerals that in turn become available as nutrients to plants. In food web nomenclature, these organisms are "consumers." Primary consumers (herbivores) feed directly on the "producers," which are the plants; secondary and tertiary consumers are predators and parasites, which feed upon each other as well as upon herbivores. Food webs also contain other decomposers and detritivores that feed on litter, such as mites, woodlice, and earthworms. Woodlands typically support more diverse assemblages of soil organisms than grasslands.

The soil food web performs the primary function of the soil, which is to cycle energy and nutrients, including nitrogen, sulfur, and phosphorus. Native soil systems are very efficient and succeed in recycling, for example, upwards of 80 percent of the nitrogen in the system. The cycling of nitrogen is intimately associated with the cycling of carbon, which is tied up largely in organic matter. Nitrogen, in part, determines the rate at which carbon is broken down. Bacteria and fungi take up the nitrogen as they decompose soil organic matter, and some fix atmospheric nitrogen. This nitrogen too is released into the soil to be again available to plants.

While herbaceous litter is primarily cellulose, the litter of the forest becomes increasingly higher in lignin, the woody component of plants. Tree leaves have more lignin than grasses, and the leaves of late successional species, like beech and oak, typically have more lignin than ash, tulip poplar, and other early successional species. In woodlands an important shift occurs as leaf fall and other litter become the most important sources of organic matter, rather than the direct contribution of carbon by the roots as in grasslands. There are also larger volumes of wood on the ground in the form of fallen twigs and limbs, which directly foster fungi because bacteria are unable to decompose lignin. The mycorrhizal filaments from tree roots reach up into the old wood to

extract the valuable nutrients. Insects such as beetles and ants are also able to break down wood. Wood in contact with the soil and standing dead trunks, "snags," create many opportunities for various wood and soil invertebrates of the forest.

Another important role of dead wood is to serve as a water reservoir for the forest in times of drought. Dead wood, especially larger logs approaching a foot or more in diameter, soaks up water like a sponge and retains it for long periods. Old logs or stumps make great nursery sites by carrying vulnerable seedlings through dry spells. Salamander populations also depend on large logs for needed moisture, which is, in part, why they are absent so long after clearcuts and timbering, although they may number one or two per square yard in old-growth forests. Logs increase local stormwater retention as well by inhibiting overland flow and by absorbing water in place.

[Therefore,] as a rule, individual dead trees should be left in the landscape as "snags" wherever possible. They are used as dens by many animal species and harbor insects and microorganisms that provide food for many other animal species. Woodpecker populations, for example, have increased dramatically in some places where gypsy moths have killed large numbers of oak trees.

A useful guideline is to leave at least three to five standing dead trees per acre for wildlife. Fallen logs and branches are also important to leave in place because they absorb and hold moisture like a sponge.… Where logs are abundant, some can be moved to other locations where there is too little dead wood. The logs can also be placed along slopes to help control erosion. Partially submerged logs can be placed along shorelines to benefit fish, birds, and amphibious organisms. Logs in a stream both aerate water and provide additional habitat opportunities. Leaf litter and woody debris also can be reused elsewhere to add organic matter to eroded sites and to foster the restoration of important soil fungi and insects.

Where access is limited and chipping wood is not feasible, you can use the fine branches to build the litter layer. Brush may be temporarily effective in limiting access and discouraging trampling. When depositing brush on a slope to help control erosion, seek to create as natural an appearance as possible, mimicking the appearance of fallen limbs.

A brush pile, if well sited… provides attractive and relatively safe shelter to wildlife in a small fragment of natural habitat, where small mammals and reptiles are often more visible and easily attacked. Such a shelter is also valuable in reducing mortality in winter and from vandalism. Brush piles also improve long-term soil quality and provide habitat for soil organisms. [See discussion of how to create a brush pile under Recommended Procedures above.]

Where there is a blowdown or other dead tree and you are not constructing a brush pile, leave the trunk and root mass in place. You can also partially cut up the branches to provide a higher degree of soil and wood contact. Cut the branches into pieces about 12 to 20 inches long and place them in the vicinity directly on the ground to maximize contact with the soil. Leave the stump as a snag if it provides no hazard. The soil mound thrown up by a fallen tree as well as the large log are ideal seedbeds for delicate species.

Deer Management

Human disruptions to natural areas and predator populations have resulted in certain species reaching population levels that threaten the health of other animal and plant populations through reductions in biodiversity and plant regeneration. Although, as with invasive plants, the "let nature take its course argument" may ultimately have merit, the risk of losing animal and plant species in the meantime justifies a reasonable effort to control pest populations. Today, the most serious wildlife pest species in our region and at Winterthur is the white-tailed deer.

Researchers believe that our native forests evolved with deer densities of 10 per square mile. At the turn of the century, white-tailed deer were nearly extirpated from many of the eastern states

through uncontrolled hunting. State agencies have had great success in revitalizing the deer population. They were not prepared, however, for the great resurgence in numbers, especially in suburban areas. Delaware does not have estimates of its deer population, but if you look at neighboring Pennsylvania, statewide the deer population now far exceeds 20 per forested square mile, which is considered the appropriate level to maintain healthy forest ecosystems. Based on staff estimates of 40–50 deer on Winterthur, the population is currently 7.5 times above this recommended level. (This estimate is computed by dividing the number of deer by the number of square miles of forested land. Only forested acreage is used in this calculation because it is the plant resources within the forest that largely sustain deer through the winter. Given that there are 192 forested acres (0.3 square miles) within Winterthur, and using the mean of the staff estimate, 45 deer, the deer density within Winterthur comes out to be 150 deer per square mile.) These levels have dire consequences for present and future forest resources.

Deer overabundance dramatically impacts the survival of native flora by overbrowsing tree and shrub regeneration and consuming tree seeds (particularly acorns) and herbaceous plants. It is believed that over 100 species of native wildflowers have become extinct in Pennsylvania as a result of deer browse. The resulting lack of cover, food, and structural diversity within our forests has undoubtedly reduced populations of small mammal and bird species. This regional problem has created degraded forests throughout the area.

Suburban deer management has been treated only recently as a science separate from managing the species in the “big woods” setting. Suburban habitats support much higher populations than the unbroken forests and farmsteads of rural America. The well maintained lawns and shrubbery of suburban yards supply highly nutritional diets year-round. Many of these yards shield deer from weather, hunters, predators, and competition from other herbivores. In combination, the nutritional benefits and shelter cause recruitment rates to soar. Deer populations explode where automobile collisions are the only cause of mortality.

Suburban deer can be healthy at densities approaching 100 per square mile. However, the habitats like those at Winterthur are not adapted to levels of this magnitude. It is difficult to protect plants like trilliums, that evolved with deer densities of 10 per square mile, when faced with such extremes. The heart of the problem is protecting native plant communities that support native fauna.

Control Methods

Control methods can be grouped into two categories, those that reduce the on-site population of a property and those that restrict deer access to desired vegetation. Non-control or letting nature take its course is employed on most properties because of economical and logistical constraints.

The most frequently used and most effective reduction method is hunting or lethal removal. Populations can also be reduced through contraception and trap and transfer. Contraception has proven effective in arresting population growth under the right circumstances, whether through surgery or remote delivery from darts and bait. Appropriate situations, however, are limited to small, contained populations such as on islands or in fenced parks and zoos. Trapping or darting deer, and then moving them to another location is the most expensive and difficult to use deer control method. It is an option fraught with problems, the biggest of which is finding a location willing to accept more deer. When most areas are at or above cultural carrying capacities, few would volunteer to take more. Attracting well-fed deer into baited traps is

the next challenge. Also, survival rates of transported deer have been discouraging.

Restriction methods which are viable and cost effective in the certain situations include fencing and deer repellents. Fencing is effective for small areas. Bowman's Hill Wildflower Preserve in Bucks County, Pennsylvania, has employed an exclosure around their 100-acre property and effectively protected its wildflower collection. It should be remembered that the exclosure need not be deer free, but rather exclude enough deer to circumvent excessive damage. Repellents can also be effective in small areas where one only needs to reduce the browse damage to tolerable limits. The manager must, however, be committed to continually monitoring application needs and experimenting with new products as deer adapt.

Most of these methods of control, while effective at hindering deer access to vegetation, are costly and simply move the problem to neighboring properties. Numerous studies have proven that removing deer through controlled hunts is the most practical and effective means for addressing the problem.

At Winterthur, the complexity of the property (mixed institutional and residential structures) and the high public use within certain areas will probably require several of these methods to maintain the deer population at a level that will result in tolerable browse levels within the woodlands and horticultural areas. To minimize the need for the more costly (time and money) and often unsightly methods, the hunting program should be modified to increase harvest numbers while ensuring the safety of visitors and staff.

The staff at Winterthur has recognized their deer problem for over a decade and have begun to address the problem through a regulated hunting program and the use of fencing and repellents in the Garden. Currently, hunting is done by members of the Garden staff. While the program has been effective in removing 18–25 deer per year, the population remains at an intolerable level (150 deer per forested square mile).

To more quickly reduce the deer population to a tolerable level Winterthur should consider modifying the program to increase the number of does taken each year. Hunters should be required to take a doe (not just an antlerless deer) prior to taking a buck. This requirement should continue until the population falls to below 10 deer. This level should be maintained (lowered if necessary) until forest regeneration becomes established and grows beyond browse height (5 feet).

In order to make wise deer management decisions in the future and to modify the program for full effectiveness, the number of hunter hours spent pursuing deer on the property should be documented, as well as the number of deer taken, their sex, approximate weight, number of points, and location and time of kill. In addition, it would be helpful to know how many deer were observed (but not taken) by hunters on each of their hunts.

If the current reliance on in-house staff to implement the deer management program proves ineffective due to time constraints or lack of participation, Winterthur should consider engaging hunters from the local community to assist in this program. Natural Lands Trust has had great success in reducing deer populations without conflicts with other preserve users. Winterthur's reluctance to engage outsiders in this program due to liability issues could possibly be reduced by partnering with a local sportsmen's club which typically carry the necessary insurance.

NATURAL LANDS TRUST

Regulated Hunting Program

Natural Lands Trust conducts controlled deer hunts on some of its properties to manage deer populations consistent with the preserve's natural resource management goals. Hunters receiving permits for the deer management program are expected to conduct themselves in a safe, honest and ethical manner. Any hunter who does not act accordingly will have his/her hunting permit revoked immediately. Unacceptable behavior includes, but is not limited, to the following:

- Failing to follow up every shot.
- Shooting in marginal situations such as at running deer, when vital organs are obstructed, and at excessive distances.
- Displaying game animals unnecessarily.
- Disrespect of Trust employees, adjacent landowners, and other preserve users.
- Drinking alcohol or using controlled substances.

The following are regulations/requirements for hunters on NLT preserves:

1. The Trust will determine the days and hours of hunting permitted at a site.
2. Hunters must comply with all Pennsylvania Game Commission regulations (including returning report cards).
3. All hunters must present proof that they have completed the Pennsylvania Game Commission Hunter/Trapper Education Course and the National Bowhunter Education Foundation course in the case of archery hunting.
4. Hunters must have an antlerless deer license for the county of the preserve.
5. All hunters must pass a proficiency test using the sporting arm they plan to hunt with. **Firearm**: At 45 yards, a hunter must place 4 out of 5 slugs in a 9-inch paper plate. No buckshot allowed. **Archery**: Shooting from a treestand 10 feet above the ground, an archer must place 5 out of 6 arrows in the vitals of a 3-D target. The target will be placed at 5, 10, and 15 yards from the base of the tree.
6. **Firearm**: Hunters must endeavor to harvest an antlerless deer. Any hunter that does not make a good faith effort to harvest an antlerless deer will have their permit revoked. **Archery**: Bow hunters must harvest an antlerless deer before being eligible to harvest a buck.
7. Hunters must hunt at least 3 half-day sessions.
8. Only portable tree stands may be used and hunters must wear a safety belt. No screw-in steps are allowed. All tree stands must be removed by the second weekend after close of the season.
9. All hunters must attend a preseason orientation course to be conducted by the preserve manager.

A metal box will be placed in a convenient spot accessible to hunters without requiring the preserve manager to be involved with opening it. Armbands and the hunting register will be stored in the box.

The hunting procedure will operate as follows: A hunter, on arriving at the site, removes one of the armbands and puts it on the exterior of his/her hunting coat. Hunters must wear the armbands at all times while hunting. Once the supply of armbands is exhausted, no additional hunters may hunt until a hunter returns from the field and returns an armband to the metal box. Hunters must return armbands to the metal box when finished hunting. Hunters must mark the map where they plan to hunt, and remove the mark when they leave. Hunters are required to fill in the hunting log each time they hunt. One hunting permit will be issued to each hunter. Hunters must carry his/her permit card while hunting. Hunters must display the parking permit on the dashboard of their vehicle.

Natural Lands Trust's Deer Management Program

At Natural Lands Trust, our goal is to preserve and enhance the plant communities within our preserve system to maximize wildlife benefits. With that goal in mind, and an understanding of the requirements of the state wildlife code, we have instituted a deer management program that focuses on reducing deer populations to a level that will allow forest regeneration and survival of native herbaceous species. First, we employ tree shelters and fencing to protect vegetation from deer browse and rub, and second, we implement controlled hunts to reduce the number of deer.

The rules that hunters must adhere to reflect an overriding concern for safety, not only for the participants of the management program, but for other preserve users, such as walkers and bird watchers (see below). The mandatory proficiency test assures that hunters are familiar and competent with their sporting arm. A flagged map locates hunter positions for the preserve manager and other hunters. Participants wear bright NLT armbands which allow preserve managers as well as others to tell from a distance if a hunter has permission to hunt. The rules also place an emphasis on removing does from the population. Harvesting does brings populations to tolerable levels more quickly than a random removal strategy.

Operating the program requires relatively little staff time to administer. In fact, staff time expended in administration is readily made up through time saved by the reduction in staff patrolling time during the hunting season. Permitted hunters monitor unwarranted access to the preserve during the hunting season, permitting managers to attend to other responsibilities.

Monitoring

A necessary part of a deer management program is to develop a monitoring method that allows analysis of success or failure. It can be as simple as regular, documented spotlight counts. However, periodic vegetation studies are more helpful, as they measure the parameters of most interest. These are very labor intensive, but necessary. Exclosures are helpful in providing a visual demonstration for both the scientist and the layman of what grows when deer are excluded. By comparing the species composition and abundance growing within and outside the exclosure, one can fully understand the impact of deer browsing on the forest.

Several exclosures should be erected as demonstration sites. Monitoring the exclosures would require counting all plants by species for each exclosure and an equal area outside each exclosure. Analysis of the tally would be required. This should be performed a minimum of once every 5 years. A partnership with a local school or university could be very useful in conducting this monitoring.

If the hunting program is effective in reducing deer numbers and alleviating the adverse effects on vegetation, adjustments will need to be made to the harvest rates in order to maintain a healthy deer population.

Controlling deer populations has many benefits. Not only does it make it possible to retain species (both plant and animal), but it also allows land managers to expand and enhance forest resources through natural regeneration and afforestation programs. A future benefit would be having the opportunity to reintroduce species that have been extirpated due to deer impact.

Other Wildlife

In wooded areas, nesting boxes can be used in conjunction with snags (standing dead trunks) to promote species such as chickadees, woodpeckers, Eastern Screech Owls, and flycatchers. Along streams, Wood Duck boxes can be placed, ideally in locations secluded from human intrusion. Appendix E contains plans for a variety of nesting and roosting boxes.

Current thinking on the placement of Wood Duck boxes is that they should be mounted 15′ high on hardwood trunks, 300′ to 1,500′ away from marshes and open water. These sites are closer to the ducks' natural nesting sites in high, hidden, tree-trunk cavities, anywhere from 100′ to half a mile from water. As reported in the May-June 1999 issue of *Audubon* magazine, "nest boxes came into vogue in the United States in the 1940s as a partial replacement for the wood ducks' natural nesting habitat — the old-growth forest around marshes, much of it lopped off in our nation's early, exuberant expansion." The traditional placement of the boxes over open water, roughly 80′ apart, was thought to protect them from land-based predators. Today, *Audubon* reports, most of the ducks' habitat has come back and the bird is the most or second-most populous duck in the eastern half of the country. A more concealed placement is also thought to help prevent "dumpnesting," a behavior common to waterfowl of depositing some or all of their eggs in other females' nests. If a female cannot locate a nest site of her own, or her first clutch of eggs is devoured by a raccoon, depositing eggs in another's nest increases the odds that at least some of her offspring will survive. This can result in occurrences of up to 30 eggs in one nest, most of which will not survive. The propensity to parasitize a nest is triggered by seeing another female enter a nest cavity to lay eggs. In forest habitat these cavities are concealed, and brood parasitism remains at a low level.

AESTHETICS / HAZARDS

Scattered within the natural areas are structural remains, materials, and refuse from past and current land use. Stockpiled and discarded building materials and organic waste are unsightly and become sites that encourage invasive vegetation. In addition, obsolete and deteriorating structures (fences, dams) are potential hazards to wildlife and human visitors.

Building materials that have potential future use should be consolidated in a central place, perhaps in unused structures such as the sheds at the Saw Mill or an area around the East Barn or Main Dairy Barn. Stockpiled woodchips should be stored on a hard surface where they can be picked up by a frontend loader. If they are coming from cleanup work in natural areas, either chip or cut brush in place (see Wildlife Management under 4.1.3 Woodland and Hedgerow Stewardship Guidelines). If they are not used on a regular basis, only chip as much as needed or investigate places that will buy chips or firewood.

While we encourage Winterthur to keep standing dead trees within the woodlands, every landowner has the legal and moral responsibility to protect visitors from hazards, including hazardous trees. Winterthur staff will need to balance the wildlife benefits with this responsibility for public safety.

4.2 Meadows

Historically, meadows occurred as breaks in the eastern deciduous forest resulting from human and natural disturbances such as clearing for agriculture by native Americans, fire, periodic flooding, insect infestation, and soil conditions (saturated, serpentine) that restricted growth of woody plants. Most meadows, therefore, existed as temporary ecosystems. Without further human or natural disturbance, natural succession would return a meadow to native woodland conditions within 50 to 100 years.

The meadows at Winterthur, like those throughout the East, are the result of the rise and fall of agriculture following European settlement. During the next three centuries all but the most restrictive (wet, steep) lands were cleared to raise crops for the growing eastern cities. As the agricultural center of the country moved south and west during the 20th century, and, more recently, development pressure has increased, much open land (particularly that on marginal soils) has reverted to woodlands or has been converted to housing developments.

The historic agricultural landscape remains at Winterthur by maintaining the open areas as meadows. Only a few small areas have been allowed to succeed into forest over the last 50 years. Indeed, meadows currently make up almost 50% of the property and total almost 470 acres. This unusually large meadow resource provides not only beautiful vistas from the Gardens but significant ecological benefits. Modifying the current management regime could significantly increase the ecological benefits without impacting the Garden vistas.

Currently the meadows are maintained through a lease agreement with a local farmer who takes two cuttings of mushroom hay each year. The first cutting is done in late June; the second is completed in September or October. The exception to this is the Point-to-Point/Crafts Fair areas where only the first cutting is taken.

In general, the meadows are in very good condition compared to most meadows in this region. They are relatively free of invasives and are dominated by native warm-season grasses, particularly broomsedge. Warm-season grasses are desirable because they are preferred as nesting and feeding sites for native animals, including grassland nesting birds. Many of these birds, such as bobolink, Eastern meadowlark, grasshopper sparrow, savannah sparrow, upland sandpiper and bobwhite quail, have declined drastically in recent years due to the loss of habitat from development and changes in farming practices, including earlier mowing times and the extensive use of non-native cool-season grasses (fescue, rye, bluegrass, orchard grass and timothy) for turf and hay.

The faunal preference for warm-season grasses is based mainly on the need for animals to freely move within the meadow to forage and avoid detection by predators. The clump-forming nature of warm-season grasses allows that movement while the sod-forming nature of cool-season grasses does not. In addition, warm-season grasses are “naturally” adapted to the soils and climate and can, if necessary, thrive on marginal soils with little rain or even through periods of drought. In addition, warm season grasses have extensive fibrous root systems, which penetrate the earth 5′ to 15′, so they have excellent soil-holding capabilities. Soil fertility is also increased, since they regenerate their root systems every three to four years and 90% of the humus they create is incorporated directly into the soil.

From an aesthetic perspective warm-season grasses are also preferred. Between early July and late October, they create lush foliage of varying shades of blue and green. As winter sets in from November to March, the warm season grasses, which remain upright, will provide a spectacle of color, often described as “wine-red, ash grey, steel blue, gold russet, ochre, copper and amethyst.” Encouraging common native meadow wildflowers such as black-eyed Susan, sunflower, aster, and goldenrod can add further to this display and diversify the food source for wildlife.

Winterthur’s meadows are not only unique in quality but also in their size. In order to support viable bird populations, a meadow generally needs to exceed 30 acres in size. Some species require meadows that are several hundred to a thousand acres. Most meadows in this region do not exceed 20 acres. The meadows at Winterthur, therefore, provide a unique opportunity to support threatened grassland dependent species.

As mentioned above, the meadows are not impacted to the same degree by deer and invasive vegetation as the woodlands. There are, however, areas where these plants are encroaching from woodland borders. In addition, biodiversity is being restrained by the current mowing schedule which discourages grassland animals, particularly birds, by disturbing them during nesting season.

Modification of current meadow management practices would greatly increase the biodiversity at Winterthur. This includes altering the time and frequency of cutting and increasing the diversity of native warm-season grasses. There are also certain areas that should be converted to woodland because they are too wet or steep to safely maintain. This would further increase wildlife benefits creating new habitats such as old field, scrub, young forest and mature woodlands as the area proceeds through natural succession.

4.2.1 General Recommendations

General management recommendations for meadow areas include the following:

- Delay the timing of haying from early June to the beginning of July to improve habitat for grassland nesting birds (e.g. Eastern Meadow Lark, Grasshopper Sparrow, Field Sparrow, and possibly Bobolink) by allowing adequate time for successful nesting and rearing of young.
- Harvest only one crop of hay per year instead of two or harvest hay in designated fields on a rotating schedule, cutting each field every other year. This will create tall grass areas in winter that provide winter habitat for grassland birds such as Song Sparrow, Field Sparrow, Tree Sparrow, and Bobwhite Quail.
- Create successional habitats by removing designated meadows from mowing to favor old field dependent species such as Blue-winged Warbler, Prairie Warbler and Yellow-breasted Chat.
- Install artificial bird nest boxes for species such as Eastern Bluebird and American Kestrel.
- Develop and maintain a trail system through the upland fields and the restoration areas to allow for routine maintenance, nature study, and passive recreation.
- Gradually increase the diversity of meadows by planting plugs or overseeding several additional native species including Indian grass, switchgrass, big bluestem and little bluestem.

4.2.2 Meadow Management Units

Refer to Figure 8 and the Management Recommendations plan.

Bidermann Meadow ± 14.5 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low to moderate

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

Trails

Miscellaneous

Armour Farm Meadow ± 23.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low on the top of the ridge and the south facing slope, heavy on the lower north facing steep slope.

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Afforest the heavily impacted steep slope above the riparian area, connecting Armour Farm Woods and Chandler Woods. Some regeneration (tuliptree, ash, maple, black cherry) is already occurring.
- Consideration should be given to creating a wetland meadow (emergent marsh) in the riparian area along Pyles Ford Road (see 4.3 Aquatic Resources for recommendations).

Trails

- Create new trail connecting existing trails in Chandler Woods with a new trail in Armour Farm Woods (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).

Miscellaneous

Lower Armour Farm Meadow ± 9.5 acres

Meadow Health

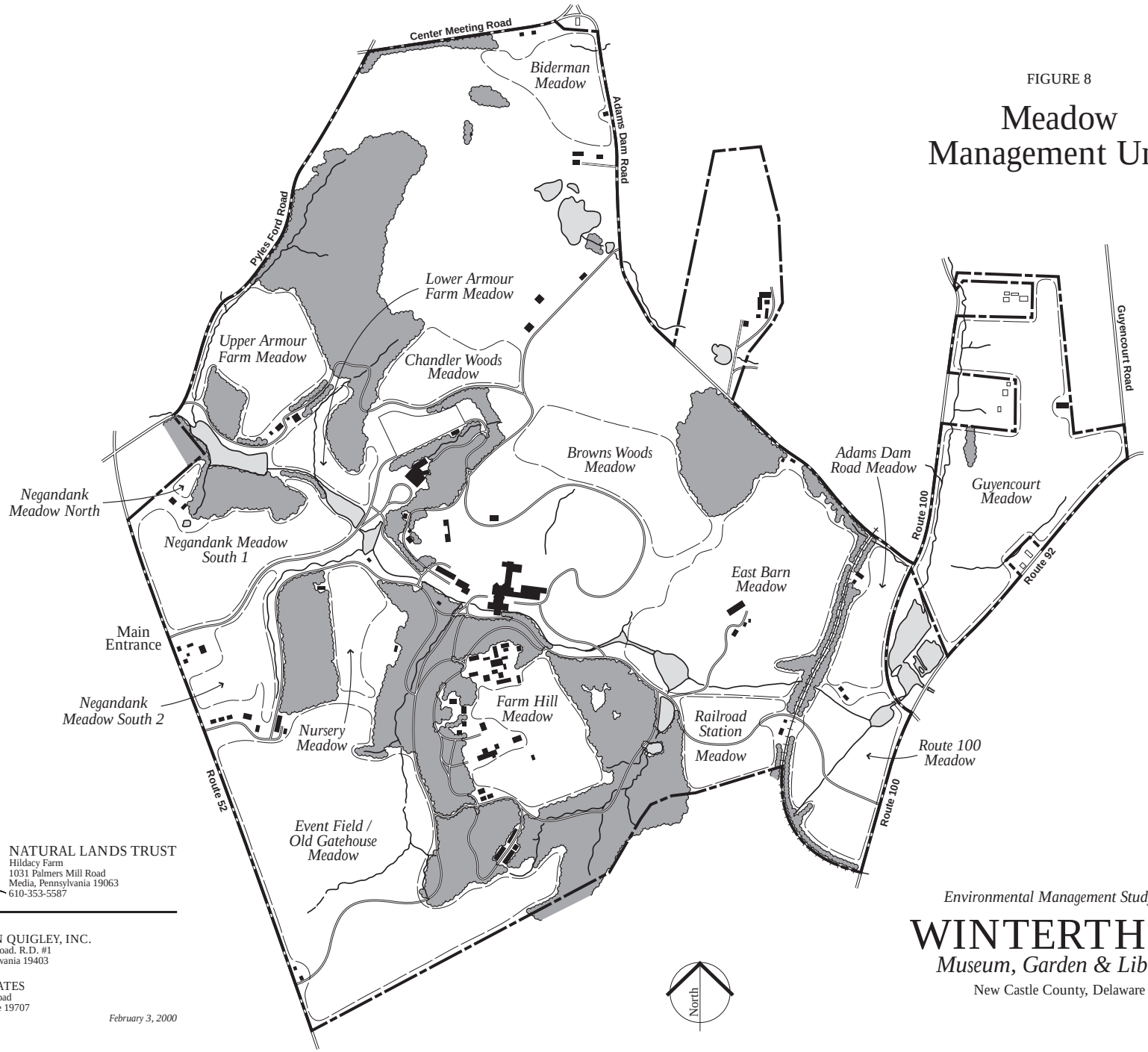
INVASIVE VEGETATION IMPACT: Moderate to heavy

Vegetation Management / Restoration

- Monitor for and control invasive plants.

FIGURE 8

Meadow Management Units



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February 3, 2000

Environmental Management Study for

WINTERTHUR
Museum, Garden & Library
New Castle County, Delaware

- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Afforest area between Armour Farm Hedgerow and Chandler Woods.
- At a minimum, the riparian area should be mowed less frequently. Consideration should be given to creating a riparian buffer along the stream flowing out of Chandler Woods and Clenny Run, possibly expanding it to a wetlands (see 4.3 Aquatic Resources for recommendations).

Trails

Miscellaneous

Chandler Woods Meadow
± 12.5 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low.

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

Trails

Miscellaneous

Negandank Meadow North
± 1.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Moderate to heavy

Vegetation Management / Restoration

- Entire meadow has been identified as an afforestation area through natural succession. Invasive vines should be removed from seedlings every winter and the afforestation process should be reassessed every 3–4 years. Augment natural regeneration with native seedlings.

Trails

Miscellaneous

Negandank Meadow South 1
± 29.5 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low, except for small, heavily impacted areas along Route 52, along edges, and patches throughout.

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

- Heavily impacted area along Route 52 - weed whip with brush blade or manually cut every few years. Consider planting area with small trees and shrubs, perhaps a horticultural display.
- Expand afforestation area to entire area between Negandank Woods and Upper Pavilion Drive Pond Hedgerow.
- Reduce width of regularly mowed area along Pavilion Drive to 10′.

Trails

- Create new trail connecting road to Gate 6, across the Armour Farm Pond dam, with Pavilion Drive (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).

Miscellaneous

- Remove scattered trash and old wire fences along edges.

Negandank Meadow South 2
± 11.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Reduce width of regularly mowed area along Pavilion Drive to 10′.

Trails

Miscellaneous

Nursery Meadow
± 9.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Moderate, primarily along edges

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

Trails

Miscellaneous

Event Field/Old Gatehouse Meadow
± 100.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low

Vegetation Management / Restoration

- Monitor for and control invasive plants.

- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Afforest and/or create a riparian buffer and/or wetlands along stream on eastern side (see 4.3 Aquatic Resources for recommendations).
- Create riparian buffer and/or plant scattered trees along tributary extending into Point-to-Point course area (see 4.3 Aquatic Resources for recommendations).
- Expand afforestation area in the far southeastern corner to round out woodlands.

Trails

- Create new trail connecting existing Nursery Woods trail with the road from Gate 2 to Old Gatehouse Road (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).

Miscellaneous

- Culvert under road from Gate 2 to Old Gatehouse Road - clean up debris below bridge that is redirecting flow and causing erosion, address slumping, don't clear out filled culvert (see 4.3 Aquatic Resources for recommendations).

Farm Hill Meadow
± 22.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low to moderate

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Afforest southern corners (low priority).

Trails

Miscellaneous

- Consolidate wood piles and clean up area. Leave down wood in woodland areas and only produce enough chips to use in-house each year.

Browns Woods Meadow
± 25.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

Trails

- Potential new trails connecting potential loop trail in Browns Woods with Garden Lane (see 3.2.4 Trails and 4.5 Trail Design and Maintenance).

Miscellaneous

East Barn Meadow
± 58.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low in general, riparian area moderate

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Afforest and/or create a riparian buffer along Clenny Run east of East Barn Road (see 4.3 Aquatic Resources for recommendations).
- Plant shrubs and scattered trees around East Barn Pond and Clenny Run west of East Barn Road.
- Plant a grove of trees north of East Barn to block views of new development.

Trails

Miscellaneous

- Regrade and seed area northeast of East Barn for easier mowing.

Railroad Station Meadow
± 14.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

Trails

Miscellaneous

Route 100 Meadow
± 26.0 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low, except on steep slopes

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

- Expand northern afforestation area between railroad tracks and Cox residence to include the steep slopes on either side of Clenny Run.
- Expand southern afforestation area between railroad tracks and Clenny Run Road to include the steep slopes on either side of the small stream.
- Create riparian buffer and/or plant shrubs and scattered trees along Clenny Run, the tributary flowing from Railroad Hedgerow, and the Routes 100/92 Pond (see 4.3 Aquatic Resources for recommendations).

Trails

Miscellaneous

Adams Dam Road Meadow
± 11.5 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.

Trails

Miscellaneous

Guyencourt Meadow
± 101.5 acres

Meadow Health

INVASIVE VEGETATION IMPACT: Low in general, riparian area moderate

Vegetation Management / Restoration

- Monitor for and control invasive plants.
- Increase diversity by planting plugs of, or overseeding with, additional native species.
- Plant scattered trees and shrubs along streams bordering Route 100 and Route 92.

Trails

Miscellaneous

4.2.3 Meadow Stewardship Guidelines

VEGETATION MANAGEMENT / RESTORATION

Mowing Schedule

In designing and maintaining any natural area, it is well to consider that landscape maintenance is a compromise between what nature wants to do and what we want nature to do. A truly

natural area does not need to be maintained, and if it were maintained, it would no longer be natural. But a naturalistic area requires judicious maintenance, meeting nature halfway, perhaps creating an idealized version of nature to satisfy the needs of the landowner.

Because a meadow is a temporary stage in the ecological parade of succession, we must interrupt the process by mowing (or burning) to delay a field from returning to woodland. The timing and frequency of the mowing will have a dramatic effect on the composition of a meadow and it's wildlife residents.

Spring is the time of year that wildlife utilizes the meadow for reproduction. Mowing between April 1 and July 1, while appealing to suburban sensibilities, is the worst time to mow. It removes nesting cover, destroys nests and eggs, and kills young birds and other meadow animals. Late June is when the cool season grasses die back and then through August, the warm season grasses do the bulk of their growing. Mowing in early to mid-July is desirable in that it removes the browning cool season species and provides growing space for the warm season species to grow, flower and provide habitat for the remainder of the year. Mowing between August and late October does not allow the vegetation enough growing season to renew itself and therefore provides little food and cover for wildlife until the following spring. Mowing at this time of year would only be desirable if there was a noxious species, such as thistle or multiflora rose, you want to stop from reproducing. Mowing between March 1 and April 1 will minimize the amount of time birds and animals lack cover because next year's growth will be on its way with the onset of warm weather. If environmental conditions, such as wet soils, prohibit early spring mowing, winter mowing, when frost has hardened the ground may be a good alternative.

The frequency of mowing will depend upon the amount of invasive plants present and any financial needs of the landowner such as income from cutting hay. If invasives and woody plants are not a problem, meadows can be mowed every other year. If a meadow has a low to moderate impact from invasives and woody plants, once a year mowing will keep it from reverting to woodland. If there are significant problems with woody seedlings, brambles, invasive vines and/or multiflora rose, twice a year mowing may be needed. Mowing more than twice a year will only encourage cool season grass species and create additional turf areas.

Recommended dates for mowing are early July for the first cutting and a second cutting, if necessary, in March. This will maximize bird and animal habitat and promote desirable and attractive vegetation. Mow meadows when the ground is dry and cut at a height of 6″–8″ during the growing season and 4″–6″ during the dormant season.

To address concerns or perceptions that a meadow is just an unkempt lawn, a sign of neglect, or a breeding ground for "vermin," maintain a mowed turf swath around the public edges. This, along with incorporating a trail network, are ways of indicating that a meadow is intentional and managed. Well maintained trails encourage people to get into a meadow and discover their beauty up close and first hand.

Invasive Vegetation

Meadows must also be monitored for intrusion by invasive plants. As mentioned above, a second mowing may be all that is necessary to discourage certain invasives. Otherwise, control invasives by spot mowing, spot spraying or wick application of an appropriate herbicide such as *Roundup, Banvel,* or *2-4-D,* or manual or mechanical pulling (refer to Invasive Vegetation under 4.1.3

Woodland and Hedgerow Stewardship Guidelines). A combination of strategies may be the best approach. Areas that are disturbed by manual or mechanical removal should be seeded with annual rye and/or oats or a mix of native grasses and wildflowers to hinder reestablishment of invasives. Do not use herbicides within 50′ of streams that are not approved for aquatic use.

Severely impacted meadows may warrant starting from scratch using the following procedure. After mowing, spray the area with a broad-range herbicide, such as *Roundup* or *Banvel*, to remove all the existing vegetation. Allow the herbicide to work for approximately two weeks, then plow and disc the site. After another two weeks, reapply herbicide to kill any surviving or newly established vegetation. Wait another two weeks and disc and plant the area with preferred species. The quick establishment of desirable species through planting is important to prevent the reestablishment of the invasive plants.

Afforestation

Afforestation is the process of converting open land (farm fields, meadow, pasture) to woodland. This is technically different from reforestation which focuses on reestablishing trees in previously wooded areas that have been subjected to human or natural disturbance (logging, hurricane, fire). Afforestation, like reforestation, can be accomplished through natural or artificial (planting) regeneration. In the past, most afforestation has been through natural succession as marginal agricultural lands were abandoned.

Today, in addition to the well-known benefit of connecting established woodlands, there is growing evidence of the benefits of afforesting open areas along streams and ponds. Trees provide nutrients for aquatic organisms and drastically reduce thermal and nutrient pollution to these water resources. Because of these important benefits, many states are encouraging landowners to speed up the conversion by planting seedlings.

Winterthur has already concluded that afforestation is appropriate and has identified several areas to experiment with the concept, citing the following reasons/factors:

1. Safety: The steep slopes and rough terrain present in many of the areas designated for [afforestation] are inherently difficult and challenging to maintain by mowing for even the most skilled and experienced operators. The potential for serious mishaps in these areas is very high and would likely increase should personnel less skilled in equipment operation or unfamiliar with these areas ever become responsible for their maintenance.
2. Environmental Stewardship: Allowing land to assume its natural evolution is generally the most environmentally sound course of action. Although the areas presently considered for [afforestation] are relatively small, any measure of effort to offset the rapid diminishing of our natural woodlands is certainly worthwhile.
3. Time Saving: [Afforested] areas are expected to be largely maintenance free, thereby saving time normally spent on mowing them.
4. Future Reference: [Afforested] areas can serve as trial or reference sites, providing insight and information on what can be expected from future, possibly larger scale [afforestation] projects. Aesthetic impact during transition will be minimal, as most sites are in outlying locations, not visible to the visiting public or most staff.

The seven areas identified are in the following meadows: Armour Farm Meadow, Negandank Meadow North, Negandank Meadow South 1, Event Field/Old Gatehouse Meadow, Route 100 Meadow, and Guyencourt Meadow.

These areas are no longer being mowed, allowing them “to grow up and evolve naturally.” The only caveat to this is that these areas will be “largely maintenance free” in the long term. Whether afforestation is achieved through natural or artificial regeneration, regular monitoring for intrusion by invasive and/or undesirable plants will be needed during the process, especially in the early stages.

Control invasive/undesirable trees and shrubs through spot spraying or wick application of an appropriate systemic herbicide or manual or mechanical pulling. Areas that are disturbed by removal should be replanted with native trees, shrubs, or grasses and wildflowers. Any resprouting invasive and undesirable vines should be prevented from climbing into trees and shrubs by pruning at a minimum. They should eventually be eliminated through spot spraying or wick application of an appropriate systemic herbicide or manual or mechanical pulling and replanting of the area with native species.

WILDLIFE MANAGEMENT

Birds

Warm season grasses are prime habitat for grassland birds because they are bunch grasses, as compared to the sod-forming growth of cool season grasses. This means that they grow upright, with bare ground between clumps. This provides the overhead protection from the elements and predators and assures quality nest sites and material. The clumping also allows for free movement (particularly for young birds) and facilitates food searching on the bare ground.

In spring, ground-nesting birds utilize the cover afforded by the grasses to brood and rear their young. Flowers attract insects, which in turn, constitutes the most important element in the diet of young birds. During the autumn months, native wildflowers and grasses produce highly nutritious seeds. These are relished by a variety of songbirds and will attract many migrants that stop over on their long journey south. Throughout the winter, the upright grasses provide food and cover for the resident birds to help them survive the winter months.

For the greatest wildlife benefit, meadows should be composed of only native warm season grasses and wildflowers that grow to different heights. The fields at Winterthur are largely dominated by the relatively short broomsedge. This can be diversified by planting additional native species through plugs or drilling. Areas that are dominated by cool season grasses will need to be treated with an herbicide before planting (see Invasive Vegetation above).

Species such as tree swallows, bluebirds, and kestrels can be attracted to nesting boxes placed in meadows. The boxes should be placed as far from the woodland edge as possible to limit competition from house wrens. Roosting boxes, which provide shelter to multiple bird species, can be placed along the edge where they will be out of the wind but able to absorb heat during the day.

Meadows also provide hunting areas for resident and migrating hawks including American Kestrel, Red-tailed Hawk, and Northern Harrier.

Other Wildlife

Other animals also benefit from meadows of native grasses and wildflowers. Many insects, particularly butterflies, have developed close relationships with native wildflowers. As our few remaining undisturbed habitats continue to be lost to development, many native plants are becoming increasingly rare. The implications for

many butterflies are dire: with the loss of their host plants, some butterfly species are inching closer toward extinction. Unless native wildflowers and butterfly habitats are restored, we can expect to see further declines in overall butterfly populations and continued losses of rare and endangered species.

Bats, of which more than half of the North American species are endangered or nearly so, can be attracted by installing bat boxes. These should be placed at least 15′ above the ground on a pole or outbuilding exterior. Trees aren't a good choice because predators like hawks and owls use them for cover. They should be placed where they will get plenty of sunshine, i.e., heat (about 6 hours of direct sunlight a day). Bats regularly feed near sources of fresh water where insects abound, so placing the boxes near these increases the likelihood of use. Appendix E contains plans for bat houses.

Various diseases, including Lyme's disease, that are carried by the black-legged (deer) and wood ticks pose a serious health concern to managers and recreational users of meadow areas. The best way to address this concern is through education and the creation of ample setbacks from property lines and wide walking trails (6′ to 8′) through naturalized landscapes.

AESTHETICS/HAZARDS

There are several aesthetic and hazard concerns within the open areas at Winterthur. Stockpiled organic waste (stumps, woodchips, etc.) is unsightly and encourages invasive vegetation. In addition, obsolete and deteriorating structures (fences, dams) are potential hazards to wildlife and human visitors.

There are a few eroded areas which make mowing difficult. As discussed earlier, a more appropriate area should be found for the chip and stump piles. The eroded areas should be filled and seeded.

The presence of groundhog burrows in trails can be extremely hazardous, especially to elderly visitors. Any holes should be filled or at least marked whenever found and trails should be mowed regularly to maintain minimum grass height. As public use of the natural areas increases, trail maintenance should be a much higher priority for staff.

4.3 AQUATIC RESOURCES

According to the Delaware Department of Natural Resources and Environmental Control (DNREC), water quality concerns in Clenny/Wilson Run on the Winterthur grounds include periodic algal blooms that occur in the many ponds and which are often transported downstream during storms. In addition, the large and increasing number of Canada geese using the ponds and mowed fields contributes significant nutrient and fecal coliform loading to the aquatic system resulting in eutrophic conditions in the ponds and periodic release of nutrient-rich waters to the Brandywine system. Other concerns noted by DNREC include the lack of riparian buffer or natural edge around the Winterthur ponds and creek edge.

It is clear that although still relatively healthy, the aquatic resources (ponds and stream complex) through the Winterthur portion of the watershed are being stressed and are in danger of becoming permanently degraded if measures are not taken to better manage the lands surrounding them.

4.3.1 General Recommendations

~ Provide more riparian buffers. Establish at least tall grass meadow buffers (preferably shrub and/or tree buffers where appropriate) along all streams and ponds. Establish or expand woodland buffers where they do not impact important viewsheds.

~ Address stormwater erosion areas through maintenance and modification of manmade structures and stabilization of terrain and natural streams.

~ Control invasive vegetation (particularly exotic vines) which prevents natural regeneration or planted trees and shrubs from becoming established. Monitor and control invasives (phragmites, knotweed) which displace native wetland species.

~ Install nest boxes for Wood Ducks and Eastern Screech Owls and basking logs for turtles. Establishing riparian buffers should discourage Canada Geese.

~ Remove cement lining from stream areas and re-establish a more natural, meandering stream channel using bioengineering techniques.

4.3.2 Aquatic Management Units

Refer to Figure 9 and the Management Recommendations plan.

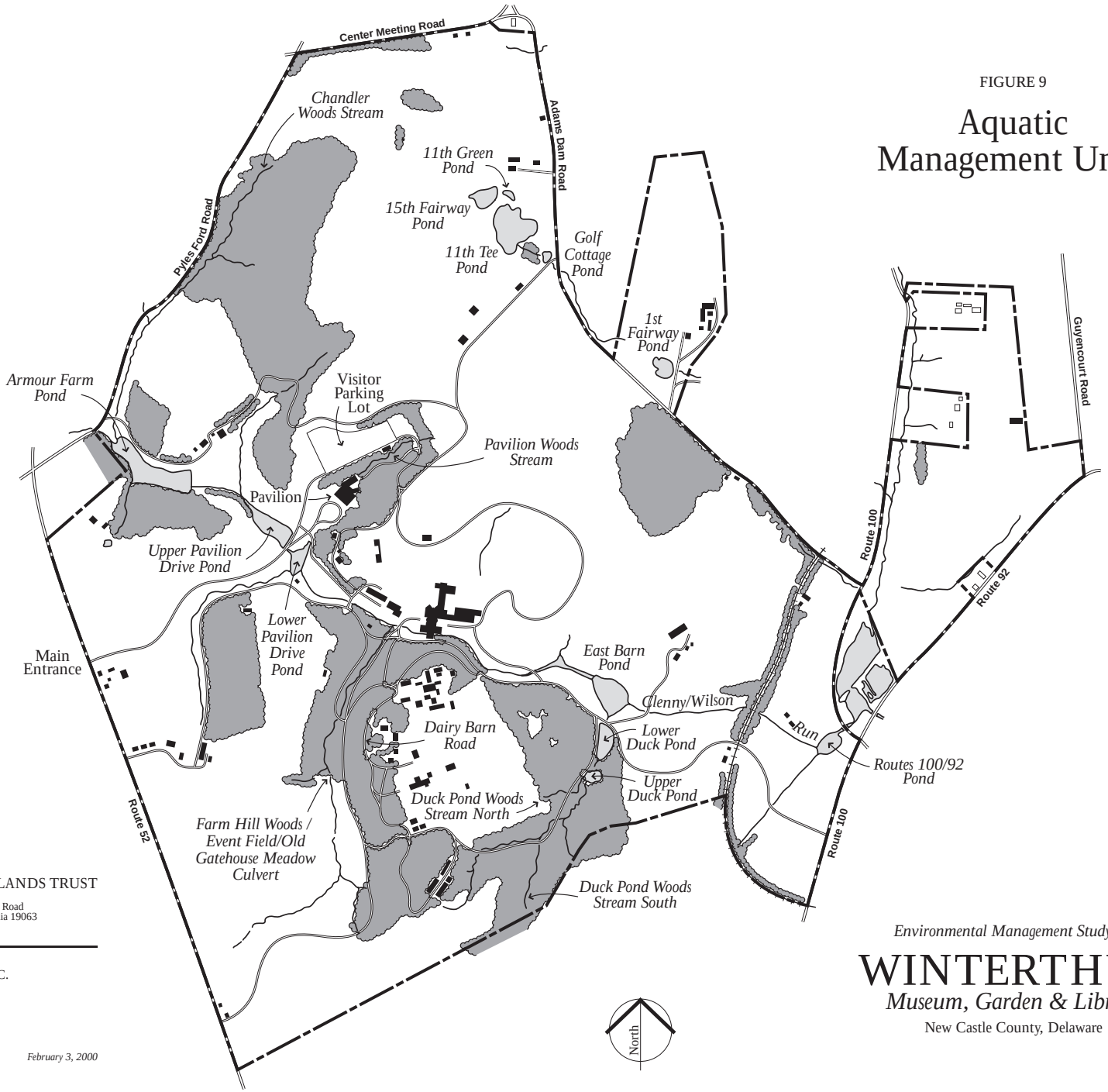
Ponds and Streams

General

- Allow riparian buffers to develop along the water's edge. The buffer, at a minimum, should be a strip of tall grass meadow a minimum of 20′ wide. Preferably, some areas should be designated and maintained as shrub zones, densely planted with native shrubs and scattered trees, providing only limited access to the water for Canada Geese or humans. Other areas, such as around portions of the ponds, can be maintained as wetland meadow and periodically mowed to restrain woody invasion. Ideally, a full woodland riparian buffer can be established along most ponds and streams. There are some instances where buffers will not be acceptable because of historical significance and/or scenic views, but wherever possible, clearing should be limited to strategic views or where direct access to water is desirable and appropriate.
- Working with DNREC and/or the Delaware Riverkeeper Network, develop a restoration plan for the degraded stream areas. Consider removing cement lining from stream areas and re-establishing a more natural, meandering stream channel using bioengineering techniques. Institutions such as the

FIGURE 9

Aquatic Management Units



NATURAL LANDS TRUST
Hildacy Farm
1031 Palmers Mill Road
Media, Pennsylvania 19063
610-353-5587

with

PATRICIA ANN QUIGLEY, INC.
1080 Quarry Hall Road. R.D. #1
Norristown, Pennsylvania 19403
610-584-1829

HYLA ASSOCIATES
1011 Center Mill Road
Hockessin, Delaware 19707
302-652-1952

February 3, 2000

Environmental Management Study for

WINTERTHUR
Museum, Garden & Library
New Castle County, Delaware

Academy of Natural Sciences would be likely partners for such a project.

Armour Farm Pond

- Consider the development of a stormwater management project to control excessive sedimentation and habitat degradation in Armour Farm Pond. The pond was recently dredged, but continues to receive silt and sediment from off-site activities upstream, particularly from the northwestern feeder stream. A stormwater best management practice that would trap incoming sediments before they accumulate in the pond would be to create a *stormwater management wetland complex* at the junction of the two incoming streams at the uppermost end of the pond. This stormwater management wetland complex would consist of:

  ~ a forebay sediment trap - an excavated area at the inlet of the pond designed to trap incoming silts and sediments; and

  ~ densely planted aquatic marsh benches - around the forebay and along the perimeter of the pond of approximately 10′ width; this strip can be continuous and can include wetland shrubs if geese are being discouraged; if waterfowl are desirable, the strip should be discontinuous, with some less densely vegetated openings.

Small triangular pond northwest of East Barn Pond

- This pond is shallow and in need of dredging. Consideration should be given to allowing it to revert to a wetland (a combination of emergent marsh with some scrub/shrub type). Some enhancement plantings around the edges of wetland species can speed the reversion and add aesthetic appeal (beds of native iris, tall bulrush, thicket of marsh rose, etc.).

11th Tee Pond

- The 11th Tee Pond is large enough to support a small island for visual interest and to create a safe haven for nesting waterfowl species such as herons. Woody species should be planted such as black willow, red maple, black gum, alders, highbush blueberry or other wetland tree or shrub species. Consideration should also be given to creation of open basking platforms for turtles here and in other ponds. Basking platforms can be simple fallen logs or tree snags, as long as part of it is in the water to allow water access.

Duck Pond Woods Stream South

- Very near to the southern Winterthur boundary with the Wilmington Country Club, an old roadbed crosses a stream. At this culvert, the twin 15″ or 18″ diameter corrugated metal pipes have been silted in to the point where flow appears to no longer go through them. The result has been sediment that has accumulated on the upstream side such that it is essentially even with the grade of the roadbed. Downstream from the culvert, serious erosion is occurring along the streambanks at several locations. Preliminary investigations revealed that most if not all of the stormwater drainage from Wilmington Country Club's main parking lot is being directed to this stream.

Because the parking lot was constructed prior to New Castle County's stormwater management ordinance, it is probably "grandfathered" from the provisions of the ordinance, however, there may be recourse through other channels. A conversation with the appropriate personnel at the Country Club may open a dialogue to formulating a solution. If this does not prove successful, contacting the County Land Use Department would be the next step.

Once the cause of the problem has been determined and hopefully addressed, dealing with the resulting erosion is the next step. After cleaning out and perhaps reconstructing the culverts, stabilization of the stream banks could occur in a number of ways. *Harder*, more structural measures could include check dams and large rip-rap or gabions placed along the banks, most notably at bends or where tributaries converge. *Softer*, greener measures could include planting along the banks, otherwise known as bioengineering. A comprehensive restoration plan will more than likely involve a combination of these measures. The Estuary Field Office of the Delaware Riverkeeper Network (Fred Stine, 609-854-5108), working with the Patrick Center for Environmental Research at the Academy of Natural Sciences, is available to assist in streambank and riparian restoration. Qualifying landowners who commit to a restoration partnership with Riverkeeper receive restoration site design, monies for materials, volunteer labor, and assistance in designing a maintenance plan for a healthy stream.

Duck Pond Woods Stream North

- The small tributary draining from Farm Hill Meadow has a section that is severely eroded. Most of the water for this stream is coming from the meadow and dump area. A number of large trees in the immediate stream area have come down in the last few years and the subsequent opening in the canopy may be a contributing factor to the current erosion.

  Measures to address the problem could include reducing the frequency of mowing of the Farm Hill Meadow or at least the southeastern portion, actively reforesting the new woodland gap, and installing a level spreader in the meadow. A level spreader is an earthen and/or rip rap berm that spreads the flow out, dissipating the concentration. Afforesting the southeastern area of the meadow should also be considered. Contacting the Delaware Riverkeeper Network (see above) is recommended.

Chandler Woods Stream (North)

- This stream is eroding although not as severely as other streams in the property. Opportunities exist to reduce flow into the stream from the Bidermann Golf Course through reduced mowing, tree and shrub plantings, and/or installation of a level spreader at the edge of the woodland. Contacting the Delaware Riverkeeper Network (see above) is recommended.

Wet Meadows

- At a minimum, riparian areas should be mowed less frequently and consideration should be given to creating some form of riparian buffer as described above.
- With guidance from a wetlands and/or wildlife consultant, wet areas in meadows can be enhanced to create wetland meadow (emergent marsh) habitat. This might involve shallow (12″–18″) excavation by a grading contractor or with Winterthur staff and equipment. Additional on-site subsoil and hydrologic assessment will be needed. If an area is determined to be an existing wetlands, such work will need a permit.
- Consider engaging a study to look at Winterthur's piped waterline network, both used and abandoned, and the potential for releasing any capped or piped springs in order to restore wetlands. Areas of seeps which are currently mowed over should be left unmowed or even planted with shrubs and wetland trees to shade these areas and prevent accidental mowing.

Wooded Wetlands

- Designate wetland areas, especially the less disturbed forested ones such as around the Duck Ponds, as "Protected Areas" and limit access by the public and maintenance staff. Any trails should be at the edges to avoid trampling and compaction of the soft soils and small wetland plants. Boardwalks may be appropriate in some areas.
- Consider enhancement of some of the wetland depressions in the wooded wetlands by deepening to create vernal pools. The creation of such wildlife habitat and wetland features would greatly increase amphibian populations on the property. Again, if an area is determined to be an existing wetlands, such work will need a permit.
- As mentioned above, consider engaging a study to look at Winterthur's piped waterline network, both used and abandoned, and the potential for releasing any capped or piped springs in order to restore wetlands.

Drainage Structures

General

- Conduct an annual inspection of all drainage structures, such as catch basins and culverts, and institute a maintenance schedule. Consider having a survey performed of all drainage structures to catalog their locations, sizes, structural condition, etc.

Farm Hill Woods / Event Field/Old Gatehouse Meadow Culvert

- This stream crossing is an example of a twin culvert where one of the two has been silted in. However, at this location, there is no evidence (erosion, undercutting, etc.) that this is resulting in any detrimental occurrences. This may be due to the possibility that the culverts were oversized to begin

with. In fact, retarding the flow may actually be resulting in benefits as the upstream side of the stream has healthy banks with wetlands acting as riparian buffers. This vegetative growth may have benefitted from stormwater stagnated due to lack of culvert capacity to pass it. In other words, this may not occur if both culverts become operational.

If the clogged culvert is to be placed out of service, it should be better and more permanently sealed (grouted, backfilled, etc.). The remaining culvert should also be cleaned-out as well as the debris immediately downstream of the bridge.

Prior to deciding to use just the one functioning culvert, a hydrologic study should be performed to better understand how a range of storm events would affect this one remaining culvert. Analyses could also estimate the amount and level of ponding upstream which could be beneficial in future planting plans. Conversely, an analysis such as this would be crucial if it is decided to open up the clogged culvert. Any increases in flow could be detrimental to the downstream stream banks that may have adjusted to the artificially decreased flow.

Dairy Barn Road

- The catch basins along this section are filled with debris and sediment and should be cleaned out. Also, it is difficult to determine how the erosion alongside the road is occurring without topographic plans. Furthermore, without knowledge of how the road is crowned (cross-sectional slope), it is also difficult to evaluate solutions to mitigate the erosion. Control measures could include gravel along the roadway sides to “soften” the transition between impervious and pervious surfaces, grading to provide an actual swale to better channel stormwater to desired locations, or placement of an asphalt “lip” or small curb to again, better control stormwater. As mentioned previously, a better understanding of flow rates and grades would make selection of controls much easier and result in a more effective design.

  A related problem in this area is erosion at the outlets of the various storm pipes under the road from the catch basins. Since the downhill slope at the outlets is steep, stopping the erosion without constructed structural controls may be difficult. A system including level spreaders or rip-rap with underlying fabric would not only protect the soil from erosion but provide energy dissipation to reduce velocities.

  Winterthur may want to consider retaining the services of an engineering firm to map out the drainage structures, perform a topographic survey, and evaluate the amount of runoff flowing into each basin and thus through each discharge pipe. Estimates of velocities and erosion potential would be subsequently provided. This additional information would enable Winterthur to better evaluate alternatives.

Pavilion Woods Stream

- There are two existing spillways in the stream adjacent to the Visitor Parking Lot that were built to develop, it appears, a cascading effect prior to the stream running

under the Pavilion. Each of these spillways is in poor condition. It may be easier to simply remove the first, more upstream spillway since it is in worse condition than the first and, due to its close proximity with the first, would add little benefit to the stream. The second spillway, however, should be rebuilt. Prior to rebuilding, a hydrologic analysis should be performed to estimate the flow rate and a hydraulic design prepared to quantify the amount of flow over the spillway and, conversely, the volume of water retained behind the dam. After this work has been done, the stream channel will need restoration.

There is also a pipe leading from a catch basin in the parking lot to the stream just up from the Picnic House that has serious erosion around its end section. It is unknown why this is occurring but placement of rip rap with underlying fabric around it would halt future erosion. Contacting the Delaware Riverkeeper Network (see above) for assistance in both these matters is recommended.

Culvert under Pavilion

- It is rare to find a building placed directly over a culvert. However, it is assumed that the building was designed such that any structural problems with the culvert would not affect the building. Still, this would also be an opportune time to evaluate the structural condition of the culvert. If it is not possible (or safe) for personnel to enter the culvert, video cameras could be used. It may also be prudent to design the dam and spillway just upstream such that the amount of flow entering the culvert is reduced particularly if the flow was increased over the years.

Visitor Parking Lot

Observations made during the course of this study indicate that the main visitor parking lot, an impervious area of almost 4.5 acres, is typically less than half full. Staff have confirmed that the lot is full only on major event days and during the peak spring season. In addition, the stormwater management system is typical of others at Winterthur with catch basins that are filled with sediment and outflows that are eroded. The stream into which the outflows deposit, in Pavilion Woods, is also experiencing gullying and scouring.

This leads to the recommendation that Winterthur consider reducing the extent of impervious area and replace it with planting islands and/or vegetated swales to mitigate stormwater quality and quantity. Planting islands are often designed to provide detention and vegetated swales are grass-lined or vegetated earthen channels designed specifically to convey water with reduced peak flows and to remove pollutants. Swales can be used in any project where they can be designed to have a stable, vegetated bed and banks that are not eroded by the conveyed flows.

These recommendations would have benefits of providing shade within the parking lot, reducing the amount of runoff, and slowing the velocity of runoff to allow infiltration before it reaches the stream. Reduction of the number of parking spaces in the main visitor parking lot will necessitate finding acceptable areas to handle the overflow when needed. However, since these overflow areas would be used infrequently, it would not be necessary for

them to be paved. Gravel, porous pavers, or even grass should be sufficient.

4.3.3 Aquatic Stewardship Guidelines

VEGETATION MANAGEMENT / RESTORATION

Riparian Buffer

In natural conditions, rivers and streams are protected by streamside forests. But decades of deforestation, agricultural expansion and increasing development have drastically reduced the extent of streambank protected by forest. The result has been an adverse effect on the quality of water and aquatic habitats. Riparian areas, the area of vegetation along a body of water, are crucial to the protection and enhancement of water resources. They are complex ecosystems that help provide optimum food and habitat for stream communities as well as to help mitigate or control nonpoint source pollution.

According to the Chesapeake Bay Program, riparian buffers provide the following benefits for water bodies and wildlife:

- Filtering runoff — Rain that runs off the land can be slowed and infiltrated in the forest, settling out sediment, nutrients and pesticides (nonpoint source pollution) before they reach streams. Infiltration rates 10–15 times higher than grass turf and 40 times higher than a plowed field are common in forested areas.
- Nutrient uptake — Fertilizers and other pollutants that originate on the land are taken up by tree roots. Nutrients are stored in leaves, limbs and roots instead of reaching the stream. Through a process called “denitrification,” bacteria in the forest floor convert nitrate to nitrogen gas, which is released into the air.
- Canopy and shade — The leaf canopy provides shade that keeps the water cool, retaining more dissolved oxygen, and encourages growth of diatoms, nutritious algae and aquatic insects. The canopy improves air quality by filtering dust and other windborne pollutants created by construction, farming, industry, and vehicles.
- Food — Leaves fall into a stream and are trapped on woody debris (fallen trees and limbs) and rocks where they provide food and habitat for small bottom-dwelling creatures, organisms that are critical to the aquatic food chain.
- Habitat — Streams that travel through woodlands provide more and better habitat for aquatic organisms. Streams within woodlands are wider, providing greater bottom surface area for macroinvertebrates (mayflies, stoneflies, etc.). More food and cooler water, in turn, improves habitat for fish and the birds (herons, egrets, osprey) that feed on them. Woody debris serves as cover for fish while stabilizing stream bottoms, thereby preserving habitat over time.

Other benefits of riparian buffers include:

- Decreased flooding — In addition to slowing the flow of water into a stream, riparian buffers increase the ability of the stream’s floodplain to retain water. Not only does this help prevent flooding, but because the water takes longer to reach the waterway, groundwater recharge increases as well.

- Migratory corridors — Forest corridors provide crucial migratory habitat for neotropical songbirds, some of which are now threatened due to loss of habitat.
- Educational and research opportunities.

The ideal riparian buffer recommended by the U.S. Forest Service is a 95′ strip along each side of a stream consisting of three zones (see Figure 10). The first zone is a 15′ strip next to the stream of an undisturbed forest that provides detritus to the stream and helps maintain lower water temperatures vital to fish. The second zone is a 60′ strip of managed forest where filtration, deposition, plant uptake, anaerobic denitrification and other natural processes remove sediment and nutrients from runoff and subsurface flows. The third zone is a 20′ grass or grass and shrub strip providing runoff control where concentrated flows are converted to dispersed flows by water bars or spreaders, facilitating ground contact and infiltration. Narrower forest and shrub buffers, as well as properly designed grass buffers, also provide degrees of benefit.

Invasive Vegetation

Refer to the Invasive Vegetation section under 4.1.3 Woodland and Hedgerow Stewardship Guidelines for general guidelines on controlling invasives. While all options (mechanical or physical removal, cutting, fire, chemical) are useful for dealing with invasives near or within aquatic resources, adjustments need to be made in the type of herbicides used to protect aquatic biota. In general, only herbicides approved for aquatic use should be applied within 100′ of streams, ponds, or wetlands. One of the more popular herbicides for aquatic use is *Rodeo,* a variation of *Roundup.* It can be used to control invasive shrubs (spray multiflora rose and honeysuckle in late May and early June), vines (spray Japanese honeysuckle in early November when all other plants are dormant), and grasses (spray phragmites in autumn). As with Roundup, it may take several applications to eliminate established plants. Oriental bittersweet vines can be cut and treated (painted) with *Roundup* mixed with a gelatin.

WILDLIFE MANAGEMENT

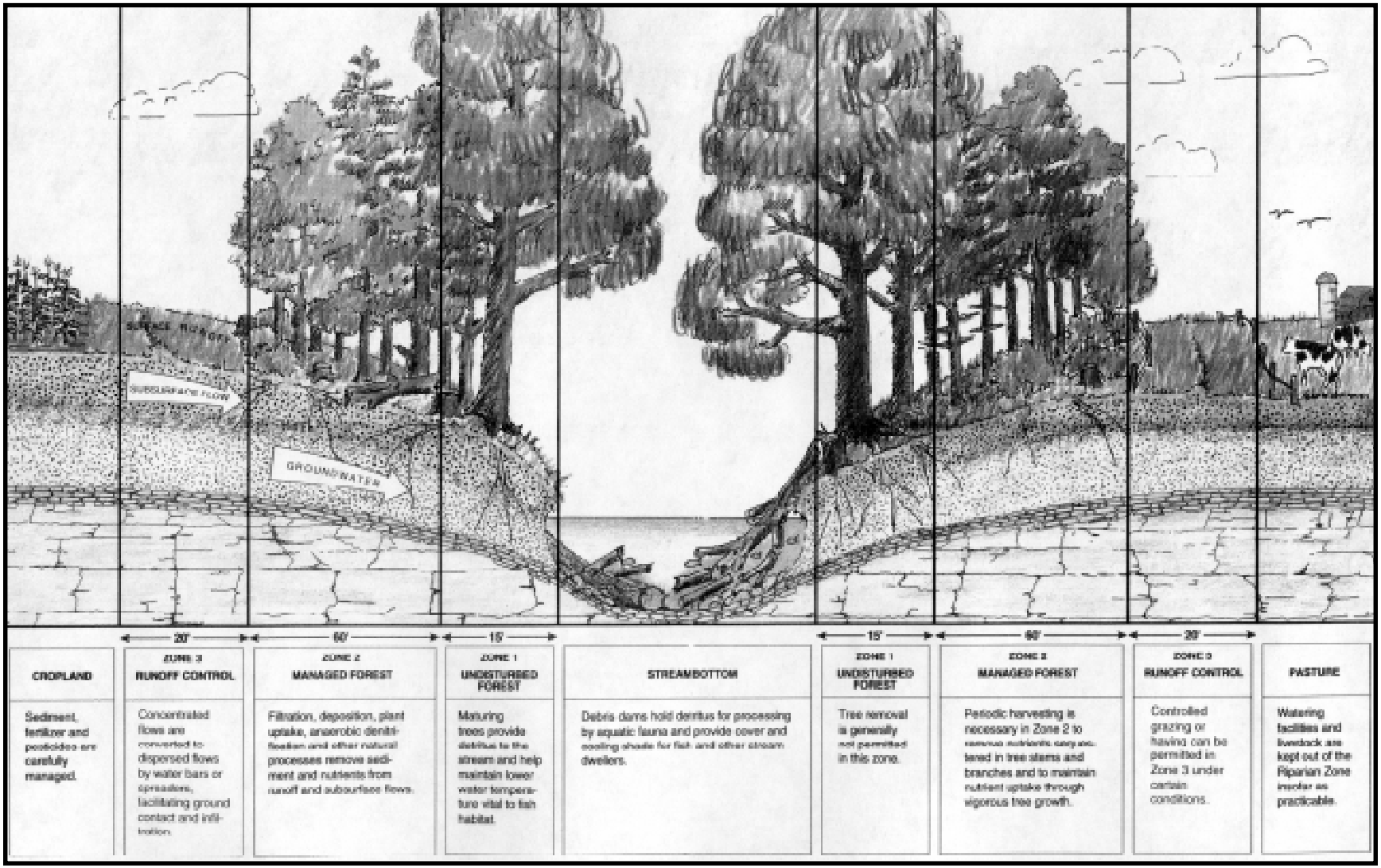
There are many management activities that can increase the wildlife benefits of aquatic areas. Basking logs can be installed along the edge or anchored in open water to provide basking areas for aquatic turtles. Leave dead or dying trees (snags) standing along the edge of wetlands (provided that they are not a potential hazard to visitors or staff) to provide hunting perches for Belted Kingfishers, Cedar Waxwings, and several flycatcher species and foraging sites for woodpeckers.

Nesting boxes can be placed along water edges for use by Screech Owls and Great-crested Flycatchers. Refer to the Wildlife Management section under 4.1.3 Woodland and Hedgerow Stewardship Guidelines for recommendations for Wood Duck boxes. Appendix E contains plans for a variety of nesting and roosting boxes.

The greatest benefits come from establishing riparian buffers along stream and ponds. This will greatly increase wildlife diversity, discourage Canada Goose use, and help improve water quality by reducing fecal input. Shading of streams created by buffer trees and shrubs will reduce summer water temperatures and increase natural diversity of stream invertebrates and fish.

Winterthur should also encourage wildlife research (in-house or external), monitoring, and surveys in all areas. These studies would provide valuable information for the management of certain wildlife taxa. Volunteers may be used for nest box monitoring and

FIGURE 10: *Riparian Forest Buffer*



From *Riparian Forest Buffers, Function and Design for Protection and Enhancement of Water Resources*, prepared by David J. Welsch, Forest Resources Management, Northeastern Area, USDA Forest Service, Radnor, PA, 1992.

bird surveys. Institutes of higher learning may be interested in wildlife research opportunities on the property.

STORMWATER MANAGEMENT

Excerpted from Vegetated Swales, *by Tom Richman, ASLA, Keith H. Lichten, AM.ASCE, Jennifer Worth, ASLA, Bruce Ferguson, FASLA, Landscape Architecture Technical Information Series, American Society of Landscape Architecture, 1998.*

Conventional stormwater management practice has been the conveyance approach, which treats runoff as waste product and seeks to remove this water off-site as quickly as possible. This "get rid of the water" approach results in paving land areas with impermeable surfaces so that water does not enter the subsoil. Rather it is collected and concentrated through a network of impervious gutter, drainage structures, and underground pipes.

Because the system is entirely impermeable, suspended pollutants and sediments have no opportunity to be dispersed or filtered and are concentrated in the rapidly flowing runoff. When the system reaches its outfall, this polluted water is emptied into a natural water body at a single, concentrated point.

An infiltration stormwater system seeks to infiltrate runoff into the soil by allowing it to flow slowly over permeable surfaces. Ideally, these permeable surfaces are designed to double as recreational and landscape areas during dry weather. Because the infiltration network allows much of the runoff to return to the soil, overall runoff volume is reduced, and more water is available to replenish groundwater and maintain stream base flows. The slow flow of runoff allows pollutants to settle into the soil where they are naturally mitigated. The reduced volume of runoff that remains takes a long time to reach the outfall, and when it empties into a natural water body its pollution load is greatly reduced.

There are many strategies for implementing this infiltration approach. They include the use of permeable pavements, extended detention basins, check dams and vegetated or grassy swales.

The internal road and parking system at Winterthur is very effective in transporting personnel and equipment throughout the property and in providing parking for staff and visitors. The large amount of impervious surface, however, fosters accelerated runoff of stormwater. In some areas this has led to gullying on steep slopes and streambank erosion, resulting in degradation to soil and water resources.

Recommendations for stormwater management fall under three main categories: maintenance of existing man-made structures, stabilization of terrain and natural streams, and recognition of the need for further, more detailed evaluations and studies in certain instances.

Existing Man-Made Structures

A general observation made during site visits was the amount of sediment and debris that has accumulated in drainage structures. Most notable was sediment in the bottom of most if not all catch basins that were inspected and debris (tree limbs, leaves, sediment, etc.) in culverts. In some instances, enough sediment had accumulated in catch basins to cover the outflow pipe, essentially rendering the basin useless. Perhaps of greater significance were the culverts that had accumulated debris. This debris could greatly constrict flow through the culvert and reduce available capacity. In at least two situations where two culverts existed side by side (twin culverts), one of the culverts was totally blocked which basically reduced the available capacity at the crossing by half. In extreme cases, the roadway over the culvert may be flooded during higher intensity events. Even infrequent overflows will often be detrimental to the roadway surface as undercutting or erosion of the asphalt itself may occur.

Winterthur should seriously consider implementing an annual inspection of all drainage structures with subsequent maintenance. It may also be beneficial to have a survey performed of these structures to catalog their locations, sizes, structural condition, etc.

Terrain and Natural Streams

In general, the numerous streams traversing the site are in good condition. There are places where erosion is occurring but many of these are within expected natural levels. In other words, streams naturally form bends due to different velocities between the banks and the center of the stream which result in mild scouring of the stream bank. However, man often exacerbates this situation by not providing adequate stormwater management controls. Erosion in the streams at Winterthur is occurring due to a combination of both.

Evaluations and Studies

The observations and recommendations above are based on field investigations coupled with professional experience. However, in some instances, it simply was not possible to determine with total certainty the causes of problems. Thus, it was difficult to know precisely the best recommendations. More detailed, further evaluations and studies would quantify information such as runoff rates, velocities, and capacities of catch basins, pipes, and culverts.

AESTHETICS/HAZARDS

There is some minor dumping of landscaping waste and rubble debris in wetlands that needs to be removed.

4.4 SPECIAL AREAS

Refer to Figure 11 and the Management Recommendations plan.

4.4.1 Pavilion Pine Grove

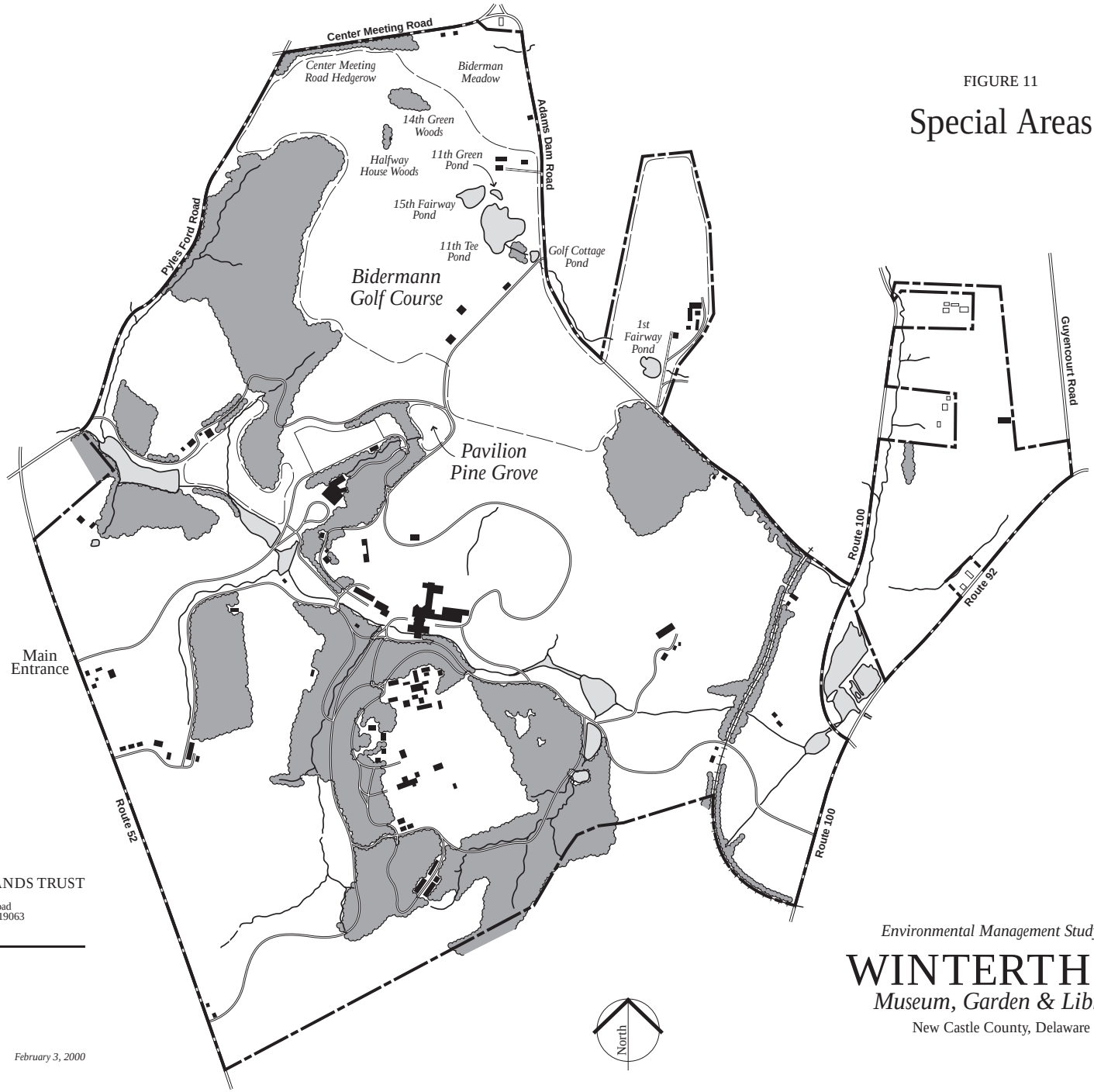
- ± 2.5 acres
- Consider installing a berm to create wetlands, also a check dam to slow runoff.
- Mow 1–2/year when dry, plant wetland wildflowers.

4.4.2 Bidermann Golf Course

- ± 150.0 acres
- Refer to 4.1 Woodlands and Hedgerows for general recommendations and stewardship guidelines.
- Refer to 4.2 Meadows for general recommendations and stewardship guidelines for meadow and/or rough areas.
- Refer to 4.3 Aquatic Resources for general and specific recommendations and stewardship guidelines.
- Continue with Audubon International program.
- Leaf and stump dumping occurring along northern edge of Chandler Woods. Remove because it is an attractive site for invasive vegetation to become established.

FIGURE 11

Special Areas



Environmental Management Study for

WINTERTHUR

Museum, Garden & Library

New Castle County, Delaware

NATURAL LANDS TRUST
Hildacy Farm
1031 Palmers Mill Road
Media, Pennsylvania 19063
610-353-5587

with

PATRICIA ANN QUIGLEY, INC.
1080 Quarry Hall Road. R.D. #1
Norristown, Pennsylvania 19403
610-584-1829

HYLA ASSOCIATES
1011 Center Mill Road
Hockessin, Delaware 19707
302-652-1952

February 3, 2000

- Just north of Chandler Woods - remove paulownia tree, herbicide area of vines and reseed.

4.5 TRAIL DESIGN AND MAINTENANCE

Adapted from: Trail Design, Construction, and Maintenance, *by William Birchard, Jr. and Robert D. Proudman, Appalachian Trail Conference, 1981,* Non-Motorized Trails/An Introduction to Planning and Development, *Pennsylvania Department of Environmental Resources, Bureau of State Parks, Division of Outdoor Recreation, The Pennsylvania Trails Program, 1980, and* AMC Field Guide to Trail Building and Maintenance *(2nd Edition), by Robert D. Proudman and Reuben Rajala, Appalachian Mountain Club, 1981.*

4.5.1 General Guidelines

In general, three types of guidelines should be followed in constructing new trails and maintaining existing trails: recreation enhancement, environmental protection, and public use and safety. If followed during trail layout, they will result in trail alignments which offer a more aesthetically pleasing and varied recreational experience, a more stable trail which can be maintained with less expense, and a safer and more enjoyable outdoor experience for users. In general, the more time spent during this phase of trail planning, the better the trail.

RECREATION ENHANCEMENT

- Trails should be varied so as to enhance the user's enjoyment and visual experience.
- Trails should provide scenic views and incorporate points of interest such as historic structures or sites, wetlands, ponds or rock outcrops.
- Trails should be buffered from the sight, sound and hazards associated with manmade features, including roadways, buildings, and developed land uses.
- The trail designer should make creative use of vegetation to enhance the hiking experience.
- Trails should blend into the natural surroundings by maintaining continuity and regularity in the way they traverse the land.
- The trail designer should look for varying vegetative cover, avoiding alignments through continuous stands of similar vegetation.
- Trails should not have long straight sections which are unbroken by vegetation or topography. Short trail sections with many broad turns are desirable.
- Sudden changes in direction or too much meandering should be avoided.
- Planting showy native plants and butterfly/hummingbird-attracting plants in a naturalistic style in key areas along trails can greatly improve user enjoyment.
- Locating resting areas (benches, etc.) near features such as streams and ponds will allow users opportunities to enjoy the sights and sounds of the resources on the property.

ENVIRONMENTAL PROTECTION

- Every attempt should be made to position trails outside of environmentally sensitive areas, but with careful planning, a

trail may incorporate a special features of the landscape into its design without adverse environmental impact.

- When locating a trail within its corridor, primary emphasis should be placed upon characteristics of soils and topography which control trail stability.
- Trails should fit the land by following the contour of the landscape.
- Trails should not go straight up steep grades.
- Areas having slopes in excess of 20% should be avoided, unless those areas are to be paved or otherwise stabilized.
- Soils which are deep, well drained, resistant to erosion, and do not have high seasonal water tables are most suitable for trail development.
- Where trails follow steep grades, sidehilling should be used to reduce grades and erosion, as well as to improve surface drainage.
- Switchbacks should be used when going up steep gradients where sidehilling cannot gain elevation fast enough.
- Switchbacks should not be visible from one another.
- Wide turns should be used in switchbacks to limit shortcutting, particularly where the trail is in an open hardwood forest where users can see ahead.
- Trail layout should provide for low impact on sensitive resources, such as wetlands. Main trails should bypass these resources where possible, with only secondary trails providing access to them. If highlighting these areas, special precautions should be taken to reduce the impact of hikers through the use of bridges and elevated walkways.
- Side trails leading to fragile resource areas should generally be longer and more difficult so as to discourage the majority of main trail users from using them.

PUBLIC USE AND SAFETY

- Where there are road crossings, the hiker's exposure should be minimized by crossing in the shortest practical manner, usually at right angles, with adequate sight distances.
- Trails should not parallel road rights-of-way.
- Trails should avoid areas of streams and ponds with steep banks, deep water, or other potential hazards to children.
- Where trails are in the vicinity of developed land uses, they should have as wide a buffer as possible, and as long sight lines as possible, so as to keep potential conflicts with adjacent landowners to a minimum.

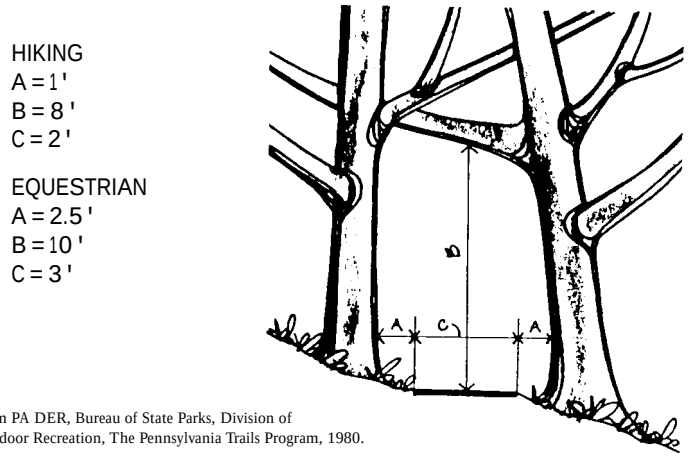
4.5.2 Trail Construction

TRAIL CLEARING

If an old trail should be re-routed or a new trail is needed, the general alignment should be walked and flagged to determine exactly how the treadway should wind and dip, which rocks should be removed and which trees should be cut. This is a critical step in the trail building process, as slight shifts in the alignment can significantly affect drainage and treadway durability.

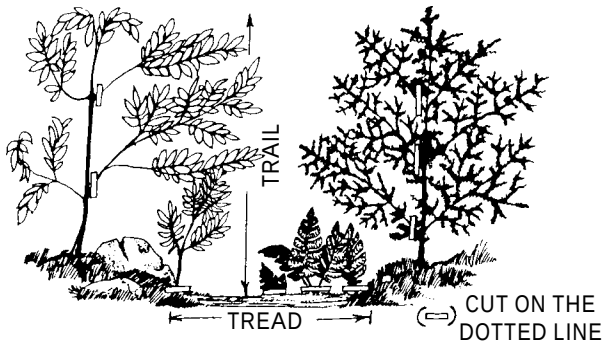
After the precise location of the trail is determined, the treadway should be cleared. For hiking trails, a 2′ treadway should be cleared with all projecting limbs cleared an additional 1′ for a total

FIGURE 12: *Trail Clearing Dimensions*



From PA DER, Bureau of State Parks, Division of Outdoor Recreation, The Pennsylvania Trails Program, 1980.

FIGURE 13: *Trail Vegetation Removal*



From Proudman, Robert D. and Reuben Rajala, 1981.

FIGURE 14: *Blowdowns*

From Proudman, Robert D. and Reuben Rajala, 1981.

horizontal width of 4′. For equestrian trails, a 3′ treadway should be cleared with all projecting limbs cleared an additional 2.5′ for a total horizontal width of 8′. The trail should be cleared to a vertical height of 8′ for a hiking trail and 10′ for an equestrian trail (Figure 12).

In clearing trails all shrubs, vines, low-hanging branches, blowdowns, small trees, and fallen logs should be removed. Shrubs and small trees should be cut flush with the ground surface. Care should be taken not to disturb the ground surface or to pull plants out by the roots as this will lead to erosion of the treadway (Figure 13). Large trees fallen across the trail should be left in place by making two cuts and removing a 4′ wide section from the trunk across the trail (Figure 14). If motorbikes or mountain bikes are a problem, the logs can be notched to provide a flat surface for hikers, yet prohibit the passage of wheeled vehicles.

When clearing is completed, cuttings should in general be scattered in areas adjacent to the trail and left to decompose. It is necessary to collect the cuttings and remove them from the immediate trail area only where it is adjacent to public roads and developed areas.

In the first year of a trail, repeated clearing will be required to deter continued vegetation growth. In subsequent years, clearing will probably be necessary only two or three times a year. The exception would be in the areas of open fields and grassy areas where mowing may be required if trail use is not adequate to maintain a clearly visible treadway.

TREADWAY STABILIZATION

The type of tread surface on trails will ultimately be determined by its rate of use and the terrain through which the trails pass. Initially, once a trail has been cleared, it should be surveyed to ascertain where special measures should be taken to stabilize the treadway. These special measures will primarily include treadway hardening and erosion control measures. Most problems are likely to occur where a trail traverses steep slopes and wet areas, or where surface water drainage flows across the trail during storms.

In most areas there will be no need for actual trail construction, as careful trail design should have selected stabilized areas. In existing stable areas with slopes of less than 10%, the exact alignment of the treadway can be located by sweeping herbaceous and trailing plants and leaf litter off the path. Where with time and use initially stable areas begin to show signs of wear and erosion, then some stabilizing type of material, such as wood chips or crushed stone, should be placed on the treadway.

If a new trail must be routed through wet areas, steps should be taken to harden the treadway before it deteriorates. There are four basic techniques typically used to accomplish this (see Figure 15):

- *Drainage Ditches*

The first step in trail hardening in wet areas is to try to enhance the drainage by creating small drainage ditches. These ditches should be dug at the lowest points along the trail, and be 1′ wide, 1′ deep, and anywhere from 3′–20′ in length. They should also be clear of roots and rocks, have sloping sides that prevent collapse, and be cleaned out annually.

- *Stepping Stones*

Where drainage ditches alone cannot adequately harden the treadway, then stepping stones should be placed across wet areas. These should be located close together, flat side up, and sunk low enough so that they do not rock.

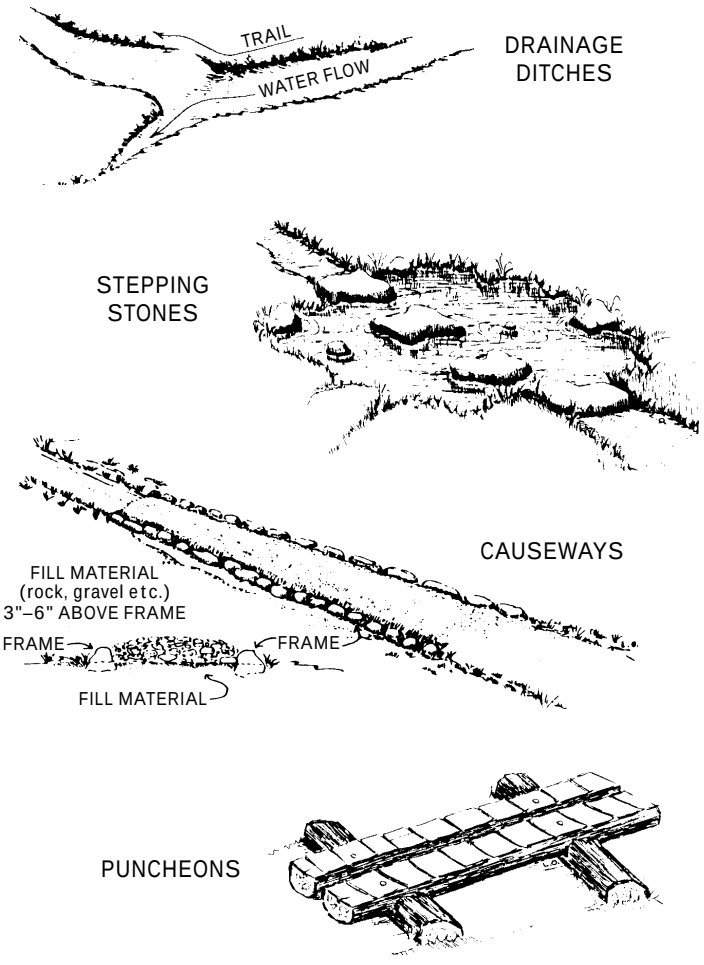
- *Causeways*

Causeways can be used to elevate the trail above the saturated terrain using rock, gravel or fill. The preferred method of construction is with gravel and rock which is placed inside a log frame. The fill is packed and mounded to a height of 3″–6″ above the frame. A drainage ditch is then dug parallel to and on both sides of the causeway.

- *Puncheons*

Puncheons are used where there is little rock available or where the underlying soil is mucky or peaty. The simplest type of puncheon is a topped-log puncheon, made with two stringers that form the treadway, set on two base logs that serve as mud sills.

FIGURE 15: *Treadway Hardening Techniques*



From Birchard, William and Robert D. Proudman, 1981.

Where a new trail traverses slopes greater than 10%, certain trail building techniques should be used to prevent trail widening and erosion. The major technique used is sidehill construction in which the trail is excavated so that water crosses the trail but does not run down the treadway at high velocities. Sidehilling is coupled with several additional techniques for erosion control such as shoring, cribbing, coweeta dips, bleeders, wonder bars, and steps. The process of sidehill trail construction and construction of the other erosion control techniques is somewhat complicated. For details refer to Chapter 8 of the Appalachian Trail Conference's publication entitled *Trail Design, Construction, and Maintenance* (1981).

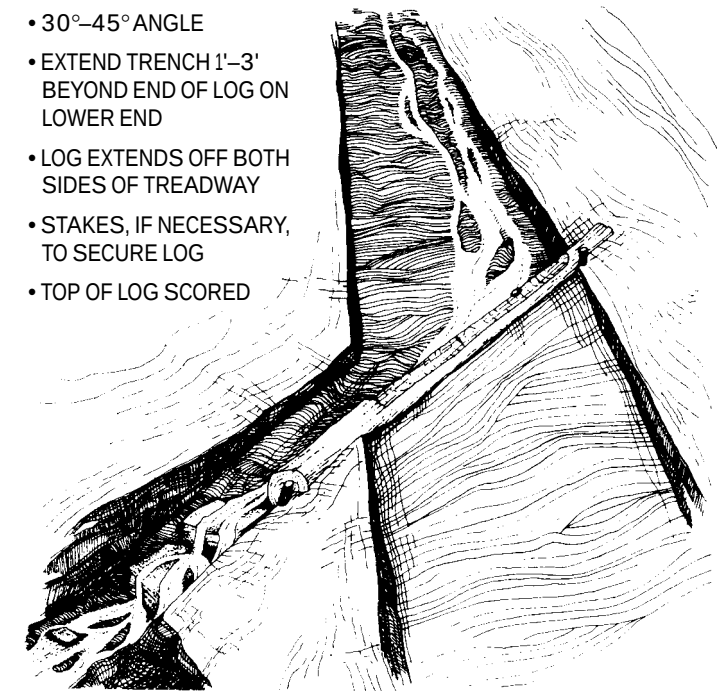
WATERBARS

Waterbars, barriers that divert water off the treadway, are not only erosion control techniques, but are also erosion preventative techniques. In other words, trails should be waterbarred as a preventative measure, even if erosion is not yet evident. Waterbars should be installed on trails at every significant change in direction, at the top of downgrades, at points where water is entering trails, and at roughly the following intervals: every ±75′ when the slope is 3–8%, every ±50′ when the slope is 8–15%, and every ±25′ when the slope is greater than 15%.

Waterbars can be constructed from any rot-resistant type of wood. Use logs with a minimum diameter of 6″–8″ at the small end, greater if water flow is heavy, and remove all bark. The length depends on the width of the trail; it should extend at least 1′ past the outside edge of the treadway on both sides.

Dig a trench across the trail at a 30˚–45˚ angle (Figure 16). The depth of the trench should be about the same as the diameter of

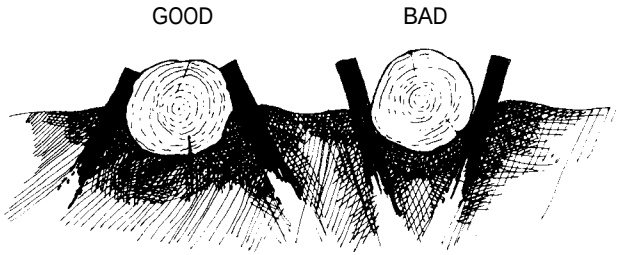
FIGURE 16: *Waterbars*



From Proudman, Robert D. and Reuben Rajala, 1981.

the waterbar, enabling it to be almost flush with the trail on its downhill side once in place. The trench should be at least as long as the log, and in most cases greater. On the lower end, to ensure that the water is directed well off the trail and cannot return, the trench should be extended 1′–3′ beyond the end of the log, unless natural topography adequately channels water away from the trail. Make sure the trench is wide and free of rocks and roots.

FIGURE 17: *Stakes*



From Proudman, Robert D. and Reuben Rajala, 1981.

Place the log in the trench so that at least half of its diameter is below the treadway surface and it extends off both sides of the treadway. Neither water nor hikers should be able to pass around the bar. Seat the log solidly, if possible wedging it between rocks to make it stay in place. If the log is not completely stable, secure it by weighting the ends with heavy rocks or staking it in place with 3–5 stakes, one against the lower end and one or two on either side, placed near each end of the log, out of the main flow of traffic. Stakes on the uphill side of the bar should be notched into the log for added security and to minimize drag when water passes. To obtain stakes, cut 2″–3″ diameter undesirable trees into 18″ pieces with a bow saw. Drive the stakes at an angle, the top slanting over the log, so the stakes tend to pin the log to the ground (Figure 17). Pound the stakes until they are flush with the top of the log to prevent them from posing an obstacle or from becoming loose by being kicked. Saw off flush with the log any extra that cannot be driven.

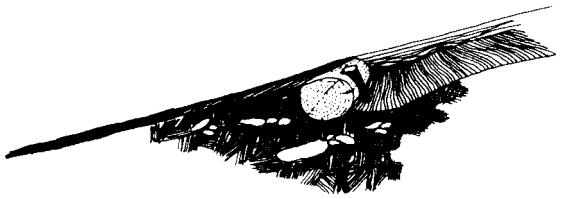
To finish the waterbar, score the top to provide a rough surface for hikers to step on. Grade the treadway above the bar gradually

down into the trench, packing some soil underneath the log to prevent water from undercutting it. Pack all excavated soil and rock below the bar into a mound slightly higher than the top of the waterbar. With traffic it will pack and wear down flush with the top of the waterbar (Figure 18).

The drainage ditch off the end of the waterbar should be broad (6″–8″ or more), free of roots, and the sides should be sloped. A narrow ditch or one with roots in it will clog easily; steep sides are apt to collapse. Where water flow is heavy or the bar directs water down a steep slope, runoff may erode the soil adjacent to the treadway. Where this is a problem, rocks should be placed in the channel to slow the water and make it drop its sediment.

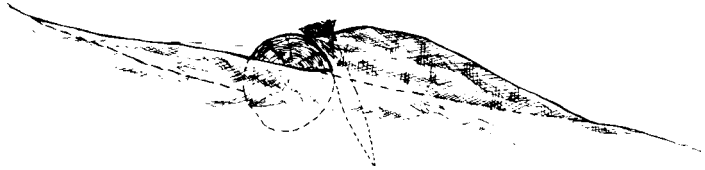
Waterbars should be cleaned out annually in order to keep them working at maximum effectiveness. Deposited soil, leaf litter, and organic matter will clog waterbars, especially those which are not self-maintaining. Debris should be dug out on the upper side, with sediments being spread over the trail below the bar to backfill it (Figure 19). Any ditch that has filled in should be cleaned at the same time, using the debris for backfill as well.

FIGURE 18: *Waterbar Cross Section*



From Proudman, Robert D. and Reuben Rajala, 1981.

FIGURE 19: *Waterbar Maintenance*



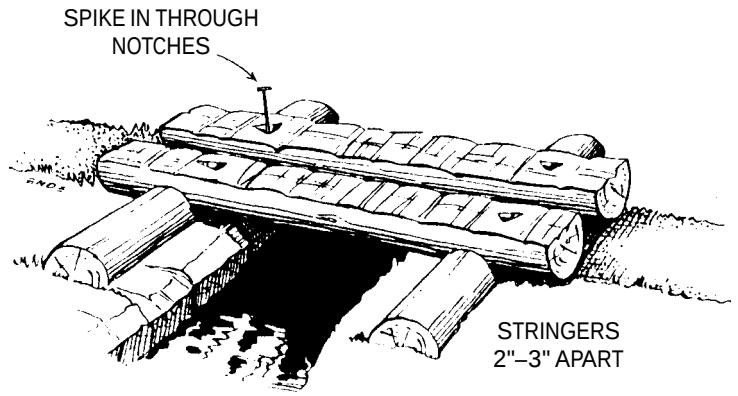
From Proudman, Robert D. and Reuben Rajala, 1981.

DRAINAGE SWALES, STREAM CROSSINGS AND BOARDWALKS

Any trail in Winterthur will more than likely have only minor crossings of small streams and drainage swales. For these conditions, there is no need for construction of elaborate bridges. Natural stream crossings using stepping stones are ideal in this setting where the stream flow is generally low and there are not significant fluctuations in flow, except following major storm events. The stepping stones should be large and flat-topped. They should be placed approximately 2′ apart across the stream. Ideally, the bottom on which the stones are laid should be stone in order to prevent movement (Figure 15).

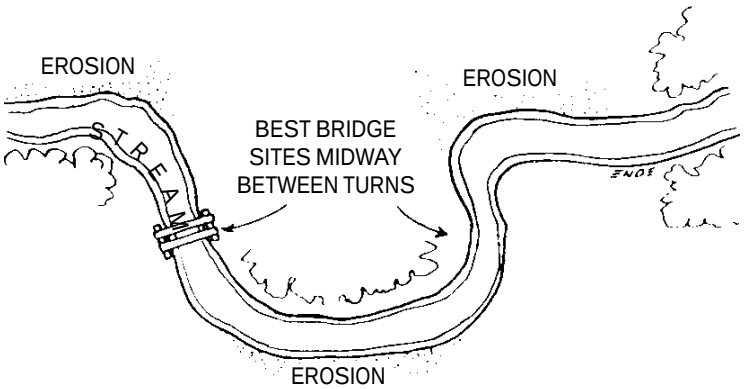
As an alternative to stepping stones, a simple bridge could be constructed of a single or double stringer with two base logs (Figure 20). The base logs should be placed on each bank above the flood level on a flat stone or ledge, secured with drift pins if possible. The stringer(s) should be secured to the base log on each end using 10″ or 12″ spikes or large bolts. Both the base logs and the stringers should be of rot-resistant wood such as hemlock, locust, white oak, or spruce from which all the bark has been

FIGURE 20: *Stringer Bridge*



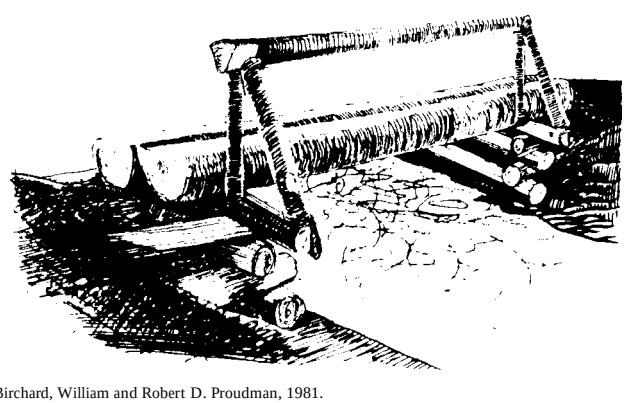
From Birchard, William and Robert D. Proudman, 1981.

FIGURE 21: *Bridge Siting*



From Birchard, William and Robert D. Proudman, 1981.

FIGURE 22: *Two Stringer Bridge with Handrail*



From Birchard, William and Robert D. Proudman, 1981.

removed. To facilitate construction, crossing sites for bridges should be selected where the banks are the same height and midway between turns (Figure 21). A handrail would be needed for safety only if the top of the stringer is more than 3′ above the stream (Figure 22). The stringer surface should be randomly scored to provide safer footing when wet.

Winterthur should be aware that any new stream crossing by a bridge that involves a structure in the water will require a permit from the Delaware Department of Natural Resources and Environmental Control (DNREC), Division of Water Resources, Wetlands and Subaqueous Lands Section (302-739-4691).

Boardwalks are elevated post and decking structures that provide access to marsh and wetland ecosystems with minimal negative impacts. Boardwalks are usually constructed of wood and the foundation is usually a pier or wood post. If touching the ground

or submerged in water, the posts most often are chemically treated with an oil-based or water-borne wood preservative such as creosote, pentachlorophenol, chromated copper arsenate, or zinc chloride. Most of these wood preservatives are toxic to the natural environment and can be harmful to human health. They do, however, add the necessary longevity and structural safety. Two alternatives are posts made from recycled plastics which do not release harmful chemicals into the ground or water system and galvanized steel helical piers and anchors. The recycled plastic post is either mechanically driven to the depth of firm soil or bedrock or secured in a concrete footing set in an excavated hole. The helical piers and anchors screw into the ground quickly, much the same as a wood screw goes into a piece of wood. Railings are an optional consideration for boardwalks that meander through wetland habitat. When the height of the decking above the ground exceeds 30″, rails are recommended.

Again, permits may be required for a boardwalk. The U.S. Army Corps of Engineers (Philadelphia District, 215-656-6729) requires a permit for any discharge of fill within wetlands. Any such project will also have to obtain clearance through the Historic Preservation Act because of Winterthur's status as a registered historic landmark.

4.5.3 Trail Marking

Trails should be marked in an understandable, systematic, and vandal-proof manner. This can be done with a combination of techniques, the principal ones being paint blazes, signs, and, for treeless areas, posts. Application of the techniques will, of course, vary somewhat with each particular trail situation.

Paint blazes are probably the most effective and commonly used techniques for marking hiking trails. Paint's durability, universal availability, inexpensiveness, and ease of application make it the most practical method for marking most hiking trails. Plastic or metal markers of various shapes and colors and nailed to trees and posts may be removed by vandals as easily as they are put up. They are also expensive, and color and lettering, if present, often fade after several years.

Each major trail should have its own primary color and a standard color should be used for all secondary trails so that hikers will know they have diverged from a main trail whenever they see that color, regardless of which of the major trails they may be following. Those colors considered most visible by experienced trail builders include blue, red, yellow, white, and orange.

MARKER PLACEMENT

Markers should be placed perpendicular to the trail in both fore and aft directions, treating each direction separately. They should be placed on trees or rocks which "strike the eye" while traveling along the trail, but not on ones that are important elements of a view or setting. They should be visible but not mar the visual character of the trail.

A large tree is preferable for marking to a small one and a live tree is better than a dead one because should the tree blow over, the marker is lost. Avoid placing markers on both sides of the same tree — the loss of one tree will result in a twofold loss in marking. Place markers where they will be visible in all seasons. With light-colored markers, darker trees are best for contrast, and vice versa.

At significant changes in direction of the trail or where it turns into a less well defined trail or road, two markers should be placed

on the same tree, rock, or post, one 2″ above the other (Figure 23). After changes in trail direction, the first marker should be placed with particular care so that hikers can clearly see it from the turning point.

MARKER FREQUENCY

Do not overmark. The frequency of marking will be determined by the character of the trail, ideally with no more than one mark visible at one time in either direction. On narrow woods trails with an obvious tread and trail corridor and with little opportunity for the hiker to stray off track, marks can be widely spaced, perhaps every 100′–200′. On the other hand, a trail without an obvious treadway through an open hardwood forest or meadow should be closely marked — possibly every 30′–50′. This is particularly true if the trail is used in winter.

FIGURE 23: *Trail Markers*

From Birchard, William and Robert D. Proudman, 1981.

PAINT BLAZES

Paint blazes should be a vertical rectangle 2″ wide by 6″ long and placed at eye height, approximately 6′ (Figure 23). This shape, used by the Appalachian Trail, has proved to be a good, easily spotted one for trail marking.

Use an oil-based, gloss exterior house paint or boundary-marking ink. Apply paint to dry surfaces only, preferably during fair weather at temperatures above 50˚ F. Do not blaze during rainy or damp weather. The surface of trees with smooth bark or rocks to be used for blazing should be prepared for painting by removing dirt, lichens, etc., with a wire brush or nylon scrub pad. The surface of trees with rough bark should be prepared by using a paint or hardwood floor scraper to scrape a flat, fairly smooth surface the size of the paint blaze. Do not cut through the bark on any tree, as it will damage the tree and resin will ooze out, discoloring the blaze.

The paint may be applied through a stencil, using either a brush or a spray can; with a 2″ x 6″ stamp made from a sponge; or painted freehand. In all cases, do not drip paint or leave blotch marks or over-sized blazes. If painting freehand, carry a cardboard template to gauge the size of the blaze.

It may become necessary to obliterate paint blazes at some time, typically because of relocation of the trail. To eliminate all or a portion of a blaze, use a brown, gray, or custom-mixed paint matched to the surface being covered. When a trail is relocated, all blazes on the abandoned section should be obliterated. It is not sufficient to simply eliminate those at each end, since persons straying onto the old route may see blazes in between, assume they are on the trail, and be misled.

POSTS

While trails in meadows may be obvious while the grasses are high, after mowing, the treadway may be harder to follow. Wooden

posts are a good way to mark meadow trails (Figure 24). Using 4″ x 4″ black locust or white oak lumber, cut posts 6′–8′ long and slant the top of the post to drain water. Sink them two or three feet into the ground, and blaze them, as described above, on both sides. To give the post greater stability and to prevent turning and removal by vandals, attach a 6″–12″ cross piece to the bottom. The cross piece may be made in a variety of ways: 1) attach a wooden board or a piece of angle iron with a lag screw; 2) drill a hole through the bottom of the post and hammer a piece of reinforcing bar or threaded rod through the timber; 3) simplest of all — though least effective — drive a 10″–12″ spike halfway through the post.

Post Markers

From Birchard, William and Robert D. Proudman, 1981.

4.5.4 Trail Signage

Well designed, coordinated trail signs are an essential component of any trail system. Signs identify and label facilities and points of interest. They warn hikers of danger from natural hazards and unusual trail conditions. They educate hikers in the proper use of the outdoors, list regulations and guidelines, and promote the protection of nature. They explain and interpret interesting features along the trail, such as natural and cultural history. Most important, they direct the hiker by listing destinations and distances along the route.

SIGN PURPOSE AND CONTENT

Directional signs list direction, destinations, and distances along the trail. They are posted at trailheads, side trail junctions, and alternate routes. In general, they should make the trail easy to follow. They should list five pieces of information:

1. The trail name
2. Two or more well known destinations along the trail such as road crossings, streams, or areas of special interest.
3. The direction to the listed destinations, indicated by either arrows or a pointed signboard.
4. The distances to the listed destinations in miles and tenths of a mile.
5. The Winterthur logo.

Identification signs identify the most important features along the trail such as streams, springs, unusual trees, vistas, etc. They should be small signs, containing only one or two words.

Interpretive signs can point out areas of interest that make the trail unique such as ecologically or historically significant sites. These signs should be placed sparingly, since interpretive signs can clash with the natural character of some areas. Educating the users of the trail about flora, fauna, and special terrain can be more effective than setting up barriers and “Do Not Enter” signs.

Regulatory signs list regulations for trail use related to hiking, trespassing on private property, fire building, camping, pets,

firearms, etc. Regulatory signs should be posted at all trail heads and major trail junctions. Specific regulatory signs, particularly no trespassing signs, should be posted as appropriate, given proximity to private property lines and areas which are particular problems with respect to trespassing. They should also list the person to whom problems should be reported.

SIGN DESIGN

Signs can be made of a variety of materials, the most common being wood (with either routed or painted letters), metal, and plastic. Sign size should be kept as small as possible. Most signs should vary from 6″ by 15″ to 12″ by 20″. The primary exception would be trailhead and interpretive signs which could be as large as 2′ by 3′.

Lettering for primary headings on directional signs should be no more than 1″ or 1.5″ high. The message of the sign should be in 0.5″, 0.75″, or 1″ letters. Large trailhead signs may demand 1.5″ letters. Wordy signs should generally be in 0.5″ letters.

Sign layout should leave ample space between word, number, arrows and lines to be sure the message does not run together visually. On signs with a combination of 1″ and 0.75″ letters, 0.25″ between lines is adequate. Arrows should generally be the same width as the letters so that they can be seen easily. Arrowheads should be as wide as the message letters are high. Each entry on directional signs should be on a separate line. Anticipate the location of drill holes and mounting hardware to prevent them from later covering some of the letters. Try to lay out the message so that a minimum of space is left for vandals to put graffiti.

It is best to limit colors to two, one for the background and one for the lettering. The color scheme should blend with the natural surroundings yet be easy to read because the letter and background colors contrast sharply. A brown background with white, yellow, or cream-colored letters is often used on state and federal park land, as well as the Appalachian Trail. A white background with green or black letters also makes an attractive sign. It is important that a sign system be designed and constructed in the same style and with the same materials for all types of signs — directional, identification, interpretive, and regulatory. These types of signs will have a broad range of letter sizes, colors, and layout depending upon their purpose. However, they should have a standard theme which clearly establishes them as an element of the Winterthur trail signage system, including the Winterthur logo.

SIGN CONSTRUCTION

The method of sign construction will depend upon the materials to be used to make the signs. Paper, plastic, and metal signs can be produced through standard fabrication and printing processes. Routed wood signs would be a more specialized product, requiring sign making equipment such as a router or sign making machine and generally with hand painting of the letters.

SIGN INSTALLATION

The location of each sign should be selected with care. Except for areas where theft or vandalism are recurrent problems, signs should be placed at eye level, between 4′ and 5′ above the ground.

Although more expensive, mounting signs on posts is generally preferable to mounting signs on trees. This eliminates damage to trees as well as the need to replace signs as they are damaged by tree growth. Posts should be 6″–10″ in diameter, buried to a depth of 3′. Cedar, locust or hemlock posts will tend to last longer and

are preferable to pressure treated materials. To give the post greater stability and to prevent turning and removal by vandals, attach a 6″–12″ cross piece to the bottom. The cross piece may be made in a variety of ways: 1) attach a wooden board or a piece of angle iron with a lag screw; 2) drill a hole through the bottom of the post and hammer a piece of reinforcing bar or threaded rod through the timber; 3) simplest of all — though least effective — drive a 10″–12″ spike halfway through the post. The post top should be bevelled or slanted to drain water and a flat recess cut in the side for mounting the sign snugly.

Secure hanging techniques are necessary, particularly for attractive signs. All bolts, washers and nails should be galvanized or at least zinc-plated. Hot-dip or marine-galvanized hardware is most rust resistant. Special nuts and bolts such as *Vandlgard* or *Tufnut* brands are most vandalproof. Bolts can also be countersunk and the tops covered with wooden plugs or putty.

At trailheads a larger sign or bulletin board should be constructed to hold numerous signs, including at a minimum a map of the Winterthur trail system, a map of the specific trail at that trailhead, and a set of regulations for the trail. A bulletin board should be weatherproof and vandal resistant, with a roof and plexiglass over the maps and signs.

4.6 STAFFING AND EQUIPMENT

4.6.1 Staffing

The natural areas (forest, meadow, streams) encompass over 70% of the land area at Winterthur, yet there is no personnel dedicated exclusively to their management. Currently, management within these areas is done on an as-needed basis by members of the Horticultural Department as part of their job responsibilities that focus on maintenance of the hardscape (roads, bridges, garden structures) within the Garden and setting up for the Point-to-Point and Craft Fair. While this has served to handle urgent maintenance needs, such as removal of hazardous trees, it has fallen far short in protecting these areas from natural and human degradation. To seriously address existing problems and to realize potential opportunities highlighted within this plan, a greater commitment of staff time will be needed for the management of Winterthur's natural areas.

It is recommended that Winterthur dedicate one staff member to focus exclusively on the management of the natural areas. This person should have an educational background and hands-on experience in natural resource management and environmental education. Responsibilities would include (1) to prioritize and organize restoration and enhancement projects, (2) to coordinate with other staff for time and equipment, (3) to monitor ongoing projects, and (4) to develop and implement an environmental education program to compliment the tours of the formal gardens. This person would also provide a natural resource perspective to

review activities proposed by other departments that might impact the natural areas.

Outside of the basic resource management training, the only specialized training would be in the use of prescribed fire to manage the meadows. If Winterthur wished to pursue use of this management tool, it would be best to train in-house staff to perform this task given the scarcity of outside contractors and the narrow window for using this tool each year. A burn crew of 5 or 6 people would be required, although only one person, the Fire Leader, would need to have advanced training. The existing fire crew would be an obvious choice to undertake this work.

4.6.2 Equipment

The staff at Winterthur appears to be well-equipped to effectively handle management needs within the natural areas. Most maintenance and restoration work within the woodlands can be accomplished with small hand tools (pruners, loppers, pruning saw), a small chainsaw, and a handheld or backpack herbicide applicator.

The only specialized equipment would be that needed for meadow restoration and maintenance. A field sprayer (to remove cool-season grasses) and a no-till drill (to plant warm-season grasses) are needed to restore/enhance the meadows, although this work could be performed by a contractor. If fire is used to maintain the meadows, ignition, fire control, and personal protection equipment (Nomex suits, helmets, fire shelters) will be needed. Costs per person for ignition and protection equipment are approximately $700. Given the established fire department at Winterthur and the accessibility of the meadows there should be a minimal expense for additional control equipment.

4.7 PRIORITIES

This report offers numerous recommendations for the restoration and management of the extensive natural areas of Winterthur. Given the many other on-site priorities of the management staff there is currently insufficient time to address all of these recommendations. Therefore, ***the first priority Winterthur should consider is the dedication of one staff member (or equivalent) to focus exclusively on the management of the natural areas.*** This person would oversee and coordinate the necessary restoration and enhancement projects, monitor ongoing projects, and oversee and coordinate public use and research and environmental education programs.

To assist Winterthur in making the most efficient and effective use of the time and resources available, we are providing a list of overall priorities for work within the natural areas. Initiating these will have the greatest environmental and ecological benefits with the least investment of staff resources. These priorities are based upon current conditions and should be reviewed on a periodic basis as conditions and internal priorities change.

- ***Reduce the local deer population***
  Continue efforts to lower the population to encourage native tree and shrub regeneration and protect woodland wildflowers.

- ***Modify the meadow mowing schedule***
  Mow only once per year after July 15th and consider mowing only half of the meadows each year to provide better habitat for grassland dependent fauna, particularly birds.

~ *Cut invasive vines on canopy trees*
Protect the existing canopy to help shade invasives and provide a native seed source.

~ *Address stormwater runoff*
Reducing the rate of flow from the main parking lot and from the golf courses will protect on-site soil resources and water resources within and outside of Winterthur.

~ *Reduce ornamental groundcovers*
Eradicate or at least control patches of invasive exotic groundcovers in order to maintain and/or restore the native herbaceous vegetation.

~ *Cut understory invasive trees and shrubs*
Removing these trees will allow more light to penetrate to the forest floor and encourage tree regeneration. It will also reduce the invasive seed source.

~ *Riparian buffer*
Establish at least tall grass meadow riparian buffers (preferably shrub and/or tree buffers where appropriate) along all streams and ponds to improve water quality.

~ *Promote research and education*
Contact local schools and universities and offer the site for appropriate research and education projects. Students and researchers will benefit by having diverse and relatively secure sites and property managers will benefit with an increased understanding of the on-site resources.

~ *Establish public trail system*
Creating an interpretive trail system (starting with Phase I) will provide visitors a contrasting experience to the formal gardens and perhaps garner support for needed management.

APPENDIX A

Vegetation Inventory

Inventory dates:	October 1, 2, 1997 October 16, 1997 April 15, 16, 1998 April 29, 1998 May 7, 1998 May 28, 1998 June 18, 1998 July 10, 1998 July 22, 1998 August 7, 1998 August 26, 1998 September 16, 1998 September 23, 1998 October 6, 1998
Nomenclature:	(1) Rhoads, (2) Dirr, (3) Lauren Brown
Native/Introduced:	(1) Rhoads, (2) Dirr
* :	dominant vegetation
(?) :	not sure of identification
State/Global Rankings:	Delaware Natural Heritage Program, March 1998

WOODLANDS

14th Green and Halfway House Woods

± 1.0 acres and ± 0.3 acres

CANOPY

	Carya glabra	pignut hickory	native
	Fagus grandifolia	American beech	native
	Fraxinus americana var. *americana*	white ash	native
	Juglans nigra	black walnut	native
	Nyssa sylvatica	black-gum	native
	Prunus avium	mazzard cherry	introduced
	Prunus serotina	wild black cherry	native
*	*Quercus alba*	white oak	native
*	*Quercus rubra*	northern red oak	native
*	*Quercus velutina*	black oak	native

UNDERSTORY

	Acer platanoides	Norway maple	introduced
	Carya ovata	shagbark hickory	native
*	*Cornus florida*	flowering dogwood	native
	Nyssa sylvatica	black-gum	native
	Prunus avium	mazzard cherry	introduced
	Prunus serotina	wild black cherry	native
	Quercus alba	white oak	native

SHRUB

VINE

HERBACEOUS

	Antennaria neglecta	field pussytoes	native
	Aster divaricatus	white wood aster	native

Carex pensylvanica	sedge	native	
Luzula echinata	common wood-rush	native	
Ranunculus bulbosus	bulbous buttercup	introduced	
Taraxacum officinale	dandelion	introduced	
Viola sororia var. *sororia*	common blue violet	native	

Chandler Woods

± 48.5 acres

CANOPY

Ailanthus altissima	tree-of-heaven	introduced		
Acer platanoides	Norway maple	introduced		
Acer rubrum	red maple	native		
Carya glabra	pignut hickory	native		
Carya hybrid	hickory	native	*C. glabra x C. ovata or C. cordiformis*	
Carya ovata	shagbark hickory	native		
Carya tomentosa	mockernut hickory	native		
* *Fagus grandifolia*	American beech	native		
Fraxinus americana var. *americana*	white ash	native		
Juglans nigra	black walnut	native		
* *Liriodendron tulipifera*	tuliptree	native	** 64" dia.*	
Nyssa sylvatica	black-gum	native		
Pinus strobus	Eastern white pine	native	*along edge of golf course*	
Prunus avium	mazzard cherry	introduced		
* *Quercus alba*	white oak	native		
Quercus macrocarpa	bur oak	native		
* *Quercus rubra*	northern red oak	native	** 36" dia.*	
* *Quercus velutina*	black oak	native		
Robinia pseudoacacia	black locust	native		

UNDERSTORY

Ailanthus altissima	tree-of-heaven	introduced	
* *Acer platanoides*	Norway maple	introduced	

*	*Acer rubrum*	red maple	native	
	Carpinus caroliniana	hornbeam	native	
*	*Carya glabra*	pignut hickory	native	
*	*Carya tomentosa*	mockernut hickory	native	
	Castanea dentata	American chestnut	native	SU, G4
	Cornus florida	flowering dogwood	native	
	Evodia daniellii	Korean evodia	introduced	
*	*Fagus grandifolia*	American beech	native	
	Fraxinus americana var. *americana*	white ash	native	
	Fraxinus nigra	black ash	native	S2, G5
	Fraxinus pennsylvanica	red ash	native	
	Ginkgo biloba	ginkgo	introduced	
	Ilex opaca	American holly	native	
	Liriodendron tulipifera	tuliptree	native	
*	*Nyssa sylvatica*	black-gum	native	
	Paulownia tomentosa	empress-tree	introduced	
	Pinus strobus	Eastern white pine	native	
	Prunus sp.	cherry	—	
	Prunus avium	mazzard cherry	introduced	
	Prunus pensylvanica	pin cherry	native	
	Prunus serotina	wild black cherry	native	
	Quercus alba	white oak	native	
	Sassafras albidum	sassafras	native	
	Styrax japonicus	Japanese snowbell	introduced	
	Tilia americana	basswood	native	
	Ulmus rubra	red elm	native	

SHRUB

Berberis thunbergii	Japanese barberry	introduced	
Euonymus alatus	winged euonymus	introduced	
Kalmia latifolia	mountain laurel	native	
Ligustrum obtusifolium	privet	introduced	
* *Lindera benzoin*	spicebush	native	
Lonicera xylosteum	European fly honeysuckle	introduced	
Rhododendron periclymenoides	pinxter flower	native	

	Rhodotypos scandens	jetbead	introduced		
	Rosa multiflora	multiflora rose	introduced		
	Rubus allegheniensis	common blackberry	native		
	Rubus phoenicolasius	wineberry	introduced		
	Sambucus canadensis	American elder	native		
	Vaccinium pallidum	lowbush blueberry	native		
*	*Viburnum acerifolium*	maple-leaved viburnum	native		
*	*Viburnum dentatum*	southern arrow-wood	native		
*	*Viburnum dilatatum*	linden viburnum	introduced		
*	*Viburnum plicatum* var. *tomentosum*	doublefile viburnum	introduced		
*	*Viburnum prunifolium*	black-haw	native		

VINE

	Celastrus orbiculatus	Oriental bittersweet	introduced		
	Hedera helix	English ivy	introduced		
	Lonicera japonica	Japanese honeysuckle	introduced		
	Menispermum canadense	moonseed	native		
	Parthenocissus quinquefolia	Virginia-creeper	native		
	Smilax rotundifolia	catbrier	native		
	Toxicodendron radicans	poison-ivy	native		
	Vitis labrusca/V. labrusca x *riparia* (?)	grape	native		

GROUNDCOVER

	Vinca minor	common periwinkle	introduced		

HERBACEOUS

	Agrimonia striata	roadside agrimony	native	S1, G5	
	Alliaria petiolata	garlic-mustard	introduced		
	Allium vineale	field garlic	introduced		
	Arenaria serpyllifolia	thyme-leaved sandwort	introduced		
	Arisaema triphyllum var. *triphyllum*	Jack-in-the-pulpit	native		
	Aster divaricatus	white wood aster	native		
	Barbarea vulgaris var. *vulgaris*	common winter-cress	introduced		
	Boehmeria cylindrica	bog-hemp	native		
	Botrychium virginianum	rattlesnake fern	native		
	Caltha palustris	cowslip	native	S1, G5	*observed by Janet Ebert, 1991*

Cardamine concatenata	cut-leaved toothwort	native		*formerly Dentaria laciniata*
Carex debilis var. *debilis*	sedge	native		
Carex intumescens	sedge	native		
Carex vulpinoidea var. *vulpinoidea*	sedge	native		
Chelone glabra	turtlehead	native		
Chimaphila maculata	pipsissewa	native		
Chrysosplenium americanum	golden saxifrage	native		
Cimicifuga americana/racemosa	mountain bugbane/black snakeroot	native		
Circaea lutetiana ssp. *canadensis*	enchanter's-nightshade	native		
Claytonia virginica	spring-beauty	native		
Clematis virginiana	virgin's-bower	native		
Collinsonia canadensis	horse-balm	native		
Commelina communis	dayflower	introduced		
Dennstaedtia punctilobula	hayscented fern	native		
Deparia acrostichoides	silvery glade fern	native		
Dryopteris sp.	wood fern	native		
Duchesnea indica	Indian strawberry	introduced		
Epifagus virginiana	beech-drops	native		
Erigeron philadelphicus	daisy fleabane	native		
Eupatorium rugosum	white-snakeroot	native		
Fagopyrum sagittatum	buckwheat	introduced		
Fragaria vesca	sow-teat strawberry	introduced		
Galium aparine	bedstraw	native		
Galium asprellum	rough bedstraw	native	S1, G5	
Galium circaezans	wild licorice	native		
Galium concinnum	shining bedstraw	native		
Galium lanceolatum	wild licorice	native	S2, G5	
Galium mollugo/verum	white/yellow bedstraw	introduced		
Geranium maculatum	wood geranium	native		
Geum canadense	white avens	native		
Geum virginianum	cream-colored avens	native	S1, G5	
Geum vernum	spring avens	native	S1, G5	*observed by Janet Ebert, 1991*
Hepatica nobilis var. *obtusa*	liverleaf	native		
Hypericum perforatum	St.-John's-wort	introduced		
Impatiens capensis	jewelweed	native		

Lamium purpureum	purple dead-nettle	introduced	
Lappula squarrosa	beggar's-lice	introduced	
Lobelia inflata	Indian-tobacco	native	
Medeola virginiana	Indian cucumber-root	native	
Microstegium vimineum	stilt grass	introduced	
Mitchella repens	partridge-berry	native	
Monotropa uniflora	Indian-pipe	native	
Nasturtium officinale	watercress	introduced	
Onoclea sensibilis	sensitive fern	native	
*Orobanche uniflo*ra	broom-rape	native	S2, G5
Osmorhiza claytoni	sweet-cicely	native	S2, G5
Osmorhiza longistylis	anise-root	native	
Osmunda cinnamomea	cinnamon fern	native	
Oxalis stricta	common yellow wood-sorrel	native	
Panicum clandestinum	deer-tongue grass	native	
Phlox divaricata ssp. *divaricata*	wild blue phlox	native	
Phryma leptostachya	lopseed	native	
Phytolacca americana	pokeweed	native	
Pilea pumila	clearweed	native	
Podophyllum peltatum	may-apple	native	
Polygonatum biflorum	Solomon's-seal	native	
Polygonum cuspidatum	Japanese knotweed	introduced	
Polygonum persicaria	lady's-thumb	introduced	
Polygonum virginianum	jumpseed	native	*formerly Tovara virginiana*
Polystichum acrostichoides	Christmas fern	native	
Potentilla simplex	old-field cinquefoil	native	
Prenanthes altissima	rattlesnake-root	native	
Primula sp.	primrose	introduced	
Ranunculus abortivus var. *abortivus*	kidney-leaf buttercup	native	
Ranunculus recurvatus	hooked crowfoot	native	
Rumex crispus	curly dock	introduced	
Sanguinaria canadensis	bloodroot	native	
Sanicula marilandica	black snake-root	native	S1.1, G5
Scirpus sp.	bulrush	native	
Sisyrinchium angustifolium	blue-eyed-grass	native	

Smilacina racemosa	false Solomon's-seal	native		
Smilax herbacea	carrion-flower	native		
Smilax pulverulenta	carrion-flower	native		
Solidago sp.	goldenrod	native		
Symplocarpus foetidus	skunk-cabbage	native		
Taraxacum officinale	dandelion	introduced		
Thalictrum dioicum	early meadow-rue	native	S1, G5	*observed by Janet Ebert, 1991*
Thalictrum thalictroides	rue-anemone	native		*abundant*
Thelypteris hexagonoptera	broad beech fern	native		
Thelypteris noveboracensis	New York fern	native		
Trillium sessile	toadshade	native		*yellow-green form*
Uvularia perfoliata	bellwort	native		
Veratrum viride	false hellebore	native		
Verbena urticifolia	white vervain	native		
Viola affinis	LeConte's violet	native	SU, G5	
Viola blanda (?)	sweet white violet	native		
Viola cucullata	blue marsh violet	native		
Viola eriocarpa	smooth yellow violet	native		
Viola pubescens	downy yellow violet	native		
Viola sororia var. *sororia*	common blue violet	native		
Viola striata	striped violet	native		

Armour Farm Woods

± 4.0 acres

CANOPY

Acer rubrum	red maple	native	
Carya glabra	pignut hickory	native	
Carya glabra hybrid	hickory	—	
Carya tomentosa	mockernut hickory	native	
* *Fagus grandifolia*	American beech	native	
Liriodendron tulipifera	tuliptree	native	
Morus alba	white mulberry	introduced	

	Nyssa sylvatica	black-gum	native	
	Quercus sp.	oak	—	*possibly Q. alba hybrid*
*	*Quercus alba*	white oak	native	
*	*Quercus rubra*	northern red oak	native	
*	*Quercus velutina*	black oak	native	
	Sassafras albidum	sassafras	native	

UNDERSTORY

	Acer rubrum	red maple	native	
	Carya tomentosa	mockernut hickory	native	
	Cornus florida	flowering dogwood	native	
*	*Fagus grandifolia*	American beech	native	*including seedlings*
	Fraxinus pennsylvanica	red ash	native	*seedlings*
	Ilex opaca	American holly	native	
	Platanus occidentalis	sycamore	native	
	Prunus avium	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	
	Quercus alba	white oak	native	*seedlings*
	Sassafras albidum	sassafras	native	*seedlings*

SHRUB

Berberis sp.	barberry	introduced	
Ligustrum obtusifolium.	privet	introduced	*along edges*
Lindera benzoin	spicebush	native	
Rhododendron sp.	native azalea	native	
Rhodotypos scandens	jetbead	introduced	
Rubus allegheniensis	common blackberry	native	
Vaccinium pallidum	lowbush blueberry	native	
Viburnum acerifolium	maple-leaved viburnum	native	
Viburnum dentatum	southern arrow-wood	native	
Viburnum prunifolium	black-haw	native	
Zanthoxylum piperitum	Japanese prickly-ash	introduced	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	*along edges*
Lonicera japonica	Japanese honeysuckle	introduced	*edges and interior*

Parthenocissus quinquefolia	Virginia-creeper	native	
Smilax rotundifolia	catbrier	native	
Toxicodendron radicans	poison-ivy	native	
Vitis sp.	grape vine	—	*along edges*

HERBACEOUS

Arisaema triphyllum	Jack-in-the-pulpit	native
Asplenium platyneuron	ebony spleenwort	native
Aster divaricatus	white wood aster	native
Carex swanii	sedge	native
Chimaphila maculata	pipsissewa	native
Commelina communis	dayflower	introduced
Epifagus virginiana	beech-drops	native
Geum canadense	white avens	native
Glechoma hederacea	Gill-over-the-ground	introduced
Oxalis stricta	common yellow wood-sorrel	native
Phytolacca americana	pokeweed	native
Podophyllum peltatum	may-apple	native
Polygonatum biflorum	Solomon's-seal	native
Prenanthes altissima	rattlesnake-root	native
Taraxacum officinale	dandelion	introduced
Verbascum thapsus	common mullein	introduced

Negandank Woods

± 8.0 acres

CANOPY

Acer platanoides	Norway maple	introduced	
Acer rubrum	red maple	native	
Carya ovata	shagbark hickory	native	
Carya tomentosa	mockernut hickory	native	
* *Fagus grandifolia*	American beech	native	
* *Fraxinus americana*	white ash	native	
Fraxinus pennsylvanica	red ash	native	

	Juglans nigra	black walnut	native	
*	*Liriodendron tulipifera*	tuliptree	native	
	Prunus avium	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	
*	*Quercus alba*	white oak	native	
*	*Quercus rubra*	northern red oak	native	*western half*
*	*Quercus velutina*	black oak	native	
	Robinia pseudoacacia	black locust	native	
	Sassafras albidum	sassafras	native	*seedlings*
	Ulmus rubra	red elm	native	

UNDERSTORY

	Acer sp.	maple	native	
	Ailanthus altissima	tree-of-heaven	introduced	
*	*Carpinus caroliniana*	hornbeam	native	
	Carya tomentosa	mockernut hickory	native	
	Cornus florida	flowering dogwood	native	
*	*Fagus grandifolia*	American beech	native	
	Fraxinus pennsylvanica	red ash	native	
	Ilex aquifolium	English holly	introduced	
	Ilex opaca	American holly	native	
	Malus sp.	crabapple	—	
	Nyssa sylvatica	black-gum	native	
*	*Prunus avium*	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	*seedlings*
	Quercus alba	white oak	native	*seedlings*
	Quercus velutina	black oak	native	
	Sassafras albidum	sassafras	native	*seedlings*

SHRUB

	Berberis thunbergii	Japanese barberry	introduced	
	Buxus sp.	boxwood	introduced	
*	*Euonymus alatus*	winged euonymus	introduced	
	Ligustrum sp.	privet	introduced	
	Lindera benzoin	spicebush	native	
	Lonicera sp.	honeysuckle	introduced	

	Rhodotypos scandens	jetbead	introduced	
	Rosa multiflora	multiflora rose	introduced	
	Rubus allegheniensis	common blackberry	native	
	Rubus phoenicolasius	wineberry	introduced	
	Vaccinium corymbosum	highbush blueberry	native	
	Vaccinium pallidum	lowbush blueberry	native	*western half*
*	*Viburnum acerifolium*	maple-leaved viburnum	native	*western half*
*	*Viburnum dentatum*	southern arrow-wood	native	
*	*Viburnum dilatatum* var. or cv.	linden viburnum	introduced	
*	*Viburnum plicatum* var. *tomentosum*	doublefile viburnum	introduced	
*	*Viburnum prunifolium*	black-haw	native	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	
Hedera helix	English ivy	introduced	
Lonicera japonica	Japanese honeysuckle	introduced	
Parthenocissus quinquefolia	Virginia-creeper	native	
Smilax rotundifolia	catbrier	native	
Toxicodendron radicans	poison-ivy	native	
Vitis sp.	grape vine	—	
Vitis labrusca	fox grape	native	

HERBACEOUS

Alliaria petiolata	garlic-mustard	introduced	
Arisaema triphyllum	Jack-in-the-pulpit	native	
Aster divaricatus	white wood aster	native	
Boehmeria cylindrica	bog-hemp	native	*along stream*
Botrychium virginianum	rattlesnake fern	native	
Carex sp.	sedge	native	*along stream*
Carex stricta	tussock sedge	native	*along stream*
Chimaphila maculata	pipsissewa	native	*western half*
Circaea lutetiana ssp. *canadensis*	enchanter's-nightshade	native	
Claytonia virginica	spring-beauty	native	
Dennstaedtia punctilobula	hayscented fern	native	
Epifagus virginiana	beech-drops	native	*western half*
Eupatorium rugosum	white-snakeroot	native	

Galium aparine	bedstraw	native	
Galium circaezans	wild licorice	native	
Geranium maculatum	wood geranium	native	
Geum sp.	avens	—	
Glyceria striata	fowl mannagrass	native	*along stream*
Hieracium venosum	rattlesnake-weed	native	
Impatiens capensis	jewelweed	native	
Microstegium vimineum	stilt grass	introduced	
Myosotis scorpioides	forget-me-not	introduced	*along pond edge*
Narcissus sp.	daffodil	introduced	
Onoclea sensibilis	sensitive fern	native	
Pilea pumila	clearweed	native	*along stream*
Poa trivialis	rough bluegrass	introduced	
Podophyllum peltatum	may-apple	native	
Polygonatum biflorum	Solomon's-seal	native	
Polygonum caespitosum	smartweed	introduced	*along stream*
Polygonum hydropiperoides	mild water-pepper	native	*along stream*
Polygonum sagittatum	arrow-leaved tearthumb	native	*along stream*
Polygonum virginianum	jumpseed	native	*formerly Tovara virginiana*
Sagittaria latifolia	arrowhead	native	
Sanguinaria canadensis	bloodroot	native	
Sanicula odorata	yellow-flowered sanicle	native	
Solidago caesia var. *caesia*	blue-stem goldenrod	native	
Symplocarpus foetidus	skunk-cabbage	native	
Thalictrum thalictroides	rue-anemone	native	
Thelypteris noveboracensis	New York fern	native	
Viola sororia var. *sororia*	common blue violet	native	

Pavilion Woods

± 10.0 acres

CANOPY

	Carya glabra	pignut hickory	native	
*	*Fagus grandifolia*	American beech	native	
*	*Liriodendron tulipifera*	tuliptree	native	
	Nyssa sylvatica	black-gum	native	
	Pinus strobus	Eastern white pine	native	
	Platanus x *acerifolia*	London planetree	introduced	
	Prunus avium	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	
*	*Quercus alba*	white oak	native	
*	*Quercus rubra*	northern red oak	native	
*	*Quercus velutina*	black oak	native	

UNDERSTORY

	Acer negundo	box-elder	native	*seedlings*
*	*Acer rubrum*	red maple	native	*including seedlings*
	Carpinus caroliniana	hornbeam	native	
	Carya glabra	pignut hickory	native	*seedlings*
	Carya tomentosa	mockernut hickory	native	*seedlings*
	Cornus florida	flowering dogwood	native	
*	*Fagus grandifolia*	American beech	native	
	Fraxinus americana	white ash	native	*including seedlings*
	Fraxinus pennsylvanica	red ash	native	
	Hamamelis virginiana	witch-hazel	native	
	Ilex opaca	American holly	native	
*	*Liriodendron tulipifera*	tuliptree	native	*including seedlings*
	Prunus avium	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	*including seedlings*
	Quercus alba	white oak	native	*seedlings*
	Quercus rubra	northern red oak	native	*seedlings*
	Sassafras albidum	sassafras	native	*seedlings*

SHRUB

	Berberis thunbergii	Japanese barberry	introduced
	Euonymus alatus	winged euonymus	introduced
	Forsythia sp.	forsythia	introduced
	Hydrangea spp.	hydrangea	—
	Ligustrum sp.	privet	introduced
	Lindera benzoin	spicebush	native
	Lonicera sp.	honeysuckle	introduced
	Poncirus trifoliata	hardy orange	introduced
	Rhododendron sp.	azalea	—
*	*Rhododendron* sp.	rhododendron	—
	Rhododendron periclymenoides (?)	pinxter flower	native
	Rosa multiflora	multiflora rose	introduced
	Rubus sp.	bramble	—
	Rubus phoenicolasius	wineberry	introduced
*	*Viburnum acerifolium*	maple-leaved viburnum	native
*	*Viburnum dentatum*	southern arrow-wood	native
	Viburnum dilatatum var. or cv.	linden viburnum	introduced
	Viburnum macrocephalum	Chinese snowball viburnum	introduced

VINE

	Celastrus orbiculatus	Oriental bittersweet	introduced
	Hedera helix	English ivy	introduced
	Lonicera japonica	Japanese honeysuckle	introduced
	Parthenocissus quinquefolia	Virginia-creeper	native
	Smilax rotundifolia	catbrier	native
	Toxicodendron radicans	poison-ivy	native
	Vitis sp.	grape vine	—

GROUNDCOVER

	Pachysandra terminalis	Japanese spurge	introduced
	Vinca minor	common periwinkle	introduced

HERBACEOUS

	Alliaria petiolata	garlic-mustard	introduced
	Arisaema triphyllum	Jack-in-the-pulpit	native

Aster divaricatus	white wood aster	native	
Bidens sp.	beggar-ticks	—	possible
Botrychium virginianum	rattlesnake fern	native	
Cardamine concatenata	cut-leaved toothwort	native	*formerly Dentaria laciniata*
Chelidonium majus	greater celandine	introduced	
Cimicifuga racemosa	black snakeroot	native	
Circaea lutetiana ssp. *canadensis*	enchanter's-nightshade	native	
Claytonia virginica	spring-beauty	native	
Collinsonia canadensis	horse-balm	native	
Commelina communis	dayflower	introduced	
Cryptotaenia canadensis	honewort	native	
Dactylis glomerata	orchard grass	introduced	
Dennstaedtia punctilobula	hayscented fern	native	
Dianthus armeria	Deptford pink	introduced	
Dicentra cucullaria	Dutchman's-breeches	native	
Duchesnea indica	Indian strawberry	introduced	
Epifagus virginiana	beech-drops	native	
Equisetum arvense	common horsetail	native	
Erigeron annuus	daisy fleabane	native	
Erythronium americanum	trout lily	native	
Galium asprellum	rough bedstraw	native	S1, G5
Galium circaezans	wild licorice	native	
Geranium maculatum	wood geranium	native	
Geum canadense	white avens	native	
Glechoma hederacea	Gill-over-the-ground	introduced	
Hemerocallis sp.	daylily	introduced	
Hesperis matronalis	dame's-rocket	introduced	
Heuchera sp.	alum-root	introduced	*horticultural planting*
Hieracium caespitosum	king-devil	introduced	*formerly H. pratense*
Hosta sp.	hosta	introduced	
Impatiens capensis	jewelweed	native	
Lapsana communis	nipplewort	introduced	
Medeola virginiana	Indian cucumber-root	native	
Mertensia virginica	Virginia bluebells	native	S3, G5
Microstegium vimineum	stilt grass	introduced	

Narcissus sp.	daffodil	introduced		
Onoclea sensibilis	sensitive fern	native		
Osmorhiza claytoni	sweet-cicely	native	S2, G5	
Oxalis corniculata	creeping yellow wood-sorrel	introduced		
Oxalis stricta	common yellow wood-sorrel	native		
Phlox divaricata ssp. *divaricata*	wild blue phlox	native		
Phytolacca americana	pokeweed	native		
Pilea pumila	clearweed	native		
Podophyllum peltatum	may-apple	native		
Polygonatum biflorum	Solomon's-seal	native		
Polygonum sp.	smartweed	—		
Polygonum cuspidatum	Japanese knotweed	introduced		
Polystichum acrostichoides	Christmas fern	native		
Prenanthes altissima	rattlesnake-root	native		
Ranunculus ficaria	lesser celandine	introduced		
Rumex obtusifolius	bitter dock	introduced		
Sanguinaria canadensis	bloodroot	native		
Sanicula canadensis	Canadian sanicle	native		
Sanicula odorata	yellow-flowered sanicle	native		
Smilacina racemosa	false Solomon's-seal	native		
Smilax herbacea	carrion-flower	native		
Solidago sp.	goldenrod	native		
Solidago flexicaulis	zigzag goldenrod	native		
Sonchus arvensis	field sow-thistle	introduced		
Symplocarpus foetidus	skunk-cabbage	native		
Taraxacum officinale	dandelion	introduced		
Thalictrum thalictroides	rue-anemone	native		
Thelypteris hexagonoptera	broad beech fern	native		
Thelypteris noveboracensis	New York fern	native		
Thelypteris palustris	marsh fern	native		
Trillium grandiflorum	white trillium	native		
Trillium sessile	toadshade	native		*maroon and yellow-green forms*
Verbascum blattaria	moth mullein	introduced		
Viola spp.	violet	—		

Viola eriocarpa	smooth yellow violet	native	
Viola sororia var. *sororia*	common blue violet	native	

Browns Woods

± 14.5 acres

CANOPY

	Carya glabra	pignut hickory	native	
	Carya tomentosa	mockernut hickory	native	
	Fagus grandifolia	American beech	native	
	Juglans nigra	black walnut	native	
*	*Liriodendron tulipifera*	tuliptree	native	** 63" dia., many at 39" dia.*
	Nyssa sylvatica	black-gum	native	
	Prunus avium	mazzard cherry	introduced	
*	*Quercus alba*	white oak	native	
	Quercus marilandica	blackjack oak	native	S3, G5
*	*Quercus rubra*	northern red oak	native	** 45" dia.*
	Quercus stellata	post oak	native	
*	*Quercus velutina*	black oak	native	
	Robinia pseudoacacia	black locust	native	
	Tilia americana	basswood	native	

UNDERSTORY

	Acer rubrum	red maple	native	
*	*Acer platanoides*	Norway maple	introduced	
	Carpinus caroliniana	hornbeam	native	
*	*Carya glabra*	pignut hickory	native	
*	*Carya tomentosa*	mockernut hickory	native	
	Cercis canadensis	redbud	native	SH, G5
	Cornus florida	flowering dogwood	native	
	Evodia daniellii	Korean evodia	introduced	
*	*Fagus grandifolia*	American beech	native	*including seedlings*
	Fraxinus americana	white ash	native	*including seedlings*

Fraxinus pennsylvanica	red ash	native	*seedlings*
Ilex opaca	American holly	native	
Liriodendron tulipifera	tuliptree	native	
Malus sp.	crabapple	—	
Nyssa sylvatica	black-gum	native	
Paulownia tomentosa	empress-tree	introduced	
Photinia villosa	photinia	introduced	
Prunus avium	mazzard cherry	introduced	
Prunus serotina	wild black cherry	native	
Quercus alba	white oak	native	*including seedlings*
Quercus rubra	northern red oak	native	
Sassafras albidum	sassafras	native	

SHRUB

Berberis thunbergii	Japanese barberry	introduced	
* *Euonymus alatus*	winged euonymus	introduced	*many seedlings/groundcover in areas*
Ligustrum vulgare	common privet	introduced	
Lindera benzoin	spicebush	native	
Lonicera maackii	Amur honeysuckle	introduced	
Lonicera xylosteum	European fly honeysuckle	introduced	
Prinsepia sinensis	cherry prinsepia	introduced	
Rhododendron periclymenoides	pinxter flower	native	
* *Rhodotypos scandens*	jetbead	introduced	
Rosa multiflora	multiflora rose	introduced	
Rubus phoenicolasius	wineberry	introduced	
Spiraea japonica	Japanese spiraea	introduced	
* *Viburnum acerifolium*	maple-leaved viburnum	native	
* *Viburnum dentatum*	southern arrow-wood	native	
Viburnum dentatum var. or cv.	arrow-wood	introduced	
Viburnum dilatatum var. or cv.	linden viburnum	introduced	
* *Viburnum prunifolium*	black-haw	native	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	
Hedera helix	English ivy	introduced	
Lonicera japonica	Japanese honeysuckle	introduced	

Parthenocissus quinquefolia	Virginia-creeper	native	
Toxicodendron radicans	poison-ivy	native	
Vitis sp.	grape vine	—	

GROUNDCOVER

Euonymus sp.	euonymus	introduced	

HERBACEOUS

Actaea pachypoda	white baneberry	native	S1, G5	
Alliaria petiolata	garlic-mustard	introduced		
Aralia nudicaulis	wild sarsaparilla	native		
Aralia racemosa	spikenard	native	S2, G5	*observed by Janet Ebert, 1990*
Arisaema triphyllum ssp. *stewardsonii*	Jack-in-the-pulpit	native		
Arisaema triphyllum ssp. *triphyllum*	Jack-in-the-pulpit	native		
Asarum canadense	wild ginger	native		
Aster divaricatus	white wood aster	native		
Botrychium virginianum	rattlesnake fern	native		
Brachyelytrum erectum	long-awned wood grass	native		
Caulophyllum thalictroides	blue cohosh	native		
Circaea lutetiana ssp. *canadensis*	enchanter's-nightshade	native		
Cirsium arvense	Canada thistle	introduced		
Collinsonia canadensis	horse-balm	native		
Dennstaedtia punctilobula	hayscented fern	native		
Duchesnea indica	Indian strawberry	introduced		
Eupatorium rugosum	white-snakeroot	native		
Fragaria vesca	sow-teat strawberry	introduced		
Galium asprellum	rough bedstraw	native	S1, G5	
Galium triflorum/verum	sweet-scented/yellow bedstraw	—		
Geranium maculatum	wood geranium	native		
Geum canadense	white avens	native		
Geum canadense/virginianum	white/cream-colored avens	native		
Hemerocallis sp.	daylily	introduced		
Hesperis matronalis	dame's-rocket	introduced		
Medeola virginiana	Indian cucumber-root	native		
Mertensia virginica	Virginia bluebells	native	S3, G5	
Microstegium vimineum	stilt grass	introduced		

Mitchella repens	partridge-berry	native	
Ornithogalum umbellatum	Star-of-Bethlehem	introduced	
Osmunda cinnamomea	cinnamon fern	native	
Oxalis sp.	wood-sorrel	—	
Oxalis corniculata	creeping yellow wood-sorrel	introduced	
Podophyllum peltatum	may-apple	native	
Polygonum persicaria	lady's-thumb	introduced	
Prenanthes altissima	rattlesnake-root	native	
Sanguinaria canadensis	bloodroot	native	
Sanicula canadensis	Canadian sanicle	native	
Sanicula marilandica	black snake-root	native	S1.1, G5
Smilacina racemosa	false Solomon's-seal	native	
Smilax herbacea	carrion-flower	native	
Solidago sp.	goldenrod	native	
Taraxacum officinale	dandelion	introduced	
Thalictrum thalictroides	rue-anemone	native	
Thelypteris hexagonoptera	broad beech fern	native	
Thelypteris noveboracensis	New York fern	native	
Uvularia perfoliata	bellwort	native	
Viola eriocarpa	smooth yellow violet	native	
Viola pubescens	downy yellow violet	native	
Viola sororia var. *sororia*	common blue violet	native	

Nursery Woods

± 12.5 acres

CANOPY

Acer platanoides	Norway maple	introduced
Carya glabra	pignut hickory	native
Fagus grandifolia	American beech	native
Fraxinus americana	white ash	native
Gymnocladus dioica	Kentucky coffee-tree	native
Juglans nigra	black walnut	native

*	*Liriodendron tulipifera*	tuliptree	native	
	Nyssa sylvatica	black-gum	native	
	Paulownia tomentosa	empress-tree	introduced	
	Prunus avium	mazzard cherry	introduced	
*	*Quercus alba*	white oak	native	
*	*Quercus rubra*	northern red oak	native	
*	*Quercus velutina*	black oak	native	

UNDERSTORY

	Acer platanoides	Norway maple	introduced	
	Acer rubrum	red maple	native	
	Carya glabra	pignut hickory	native	
	Carya tomentosa	mockernut hickory	native	
	Castanea dentata	American chestnut	native	SU, G4
	Cornus sp.	dogwood	—	
	Cornus florida	flowering dogwood	native	
*	*Fagus grandifolia*	American beech	native	
	Hamamelis virginiana	witch-hazel	native	
	Ilex opaca	American holly	native	
	Liriodendron tulipifera	tuliptree	native	
	Magnolia sp.	magnolia	—	
	Morus alba	white mulberry	introduced	
	Nyssa sylvatica	black-gum	native	
	Prunus avium	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	
	Quercus alba	white oak	native	*seedlings*
	Quercus rubra	northern red oak	native	
	Sassafras albidum	sassafras	native	*including seedlings*

SHRUB

Euonymus alatus	winged euonymus	introduced	
Kalmia latifolia	mountain laurel	native	
Ligustrum sp.	privet	introduced	
Lindera benzoin	spicebush	native	
Lonicera sp.	honeysuckle	introduced	
Lonicera maackii	Amur honeysuckle	introduced	

	Rhododendron periclymenoides	pinxter flower	native	*including seedlings*
	Rhododendron sp.	azalea	introduced	*in nursery area*
	Rhododendron sp.	rhododendron	introduced	*in nursery area*
	Rosa multiflora	multiflora rose	introduced	
*	*Rubus allegheniensis*	common blackberry	native	
*	*Rubus phoenicolasius*	wineberry	introduced	
	Spiraea sp.	spiraea	introduced	*in nursery area*
	Vaccinium pallidum	lowbush blueberry	native	
*	*Viburnum acerifolium*	maple-leaved viburnum	native	
	Viburnum prunifolium	black-haw	native	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	
Hedera helix	English ivy	introduced	
Lonicera japonica	Japanese honeysuckle	introduced	
Parthenocissus quinquefolia	Virginia-creeper	native	
Toxicodendron radicans	poison-ivy	native	
Vitis sp.	grape vine	—	

GROUNDCOVER

Pachysandra terminalis	Japanese spurge	introduced	
Vinca minor	common periwinkle	introduced	

HERBACEOUS

Alliaria petiolata	garlic-mustard	introduced	
Arisaema triphyllum	Jack-in-the-pulpit	native	
Aster divaricatus	white wood aster	native	
Aster fragilis	small white aster	native	
Botrychium virginianum	rattlesnake fern	native	
Campanula rapunculoides	creeping bellflower	introduced	
Cardamine concatenata	cut-leaved toothwort	native	*formerly Dentaria laciniata*
Chimaphila maculata	pipsissewa	native	
Circaea lutetiana ssp. *canadensis*	enchanter's-nightshade	native	
Claytonia virginica	spring-beauty	native	
Commelina communis	dayflower	introduced	
Dennstaedtia punctilobula	hayscented fern	native	

Epifagus virginiana	beech-drops	native		
Eupatorium rugosum	white-snakeroot	native		
Hemerocallis sp.	daylily	introduced		
Impatiens capensis	jewelweed	native		
Medeola virginiana	Indian cucumber-root	native		
Mertensia virginica	Virginia bluebells	native	S3, G5	
Microstegium vimineum	stilt grass	introduced		
Monotropa uniflora	Indian-pipe	native		
Narcissus sp.	daffodil	introduced		
Phytolacca americana	pokeweed	native		
Podophyllum peltatum	may-apple	native		
Polygonum persicaria	lady's-thumb	introduced		
Sanguinaria canadensis	bloodroot	native		
Scilla sp.	scilla	introduced		
Setaria viridis var. *viridis*	green foxtail	introduced		
Smilacina racemosa	false Solomon's-seal	native		
Smilax herbacea	carrion-flower	native		
Solidago sp.	goldenrod	native		
Thalictrum pubescens	tall meadow-rue	native	*formerly T. polygamum*	
Thelypteris noveboracensis	New York fern	native		
Viola sororia var. *sororia*	common blue violet	native		

Farm Hill/Saw Mill/Duck Pond Woods

± 81.5 acres

CANOPY

Acer negundo	box-elder	native	
Acer platanoides	Norway maple	introduced	
Acer rubrum	red maple	native	
Aesculus hippocastanum	horse-chestnut	introduced	
Albizia julibrissin	mimosa	introduced	*in woodchip area*
Betula lenta	black birch	native	*23" dia.*
Carya hybrid	hickory	native	*C. ovata x C. cordiformis or C. ovata x C. glabra?*

Carya aquatica	water hickory	native		
Carya glabra	pignut hickory	native		
Carya tomentosa	mockernut hickory	native		*incl. 26" dia.*
Chamaecyparis sp.	falsecypress	—		
Diospyros virginiana	persimmon	native		*Farm Hill Woods*
* *Fagus grandifolia*	American beech	native		
Fagus sp.	horticultural beech	introduced		
Fraxinus americana	white ash	native		
Gymnocladus dioica	Kentucky coffee-tree	native		*also in woodchip area*
Ilex opaca	American holly	native		
Juglans nigra	black walnut	native		
* *Liriodendron tulipifera*	tuliptree	native		
Nyssa sylvatica	black-gum	native		
Paulownia tomentosa	empress-tree	introduced		
Picea abies	Norway spruce	introduced		
Pinus strobus	Eastern white pine	native		*in woodchip area*
Prunus serotina	wild black cherry	native		
* *Quercus alba*	white oak	native		*± 160 years old/ 18" dia.*
* *Quercus rubra*	northern red oak	native		
* *Quercus velutina*	black oak	native		*± 150 years old*
Robinia pseudoacacia	black locust	native		*also in woodchip area*
Salix sp.	willow	—		*in woodchip area*
Tsuga canadensis	Canada hemlock	native		
Ulmus rubra	red elm	native		

UNDERSTORY

Acer negundo	box-elder	native		
Acer platanoides	Norway maple	introduced		
* *Acer rubrum*	red maple	native		*including seedlings*
Acer saccharum	sugar maple	native	S3, G5	*seedlings, Farm Hill Woods*
Aesculus pavia	red buckeye	introduced		
Albizia julibrissin	mimosa	introduced		
Amelanchier canadensis	shadbush	native		*3.7" dia.*
Aralia spinosa	Devil's-walking-stick	native		
Asimina triloba	pawpaw	native		

	Betula lenta	black birch	native	
	Carpinus caroliniana	hornbeam	native	
*	*Carya glabra*	pignut hickory	native	*including seedlings*
*	*Carya tomentosa*	mockernut hickory	native	*including seedlings*
	Castanea dentata	American chestnut	native	SU, G4
	Cercis canadensis	redbud	native	SH, G5
	Cornus alternifolia	alternate-leaved dogwood	native	
	Cornus florida	flowering dogwood	native	
	Euonymus bungeanus	winterberry euonymus	introduced	*Farm Hill Woods*
*	*Fagus grandifolia*	American beech	native	*including seedlings*
	Franklinia alatamaha	Franklinia	introduced	
	Fraxinus americana	white ash	native	*incl. seedlings*
	Gymnocladus dioica	Kentucky coffee-tree	native	*Farm Hill Woods*
	Hamamelis virginiana	witch-hazel	native	
	Ilex opaca	American holly	native	
	Juglans nigra	black walnut	native	
	Liriodendron tulipifera	tuliptree	native	*seedlings*
	Magnolia tripetala	umbrella magnolia	native	*Farm Hill Woods*
	Malus sp.	crabapple	—	
	Morus alba	white mulberry	introduced	
	Nyssa sylvatica	black-gum	native	
	Picea abies	Norway spruce	introduced	
	Photinia villosa	photinia	introduced	
	Prunus sp.	—	—	*Farm Hill Woods*
	Prunus avium	mazzard cherry	introduced	
	Prunus serotina	wild black cherry	native	*including seedlings*
	Quercus alba	white oak	native	*seedlings*
	Quercus rubra	northern red oak	native	
	Quercus velutina	black oak	native	*Farm Hill Woods*
	Rhamnus alnifolia	alder-leaved buckthorn	native	
	Sassafras albidum	sassafras	native	*including seedlings*

SHRUB

Aronia arbutifolia	red chokeberry	native	
Berberis thunbergii	Japanese barberry	introduced	

Clethra alnifolia	sweet pepperbush	native		
Deutzia scabra	deutzia	introduced	*Farm Hill Woods*	
Euonymus alatus	winged euonymus	introduced		
Hydrangea macrophylla	bigleaf hydrangea	introduced	*plantings*	
Kalmia latifolia	mountain laurel	native		
Leucothoe fontanesiana	drooping leucothoe	introduced		
Ligustrum sp.	privet	introduced		
* *Lindera benzoin*	spicebush	native		
Lonicera maackii	Amur honeysuckle	introduced		
Lonicera xylosteum	European fly honeysuckle	introduced		
Pieris japonica	Japanese pieris	introduced		
Poncirus trifoliata	hardy orange	introduced		
Rhododendron periclymenoides	pinxter flower	native	*including seedlings*	
Rhododendron sp.	azalea	—		
Rhododendron sp.	rhododendron	—		
Rhodotypos scandens	jetbead	introduced		
Rosa multiflora	multiflora rose	introduced		
Rosa virginiana	wild rose	native	*Farm Hill Woods*	
Rubus allegheniensis	common blackberry	native		
Rubus phoenicolasius	wineberry	introduced		
Symphoricarpos orbiculatus	coralberry	native	*Farm Hill Woods*	
Taxus sp.	yew	—		
Viburnum sp.	viburnum	introduced	*Duck Pond Woods*	
Viburnum acerifolium	maple-leaved viburnum	native		
Viburnum carlesii	Koreanspice viburnum	introduced	*Farm Hill Woods*	
Viburnum dentatum	southern arrow-wood	native	*Duck Pond Woods*	
Viburnum lantana	wayfaring-tree	introduced	*Farm Hill Woods*	
Viburnum plicatum	Japanese snowball viburnum	introduced	*Duck Pond Woods*	
Viburnum plicatum var. *tomentosum*	doublefile viburnum	introduced	*Farm Hill Woods*	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	
Euonymus sp.	euonymus	introduced	
Hedera helix	English ivy	introduced	*abundant in Farm Hill Woods*
Lonicera japonica	Japanese honeysuckle	introduced	

Menispermum canadense	moonseed	native		
Parthenocissus quinquefolia	Virginia-creeper	native		
Smilax rotundifolia	catbrier	native		
Toxicodendron radicans	poison-ivy	native		
Vitis sp.	grape vine	—		
Wisteria sp.	wisteria	—		*Farm Hill Woods*

GROUNDCOVER

Euonymus sp.	euonymus	introduced		
Pachysandra terminalis	Japanese spurge	introduced		*abundant in Farm Hill Woods*
Vinca minor	common periwinkle	introduced		

HERBACEOUS

Alliaria petiolata	garlic-mustard	introduced		
Allium tricoccum	ramps	native	S2, G5	*Duck Pond Woods*
Anemone quinquefolia	wood anemone	native		
Aralia sp.	sarsaparilla	native		
Arisaema triphyllum	Jack-in-the-pulpit	native		
Asarum canadense	wild ginger	native		*abundant in Duck Pond Woods*
Aster cordifolius ssp. *cordifolius*	blue wood aster	native		*Farm Hill Woods*
Aster divaricatus	white wood aster	native		
Aster lanceolatus ssp. *lanceolatus*	panicled aster	native		*Duck Pond Woods*
Athyrium felix-femina forma rubellum	lady fern	native		
Bidens sp.	beggar-ticks	—	possible	*along Upper Duck Pond edge*
Botrychium virginianum	rattlesnake fern	native		
Cardamine concatenata	cut-leaved toothwort	native		*formerly Dentaria laciniata*
Carex sp.	sedge	native		*along Upper Duck Pond edge*
Carex debilis var. *debilis*	sedge	native		
Chimaphila maculata	pipsissewa	native		
Cimicifuga racemosa	black snakeroot	native		
Circaea lutetiana ssp. *canadensis*	enchanter's-nightshade	native		
Claytonia virginica	spring-beauty	native		
Collinsonia canadensis	horse-balm	native		
Commelina communis	dayflower	introduced		
Dennstaedtia punctilobula	hayscented fern	native		
Deparia acrostichoides	silvery glade fern	native		

Dryopteris spinulosa	wood fern	native		
Duchesnea indica	Indian strawberry	introduced		
Eclipta prostata	yerba-de-tajo	native		*along Upper Duck Pond edge*
Epifagus virginiana	beech-drops	native		
Eranthis hyemalis	winter aconite	introduced		*Farm Hill and Duck Pond Woods*
Erythronium americanum	trout lily	native		*abundant in Farm Hill Woods*
Eupatorium rugosum	white-snakeroot	native		
Galium aparine	bedstraw	native		
Geranium maculatum	wood geranium	native		*Farm Hill and Duck Pond Woods*
Geum canadense	white avens	native		
Geum virginianum	cream-colored avens	native	S1, G5	*Duck Pond Woods*
Glyceria striata	fowl mannagrass	native		*along Farm Hill Rd stream*
Hemerocallis sp.	daylily	introduced		
Hesperis matronalis	dame's rocket	introduced		
Hosta sp.	hosta	introduced		*Farm Hill and Duck Pond Woods*
Impatiens capensis	jewelweed	native		
Laportea canadensis	wood-nettle	native		
Ludwigia palustris	marsh-purslane	introduced	R	*along Upper Duck Pond edge*
Lycopodium sp.	lycopodium	native		
Medeola virginiana	Indian cucumber-root	native		
Mertensia virginica	Virginia bluebells	native	S3, G5	
Microstegium vimineum	stilt grass	introduced		
Mitchella repens	partridge-berry	native		*Farm Hill and Duck Pond Woods*
Monotropa uniflora	Indian-pipe	native		
Narcissus sp.	daffodil	introduced		*Farm Hill and Duck Pond Woods*
Ornithogalum umbellatum	Star-of-Bethlehem	introduced		
*Orobanche uniflor*a	broom-rape	native	S2, G5	
Osmorhiza claytoni	sweet-cicely	native	S2, G5	
Osmunda cinnamomea	cinnamon fern	native		
Osmunda claytoniana	interrupted fern	native		
Oxalis sp.	wood-sorrel	—		
Panax trifolius	dwarf ginseng	native		*Duck Pond Woods*
Phlox divaricata ssp. *divaricata*	wild blue phlox	native		
Phytolacca americana	pokeweed	native		
Pilea pumila	clearweed	native		

Podophyllum peltatum	may-apple	native	
Polygonatum biflorum	Solomon's-seal	native	*Farm Hill and Saw Mill Woods*
Polygonum sp.	smartweed	—	
Polygonum arifolium	halberd-leaved tearthumb	native	*along Upper Duck Pond edge*
Polygonum cuspidatum	Japanese knotweed	introduced	
Polygonum virginianum	jumpseed	native	*formerly Tovara virginiana*
Polystichum acrostichoides	Christmas fern	native	
Ranunculus abortivus var. *abortivus*	kidneyleaf buttercup	native	
Ranunculus recurvatus	hooked crowfoot	native	
Sanguinaria canadensis	bloodroot	native	
Sanicula marilandica	black snake-root	native	S1.1, G5
Senecio aureus	golden ragwort	native	
Smilacina racemosa	false Solomon's-seal	native	
Smilax herbacea	carrion-flower	native	
Solidago sp.	goldenrod	native	
Stellaria pubera	great chickweed	native	*Farm Hill Woods*
Stylophorum diphyllum	celandine poppy	introduced	
Symplocarpus foetidus	skunk-cabbage	native	
Taraxacum officinale	dandelion	introduced	
Thalictrum thalictroides	rue-anemone	native	
Thelypteris hexagonoptera	broad beech fern	native	
Thelypteris noveboracensis	New York fern	native	
Thelypteris palustris	marsh fern	native	
Trillium grandiflorum	white trillium	native	*only seen in Farm Hill Woods*
Trillium sessile (?)	toadshade	native	*Duck Pond Woods, only leaves*
Uvularia sp.	bellwort	native	
Viola sp.	violet	—	
Viola eriocarpa	smooth yellow violet	native	
Viola sororia var. *sororia*	common blue violet	native	

HEDGEROWS

Center Meeting Road Hedgerow

CANOPY

Acer negundo	box-elder	native	
Acer platanoides	Norway maple	introduced	
Acer saccharinum	silver maple	native	
Ailanthus altissima	tree-of-heaven	introduced	
Gleditsia triacanthos	honey-locust	native	
Juglans cinerea	butternut	native	S3, G3G4
Juglans nigra	black walnut	native	
Maclura pomifera	osage-orange	introduced	
Paulownia tomentosa	empress-tree	introduced	
Prunus avium	mazzard cherry	introduced	
Prunus serotina	wild black cherry	native	
Robinia pseudoacacia	black locust	native	
Sassafras albidum	sassafras	native	

UNDERSTORY

Crataegus sp.	hawthorn	—	
Juglans nigra	black walnut	native	
Liriodendron tulipifera	tuliptree	native	
Malus sp.	crabapple	—	
Paulownia tomentosa	empress-tree	introduced	
Pyrus calleryana 'Bradford'	Bradford Callery pear	introduced	
Sassafras albidum	sassafras	native	

SHRUB

Lonicera xylosteum	European fly honeysuckle	introduced	
Rhus typhina	staghorn sumac	native	
Rosa multiflora	multiflora rose	introduced	
Rubus sp.	bramble	—	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced
Hedera helix	English ivy	introduced
Lonicera japonica	Japanese honeysuckle	introduced
Toxicodendron radicans	poison-ivy	native
Vitis sp.	grape vine	—

HERBACEOUS

Alliaria petiolata	garlic-mustard	introduced
Aster novae-angliae	New England aster	native
Cirsium/Sonchus _____	sow thistle	
Eupatorium rugosum	white-snakeroot	native
Phytolacca americana	pokeweed	native
Solidago sp.	goldenrod	native

Armour Farm Hedgerow

CANOPY

Acer rubrum	red maple	native
Acer saccharinum	silver maple	native
Ailanthus altissima	tree-of-heaven	introduced
Juglans sp.	walnut	—
Juglans nigra	black walnut	native
Liriodendron tulipifera	tuliptree	native
Platanus occidentalis	sycamore	native
Robinia pseudoacacia	black locust	native

UNDERSTORY

Ailanthus altissima	tree-of-heaven	introduced
Ilex opaca	American holly	native

SHRUB

Ligustrum obtusifolium	privet	introduced
Lonicera sp.	honeysuckle	introduced

Rosa multiflora	multiflora rose	introduced
Rubus phoenicolasius	wineberry	introduced

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced
Hedera helix	English ivy	introduced
Lonicera japonica	Japanese honeysuckle	introduced
Smilax rotundifolia	catbrier	native
Toxicodendron radicans	poison-ivy	native

HERBACEOUS

Alliaria petiolata	garlic-mustard	introduced
Arisaema triphyllum	Jack-in-the-pulpit	native
Claytonia virginica	spring-beauty	native
Galium sp.	bedstraw	—
Muscari botryoides	grape-hyacinth	introduced
Phytolacca americana	pokeweed	native
Podophyllum peltatum	may-apple	native
Ranunculus abortivus var. *abortivus*	kidney-leaf buttercup	native
Solidago sp.	goldenrod	native
Symplocarpus foetidus	skunk-cabbage	native
Taraxacum officinale	dandelion	introduced

Armour Farm Pond Hedgerow

CANOPY

Acer rubrum	red maple	native
Ailanthus altissima	tree-of-heaven	introduced
Sassafras albidum	sassafras	native

UNDERSTORY

Ailanthus altissima	tree-of-heaven	introduced
Fagus grandifolia	American beech	native

SHRUB

Ligustrum sp.	privet	introduced	
Lonicera sp.	honeysuckle	introduced	
Rosa multiflora	multiflora rose	introduced	
Rubus sp.	bramble	—	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	
Vitis sp.	grape vine	—	

HERBACEOUS

Andropogon virginicus	broom-sedge	native	
Arabis lyrata	lyre-leaved rock-cress	native	S1, G5
Arctium sp.	burdock	introduced	
Barbarea vulgaris var. *vulgaris*	common winter-cress	introduced	
Duchesnea indica	Indian strawberry	introduced	
Erigeron philadelphicus	daisy fleabane	native	
Glechoma hederacea	Gill-over-the-ground	introduced	
Hemerocallis sp.	daylily	introduced	
Muscari botryoides	grape-hyacinth	introduced	
Oxalis stricta	common yellow wood-sorrel	native	
Phytolacca americana	pokeweed	native	
Ranunculus bulbosus	bulbous buttercup	introduced	
Senecio jacobaea	tansy ragwort	introduced	
Taraxacum officinale	dandelion	introduced	
Veronica chamaedrys	bird's-eye	introduced	

Upper Pavilion Drive Pond Hedgerow

CANOPY

Acer rubrum	red maple	native	
Ailanthus altissima	tree-of-heaven	introduced	*on island*
Catalpa sp.	catalpa	introduced	
Fraxinus americana	white ash	native	

Juglans cinerea	butternut	native	S3, G3G4	*on island*
Juglans nigra	black walnut	native		
Platanus occidentalis	sycamore	native		
Prunus avium	mazzard cherry	introduced		
Prunus serotina	wild black cherry	native		
Quercus palustris	pin oak	native		
Sassafras albidum	sassafras	native		
Taxodium distichum	bald cypress	native	S2, G5	

UNDERSTORY

Alnus glutinosa	black alder	introduced	
Cornus florida	flowering dogwood	native	
Liriodendron tulipifera	tuliptree	native	

SHRUB

Ligustrum sp.	privet	introduced	
Rosa multiflora	multiflora rose	introduced	
Rubus sp.	bramble	—	

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	*on island as well*
Lonicera japonica	Japanese honeysuckle	introduced	
Parthenocissus quinquefolia	Virginia-creeper	native	
Vitis sp.	grape vine	—	

HERBACEOUS

Aster sp.	aster	—	
Podophyllum peltatum	may-apple	native	
Solidago sp.	goldenrod	native	
Symplocarpus foetidus	skunk-cabbage	native	

Adams Dam Road Hedgerow

CANOPY

Acer rubrum var. *rubrum*	red maple	native	
Acer platanoides	Norway maple	introduced	
Carya glabra	pignut hickory	native	
Carya tomentosa	mockernut hickory	native	
Fagus grandifolia	American beech	native	
Fraxinus americana var. *americana*	white ash	native	
Juglans nigra	black walnut	native	
Liriodendron tulipifera	tuliptree	native	
Platanus occidentalis	sycamore	native	
Prunus avium	mazzard cherry	introduced	
Quercus alba	white oak	native	
Quercus velutina	black oak	native	
Salix nigra	black willow	native	

UNDERSTORY

Acer platanoides	Norway maple	introduced	
Acer rubrum	red maple	native	
Carpinus caroliniana	hornbeam	native	
Carya glabra	pignut hickory	native	
Carya tomentosa	mockernut hickory	native	
Cornus florida	flowering dogwood	native	
Fagus grandifolia	American beech	native	
Fraxinus americana	white ash	native	*seedlings*
Liriodendron tulipifera	tuliptree	native	
Morus rubra	red mulberry	native	
Nyssa sylvatica	black-gum	native	
Prunus avium	mazzard cherry	introduced	
Prunus persica	peach	introduced	
Prunus serotina	wild black cherry	native	
Quercus velutina	black oak	native	
Sassafras albidum	sassafras	native	
Ulmus americana	American elm	native	

SHRUB

Alnus serrulata	smooth alder	native
Berberis thunbergii	Japanese barberry	introduced
Euonymus alatus	winged euonymus	introduced
Ligustrum sp.	privet	introduced
Lindera benzoin	spicebush	native
Rosa multiflora	multiflora rose	introduced
Rubus occidentalis	black raspberry	native
Rubus phoenicolasius	wineberry	introduced
Sambucus canadensis	American elder	native
Viburnum acerifolium	maple-leaved viburnum	native
Viburnum dilatatum	linden viburnum	introduced
Viburnum plicatum	Japanese snowball viburnum	introduced
Viburnum prunifolium	black-haw	native

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced
Hedera helix	English ivy	introduced
Lonicera japonica var. *japonica*	Japanese honeysuckle	introduced
Smilax rotundifolia	catbrier	native
Toxicodendron radicans	poison-ivy	native
Vitis sp.	grape vine	—

GROUNDCOVER

Pachysandra terminalis	Japanese spurge	introduced

HERBACEOUS

Alliaria petiolata	garlic-mustard	introduced
Allium vineale	field garlic	introduced
Apocynum cannabinum	Indian hemp	native
Arisaema triphyllum ssp. *triphyllum*	Jack-in-the-pulpit	native
Aster divaricatus	white wood aster	native
Cirsium arvense	Canada thistle	introduced
Equisetum arvense	common horsetail	native
Erigeron annuus	daisy fleabane	native
Hemerocallis sp.	daylily	introduced

Impatiens capensis	jewelweed	native	
Maianthemum canadense	Canada mayflower	native	
Microstegium vimineum	stilt grass	introduced	
Onoclea sensibilis	sensitive fern	native	
Phytolacca americana	pokeweed	native	
Podophyllum peltatum	may-apple	native	
Polygonatum biflorum var. *biflorum*	Solomon's-seal	native	
Sanguinaria canadensis	bloodroot	native	
Smilacina racemosa	false Solomon's-seal	native	
Solidago sp.	goldenrod	native	
Typha latifolia	common cat-tail	native	

Railroad Hedgerow

CANOPY

Acer negundo	box-elder	native	
Acer platanoides	Norway maple	introduced	
Acer rubrum var. *rubrum*	red maple	native	
Acer saccharinum	silver maple	native	
Ailanthus altissima	tree-of-heaven	introduced	
Celtis occidentalis	hackberry	native	
Fagus grandifolia	American beech	native	
Fraxinus americana var. *americana*	white ash	native	
Gleditsia triacanthos	honey-locust	native	
Juglans nigra	black walnut	native	
Liquidambar styraciflua	sweet-gum	native	
Liriodendron tulipifera	tuliptree	native	
Paulownia tomentosa	empress-tree	introduced	
Platanus occidentalis	sycamore	native	
Prunus serotina	wild black cherry	native	
Quercus alba	white oak	native	*52" dia.*
Quercus coccinea	scarlet oak	native	
Quercus stellata	post oak	native	
Quercus velutina	black oak	native	*53" dia.*

Salix sp.	willow	—	
Sassafras albidum	sassafras	native	

UNDERSTORY

Acer negundo	box-elder	native	
Acer platanoides	Norway maple	introduced	
Acer rubrum var. *rubrum*	red maple	native	
Ailanthus altissima	tree-of-heaven	introduced	
Carpinus caroliniana	hornbeam	native	
Cornus florida	flowering dogwood	native	
Crataegus sp.	hawthorn	—	
Fagus grandifolia	American beech	native	
Fraxinus americana var. *americana*	white ash	native	
Fraxinus pennsylvanica	red ash	native	*seedling*
Juglans nigra	black walnut	native	
Juniperus virginiana	red-cedar	native	
Liriodendron tulipifera	tuliptree	native	
Malus sp.	crabapple	—	
Paulownia tomentosa	empress-tree	introduced	
Platanus occidentalis	sycamore	native	
Prunus serotina	wild black cherry	native	
Quercus rubra	northern red oak	native	*including seedlings*
Robinia pseudoacacia	black locust	native	
Sassafras albidum	sassafras	native	

SHRUB

Elaeagnus angustifolia	Russian olive	introduced	
Euonymus alatus	winged euonymus	introduced	
Ligustrum sp.	privet	introduced	
Lindera benzoin	spicebush	native	
Lonicera tatarica	Tartarian honeysuckle	introduced	
Lonicera xylosteum x *L. tatarica* (?)	honeysuckle	introduced	
Rhus copallina	shining sumac	native	
Rhus glabra	smooth sumac	native	
Rosa multiflora	multiflora rose	introduced	
Rubus allegheniensis	common blackberry	native	

Rubus occidentalis	black raspberry	native
Rubus phoenicolasius	wineberry	introduced
Sambucus canadensis	American elder	native
Viburnum plicatum	Japanese snowball viburnum	introduced
Viburnum plicatum var. *tomentosum*	doublefile viburnum	introduced

VINE

Ampelopsis brevipedunculata	porcelain-berry	introduced
Celastrus orbiculatus	Oriental bittersweet	introduced
Lonicera japonica var. *japonica*	Japanese honeysuckle	introduced
Parthenocissus quinquefolia	Virginia-creeper	native
Smilax rotundifolia	catbrier	native
Toxicodendron radicans	poison-ivy	native
Vitis sp.	grape vine	—

HERBACEOUS

Achillea millefolium	common yarrow	introduced
Alliaria petiolata	garlic-mustard	introduced
Allium vineale	field garlic	introduced
Apocynum cannabinum	Indian hemp	native
Arisaema triphyllum	Jack-in-the-pulpit	native
Barbarea vulgaris var. *vulgaris*	common winter-cress	introduced
Dennstaedtia punctilobula	hayscented fern	native
Dianthus armeria	Deptford pink	introduced
Equisetum arvense	common horsetail	native
Erigeron annuus	daisy fleabane	native
Eupatorium rugosum	white-snakeroot	native
Galium aparine	bedstraw	native
Impatiens capensis	jewelweed	native
Linaria vulgaris	butter-and-eggs	introduced
Lysimachia quadrifolia	whorled loosestrife	native
Nasturtium officinale	watercress	introduced
Onoclea sensibilis	sensitive fern	native
Phytolacca americana	pokeweed	native
Potentilla recta	sulphur cinquefoil	introduced
Sisyrinchium angustifolium	blue-eyed-grass	native

Symplocarpus foetidus	skunk-cabbage	native		
Tradescantia virginiana	spiderwort	native	S2, G5	
Verbascum thapsis	common mullein	introduced		

MEADOWS

R - occuring only in riparian and/or wet areas
Location indicated only when not throughout

TREES

Acer rubrum	red maple	native		
Ailanthus altissima	tree-of-heaven	introduced		*Armour Farm (along pond)*
Alnus sp.	alder	—	R	
Catalpa sp.	catalpa	introduced	R	*East Barn*
Cornus florida	flowering dogwood	native		
Fraxinus pennsylvanica	red ash	native		
Juglans nigra	black walnut	native		
Juniperus virginiana	red-cedar	native		
Liriodendron tulipifera	tuliptree	native		
Malus sp.	crabapple	—		
Paulownia tomentosa	empress-tree	introduced		
Platanus occidentalis	sycamore	native	R	*East Barn*
Prunus serotina	wild black cherry	native		
Quercus spp.	oak	—		
Quercus alba	white oak	native		*Guyencourt*
Quercus palustris	pin oak	native	R	*East Barn*
Robinia pseudoacacia	black locust	native		
Salix nigra	black willow	native		

SHRUB

Alnus incana	speckled alder	native	R		
Alnus serrulata	smooth alder	native	R		
Cephalanthus occidentalis	buttonbush	native	R		*Route 100*
Cornus sericea	red-osier dogwood	native	R		*Route 100*
Elaeagnus umbellata	autumn olive	introduced			
Ligustrum obtusifolium	privet	introduced			
Ligustrum vulgare	common privet	introduced	R		*East Barn*
Lonicera sp.	honeysuckle	introduced			
Lonicera xylosteum	European fly honeysuckle	introduced	R		
Rhus copallina	shining sumac	native			*Negandank North*
Rhus typhina	staghorn sumac	native	R		*Route 100*
Rosa multiflora	multiflora rose	introduced			
Rubus sp.	bramble	—			
Rubus sp.	red raspberry	—	R		*East Barn*
Rubus allegheniensis	common blackberry	native			
Rubus hispidus	swamp dewberry	native	R		*Route 100*
Rubus occidentalis	black raspberry	native	R		*Route 100*
Rubus odoratus	purple-flowering raspberry	native	R	S1, G5	*Event Field/Old Gatehouse*
Sambucus canadensis	American elder	native			

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced			
Lonicera japonica var. *japonica*	Japanese honeysuckle	introduced			
Parthenocissus quinquefolia	Virginia-creeper	native			
Rubus flagellaris	dewberry	native			
Smilax rotundifolia	catbrier	native	R		*Guyencourt*
Toxicodendron radicans	poison-ivy	native			
Vitis sp.	grape vine	—			
Vitis labrusca	fox grape	native			*Negandank North*

HERBACEOUS

_____ _____	large mouse ear				*Negandank South 1*
Achillea millefolium	common yarrow	introduced			
Acorus calamus	sweetflag	introduced	R		
Agastache foeniculum	anise giant-hyssop	introduced			*Armour Farm (steep slope)*

Agrimonia parviflora	southern agrimony	native	R		
Agrostis sp.	bentgrass	—			*Railroad Station*
Alliaria petiolata	garlic-mustard	introduced			
Allium vineale	field garlic	introduced			
Ambrosia artemisiifolia	common ragweed	native			
Ambrosia trifida	giant ragweed	native	R		
Amphicarpaea bracteata	hog-peanut	native	R		*Guyencourt*
Andropogon virginicus	broom-sedge	native			
Antennaria neglecta	field pussytoes	native			
Antennaria plantaginifolia	plantain pussytoes	native			
Anthoxanthum odoratum	sweet vernal grass	introduced			*Railroad Station*
Apocynum androsaemifolium	pink dogbane	native	R	S1, G5	
Apocynum cannabinum	Indian hemp	native			
Arabis lyrata	lyre-leaved rock-cress	native	S1, G5		*Railroad Station*
Arctium tomentosum	wooly burdock	introduced			*Railroad Station*
Artemisia vulgaris	mugwort	introduced			*Armour Farm (along pond)*
Asclepias incarnata ssp. *incarnata*	swamp milkweed	native	SH, G5T5		
Asclepias syriaca	common milkweed	native			
Asclepias tuberosa	butterfly-weed	native			
Aster fragilis	small white aster	native			
Aster novae-angliae	New England aster	native	R		*Event Field/Old Gatehouse*
Aster pilosus	heath aster	native	R		*Lower Armour Farm*
Aster puniceus	purple-stemmed aster	native	R		
Barbarea vulgaris var. *vulgaris*	common winter-cress	introduced			*Railroad Station*
Berteroa incana	hoary alyssum	introduced			*Railroad Station*
Bidens sp.	beggar-ticks	—	R	possible	*Adams Dam Road*
Bidens cernua	bur-marigold	native	R		*East Barn*
Bidens polylepis	tickseed-sunflower	introduced	R		*East Barn*
Brassica rapa	field mustard	introduced			
Calamagrostis canadensis	Canada bluejoint	native	S1, G5		
Calystegia silvatica ssp. *fraterniflora*	bindweed	native	R		*formerly Convolvulus sepium*
Campanula aparinoides	marsh bellflower	native	R	S2, G5	*Guyencourt, observed by Janet Ebert, 1992,94*
Capsella bursa-pastoris	shepherd's-purse	introduced			*Railroad Station*
Cardamine impatiens	bitter-cress	introduced			
Carduus nutans	nodding thistle	introduced			

Carex sp.	sedge	native	R		
Carex caroliniana	sedge	native	R	S3, G5	*Guyencourt, observed by Janet Ebert, 1993*
Carex lurida	sedge	native	R		
Carex stipata var. *stipata*	sedge	native	R		
Centaurea nigrescens	knapweed	introduced	R		*Event Field/Old Gatehouse*
Cerastium fontanum ssp. *triviale*	common mouse-ear chickweed	introduced			
Chelidonium majus	greater celandine	introduced	R		*Route 100*
Chenopodium album	lamb's-quarters	introduced			*Armour Farm (along pond)*
Chrysanthemum leucanthemum	ox-eye daisy	introduced			
Cichorium intybus	blue chicory	introduced			
Cirsium sp.	sow thistle	—			*Armour Farm (steep slope)*
Cirsium arvense	Canada thistle	introduced			
Cirsium horridulum	yellow thistle	native			*Guyencourt, also observed by Janet Ebert, mid-1980s–present*
Cirsium pumilum	pasture thistle	native			*white form, Armour Farm (steep slope)*
Claytonia virginica	spring-beauty	native			*Negandank South 1*
Commelina communis	dayflower	introduced			*Armour Farm (along pond)*
Conium maculatum	poison hemlock	introduced			
Convolvulus arvensis	field bindweed	introduced			
Coronilla varia	crown-vetch	introduced			
Cuscuta gronovii	dodder	native	R		
Cyperus sp.	umbrella-sedge	—	R	possible	
Dactylis glomerata	orchard grass	introduced			
Daucus carota	Queen-Anne's-lace	introduced			
Desmodium paniculatum	beggar-ticks	native	R		
Dianthus armeria	Deptford pink	introduced			
Dipsacus sp.	teasel	introduced	R		*Event Field/Old Gatehouse*
Duchesnea indica	Indian strawberry	introduced			*Railroad Station*
Echinochloa crusgalli	barnyard grass	introduced	R		*Lower Armour Farm*
Echinocystis lobata	prickly cucumber	native	R		*Guyencourt*
Eleocharis sp.	spike-rush	native	R	possible	*Armour Farm (along pond)*
Epilobium coloratum	purple-leaved willow-herb	native			
Erechtites hieraciifolia	fireweed	native	R		
Erigeron annuus	daisy fleabane	native			
Erigeron philadelphicus	daisy fleabane	native			

Eupatorium fistulosum	Joe-pye-weed	native	R	
Eupatorium maculatum	spotted Joe-pye-weed	native	R	
Eupatorium perfoliatum	boneset	native		
Euthamia graminifolia	grass-leaved goldenrod	native		*formerly Solidago*
Galium sp.	bedstraw	—		
Galium aparine	bedstraw	native		*Armour Farm (along pond)*
Galium mollugo	white bedstraw	introduced	R	*Route 100*
Galium mollugo/verum	white/yellow bedstraw	introduced	R	*Railroad Station*
Galium triflorum	sweet-scented bedstraw	native		*Armour Farm (along pond)*
Glechoma hederacea	Gill-over-the-ground	introduced		
Glyceria striata	fowl mannagrass	native	R	
Gnaphalium obtusifolium	fragrant cudweed	native		*Route 100*
Hedyotis caerulea	bluets	native		*Negandank South 1, formerly Houstonia*
Helianthus sp.	sunflower	—	R	*Event Field/Old Gatehouse*
Hemerocallis sp.	daylily	introduced		
Hesperis matronalis	dame's-rocket	introduced		
Heteranthera reniformis	mud-plantain	native	R	
Hibiscus moscheutos	rose-mallow	native	R	*Route 100*
Hieracium caespitosum	king-devil	introduced		*formerly H. pratense*
Hypericum mutilum	dwarf St.-John's-wort	native	R	
Hypericum perforatum	St.-John's-wort	introduced		
Hypericum punctatum	spotted St.-John's-wort	native		
Impatiens capensis	jewelweed	native		
Iris sp.	iris	—	R	*Guyencourt*
Juncus canadensis	Canada rush	native		*Armour Farm (steep slope)*
Juncus effusus	soft rush	native	R	
Juncus tenuis var. *tenuis*	path rush	native		
Lactuca canadensis	wild lettuce	native	R	
Lamium purpureum	purple dead-nettle	introduced		*Railroad Station*
Leersia oryzoides	rice cutgrass	native	R	*Lower Armour Farm*
Lepidium campestre	field cress	introduced		*Railroad Station*
Linaria vulgaris	butter-and-eggs	introduced		
Lobelia cardinalis	cardinal-flower	native	R	
Lobelia inflata	Indian-tobacco	native	R	
Lobelia siphilitica	great lobelia	native	R	

Lobelia spicata	spiked lobelia	native	S2, G5	*Guyencourt, observed by Janet Ebert, 1992*
Lotus corniculatus	bird's-foot trefoil	introduced	R	
Ludwigia alternifolia	false loosestrife	native	R	*Guyencourt*
Ludwigia palustris	marsh-purslane	introduced	R	*Lower Armour Farm*
Ludwigia peploides	primrose-willow	native	R	*East Barn along pond*
Lycopus americanus	water-horehound	native		
Lysimachia ciliata	fringed loosestrife	native		
Lysimachia nummularia	creeping-charlie	introduced	R	
Lythrum salicaria	purple loosestrife	introduced	R	
Medicago sp.	alfalfa	introduced		*Farm Hill*
Mentha sp.	mint	—		
Mentha aquatica x *spicata*	peppermint	introduced		
Mentha arvensis	field mint	native	R	
Mentha spicata	spearmint	introduced	R	*Guyencourt*
Microstegium vimineum	stilt grass	introduced		
Mimulus ringens	Allegheny monkey-flower	native	R	
Miscanthus sp.	miscanthus	introduced		*Negandank North*
Myosotis scorpioides	forget-me-not	introduced	R	
Narcissus sp.	daffodil	introduced		
Nasturtium officinale	watercress	introduced		
Oenothera biennis	evening-primrose	native	R	
Onoclea sensibilis	sensitive fern	native		
Ornithogalum umbellatum	Star-of-Bethlehem	introduced		
Osmunda cinnamomea	cinnamon fern	native	R	*Armour Farm*
Oxalis stricta	common yellow wood-sorrel	native		
Panicum sp.	panicum	—		
Panicum clandestinum	deer-tongue grass	native		
Panicum oligosanthes	panic-grass	native		*Guyencourt, observed by Janet Ebert, 1994*
Panicum virgatum	switch grass	native		
Paspalum laeve	field beadgrass	native		
Phalaris arundinacea	reed canary-grass	native		
Phragmites australis	common reed	native	R	
Physalis subglabrata	ground-cherry	native		*East Barn*
Phytolacca americana	pokeweed	native		
Plantago lanceolata	English plantain	introduced		

Plantago major	broadleaf plantain	introduced			
Poa trivialis	rough bluegrass	introduced	R		
Podophyllum peltatum	may-apple	native			*Armour Farm (along pond)*
Polygonum sp.	smartweed	—			
Polygonum arifolium	halberd-leaved tearthumb	native	R		
Polygonum persicaria	lady's-thumb	introduced			
Polygonum sagittatum	arrow-leaved tearthumb	native			
Polygonum scandens var. *scandens*	climbing false-buckwheat	native	R	SU,G5T5	*East Barn*
Potentilla canadensis	cinquefoil	native			
Potentilla recta	sulphur cinquefoil	introduced			
Potentilla simplex	old-field cinquefoil	native			*Railroad Station*
Primula sp.	primrose	introduced			
Prunella vulgaris	heal-all	—			
Pycnanthemum clinopodioides	mountain-mint	native	SH, G2		*Armour Farm (steep slope)*
Pycnanthemum tenuifolium	mountain-mint	native			
Ranunculus bulbosus	bulbous buttercup	introduced			
Rhynchospora glomerata	beak-rush	native	S2, G5		
Rudbeckia hirta	black-eyed-Susan	native			
Rudbeckia laciniata	cutleaf coneflower	native	R		
Rumex acetosella	sheep sorrel	introduced			
Rumex crispus	curly dock	introduced			
Sagittaria latifolia	arrowhead	native	R		
Salvia lyrata	lyre-leaved sage	native			
Schizachyrium scoparium	little bluestem	native			*Bidermann*
Scirpus atrovirens	black bulrush	native	R	SU, G5?	*Lower Armour Farm*
Scirpus cyperinus	wool-grass	native	R		
Scutellaria integrifolia	hyssop skullcap	native			*Guyencourt*
Senecio obovatus	groundsel	native			*Railroad Station*
Senecio vulgaris	common groundsel	introduced			*Railroad Station*
Setaria pumila	yellow foxtail	introduced			
Silene alba	white campion	introduced			*formerly Lychnis*
Silphium perfoliatum	cup-plant	introduced			
Sisyrinchium angustifolium	blue-eyed-grass	native			
Sisyrinchium montanum	blue-eyed grass	native			*Armour Farm (steep slope)*
Solanum carolinense	horse-nettle	native			

Solanum dulcamara	trailing nightshade	introduced			
Solidago spp.	goldenrod	native			
Solidago canadensis var. *hargeri*	Canada goldenrod	native			
Solidago nemoralis	gray goldenrod	native	R		
Solidago patula	spreading goldenrod	native			*Armour Farm*
Solidago uliginosa	bog goldenrod	native	R	S1.1, G4G5	*East Barn along Clenny Run*
Sorghastrum nutans	Indian grass	native			
Sparganium sp.	bur-reed	native	R	possible	*Negandank North (along pond)*
Spiranthes cernua	nodding ladies'-tresses	native			*Browns Woods*
Spiranthes lacera var. *gracilis*	southern slender ladies'-tresses	native		S2, G5T4T5	*also observed by Janet Ebert, 1989*
Stellaria graminea	common stitchwort	introduced			*Armour Farm (along pond)*
Symplocarpus foetidus	skunk-cabbage	native			
Taraxacum officinale	dandelion	introduced			
Thalictrum pubescens	tall meadow-rue	native	R		*Guyencourt, formerly T. polygamum*
Thlaspi arvense	field penny-cress	introduced			*Nursery*
Tradescantia virginiana	spiderwort	native		S2, G5	*Nursery*
Tragopogon pratensis	yellow goat's-beard	introduced			*Farm Hill*
Tridens flavus	purple-top	native			
Trifolium dubium	hop-clover	introduced			
Trifolium pratense	red clover	introduced			
Trifolium campestre	low hop-clover	introduced			*formerly T. procumbens*
Trifolium repens	Dutch clover	introduced			
Typha latifolia	common cat-tail	native	R		
Verbascum blattaria	moth mullein	introduced			
Verbascum thapsus	common mullein	introduced			
Verbena hastata	blue vervain	native	R		
Verbena scabra	rough vervain	native	R		
Vernonia noveboracensis	New York ironweed	native			
Veronica agrestis	field speedwell	introduced			*Railroad Station*
Veronica officinalis	common speedwell	native			
Vicia sp.	vetch	—			
Vicia americana	purple vetch	native			*Nursery*
Viola sp.	violet	—			
Viola sororia var. *missouriensis*	Missouri violet	native			*Railroad Station*
Viola sororia var. *sororia*	common blue violet	native			*Railroad Station*

APPENDIX B

Global and State Rankings

Ranks are based on a system developed by The Nature Conservancy to measure rarity of a species. Each species is given a global rank to indicate degree of rarity worldwide and a state rank to reflect the degree of rarity within the state. The primary criteria for ranking species is the total number of documented occurrences or populations with consideration given to the total number of individuals within each population. Ranks for individual species are updated annually and are based on current knowledge. State and Global ranks are used to prioritize conservation and protection efforts so that the rarest of species receives immediate attention.

GLOBAL RANK

G1 Critically imperiled globally because of extreme rarity (5 or fewer occurrences), or because of some factor(s) making it especially vulnerable to extinction.

G2 Imperiled globally because of rarity (6–20 occurrences), or because of some other factor(s) making it very vulnerable to extinction throughout its range.

G3 Either very rare and local throughout its range (21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range (e.g., a physiographic region), or because of some other factor(s) making it vulnerable to extinction throughout its range.

G4 Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GH Historically known, with the expectation that it may be rediscovered.

GX Species believed to be extinct throughout its range with no likelihood that it will be rediscovered.

GU Possibly in peril range-wide but status uncertain; more information is needed.

G? Species has not yet been ranked.

GNE Exotic in the United States (e.g., Japanese honeysuckle).

Q If a taxon is treated as a full species, a qualifying "Q" is added after the global rank to denote its questionable taxonomic assignment.

T Global ranks containing a "T" qualifier denote that the infraspecific taxon is being ranked differently than the full species. For example, *Hydrocotyle verticillata* var. *triradiata* is ranked G5T? The full species is globally secure (G5), but the global rarity of the var. *triradiata* has not been determined (T?).

STATE RANK

S1 Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.

S2 Very rare; typically between 6 and 20 known occurrences; may be susceptible to becoming extirpated.

S3 Rare to uncommon; typically 21 to 50 known occurrences; S3 ranked species are not yet susceptible to becoming extirpated in the state but may be if additional populations are destroyed.

S4 Common; apparently secure under present conditions; typically 51 or more known occurrences, but may be fewer with many large populations; usually not susceptible to immediate threats.

S5 Very common; demonstrably secure under present conditions.

SU Status uncertain; a species thought to be uncommon in the state, but there is inadequate data to determine rarity. Also includes uncommon species of uncertain nativity in the state and of questionable taxonomic standing.

SH Historically known from the state but not verified for an extended period (usually 15+ years); there are expectations that the species may be rediscovered.

SX Species has been determined or presumed to be extirpated. All historical occurrences have been searched, or all known sites have been destroyed, and a thorough search of potential habitat has been completed.

SE Exotic or introduced in the state, not a part of the native flora; may be native elsewhere in North America (e.g., western United States).

SR Reported from the state, but without persuasive documentation that would provide a basis for either accepting or rejecting the report.

SRF Species reported falsely (in error) from the state, but this error persists in the literature.

.1 To date, only a single occurrence or population of this species has been documented.

SA A species which occasionally accidentally enters the state.

SC A species which casually enters the state on a periodic basis but there is no evidence of reproduction or of potential reproductive habitat existing within the state.

S? Species has not yet been ranked.

For long distance migrant animals a particular species' breeding status may be very different than its nonbreeding status, i.e., a species which winters commonly in Delaware may be a rare breeder within the state. "B" and "N" qualifiers are used to denote breeding and nonbreeding status respectively. For example, the Northern Harrier *(Circus cyaneus)* is a common winter resident but a very rare breeder and is, therefore, ranked S1B,S4N. A "Z" qualifier is used to denote species which regularly migrate or winter in Delaware, but do not maintain definable occurrences during such periods. For lepidoptera species, however, a SZB rank can be given for those individuals which regularly migrate through the state, breed, but no individuals survive to maturity.

APPENDIX C

Fauna Tables

TABLE 1
LIST OF FRESHWATER FISH
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE	
				POND	STREAM
American Eel	Anguilla rostrata		P,S	O	O
Common Goldfish	Carassius auratus		P,S	O	PR
Rosyside Dace	Clinostomus funduloides		S	U	O
Grass Carp	Ctenopharyngodon idella		P,S	PR	PO
Satinfin Shiner	Cyprinella analostana		S	U	PO
Spotfin Shiner	Cyprinella spiloptera	S3	S	U	PO
Common Carp	Cyprinus carpio		P,S	O	O
Cutlips Minnow	Exoglossum maxillingua		S	U	PO
River Chub	Nocomis micropogon	SR	S	U	PO
Common Shiner	Luxilus cornutus		P,S	PO	O
Comely Shiner	Notropis amoenus	S2	S	U	PO
Spottail Shiner	Notropis hudsonius		S	U	PR
Swallowtail Shiner	Notropis procne	SU	S	U	PR
Rosyface Shiner	Notropis rubellus		S	U	U
Blacknose Dace	Rhynichthys atratulus		S	PO	O
Longnose Dace	Rhynichthys cateractae		S	U	PO
Creek Chub	Semotilus atromaculatus		S	U	O
Fallfish	Semotilus corporalis		S	U	PO
White Sucker	Catostomus commersoni		S	U	O
Brown Bullhead	Ameiurus nebulosus		P,S	O	O
Redfin Pickerel	Esox americanus		P,S	PR	PR
Chain Pickerel	Esox niger		P,S	PO	PO
Rock Bass	Ambloplites rubrestris		S	U	U
Redbreast Sunfish	Lepomis auritus		P,S	O	PR

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE	
				POND	STREAM
Green Sunfish	Lepomis cyanellus		P,S	PO	PO
Pumpkinseed	Lepomis gibbosus		P,S	O	O
Bluegill Sunfish	Lepomis macrochirus		P,S	O	O
Smallmouth Bass	Micropterus dolomieu		S	U	U
Largemouth Bass	Micropterus salmoides		P,S	O	O
White Crappie	Pomoxis annualis		P	O	O
Black Crappie	Pomoxis nigromaculatus		P,S	O	O
Tessellated Darter	Etheostoma olmstedi		S	U	O

Notes:

STATUS
T = state threatened
E = state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
SR= Species reported from the state, but no evidence exists for accepting or rejecting the report
SU= Species status uncertain within the state.
FE = federally endangered
FT = federally threatened

HABITAT
P = ponds
S = stream

OCCURRENCE
O = observed
PR = probably occurs in area
PO = possibly occurs in area
U = unlikely to occur in area

Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*

TABLE 2
LIST OF AMPHIBIANS AND REPTILES
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE BY AREA								
				WOOD	FIELD	POND	STREAM	SPRING	VERNAL P	EDGE	GARDEN	GOLF C
Amphibians												
Spotted Salamander	Ambystoma maculatum	S2	W,V	PO	N	U	U	U	PO	U	U	N
N. Dusky Salamander	Desmognathus f. fuscus		W,S,SP	PR	N	U	O	O	U	U	U	N
N. Two-lined Salamander	Eurycea bislineata		W,S,SP	PR	N	U	O	O	U	U	U	N
Longtail Salamander	Eurycea l. longicauda	S1	W,S,SP	PR	N	U	PR	PR	U	U	U	N
Four-toed Salamander	Hemidactylium scutatum	S1	W,V	PO	N	U	U	PO	PO	U	U	N
Red-spotted Newt	Notophthalmus v. viridescens		W,V,P	PR	U	PO	PO	U	PR	U	U	N
Redback Salamander	Plethodon cinereus		W	O	U	N	N	PR	N	PR	O	U
N. Red Salamander	Pseudotriton r. ruber	S3	S	PR	N	U	O	PR	PO	U	U	N
Eastern American Toad	Bufo a. americanus		W,S,V,P	O	PR	PR	PO	PO	PR	PR	O	PR
Northern Spring Peeper	Pseudacris c. crucifer		W,E,V	O	U	PO	O	PO	O	O	O	PO
Bullfrog	Rana catesbeiana		F,V,P	U	U	O	PR	PO	PR	U	PO	U
Green Frog	Rana clamitans		F,V,P	U	U	O	O	PO	O	U	O	U
Pickerel Frog	Rana palustris		W,F,V,P	PO	PR	O	U	O	PR	PO	PR	U
Wood Frog	Rana sylvatica		W,F,V	O	PO	PO	PO	PO	PR	PO	PO	U
Reptiles												
Common Snapping Turtle	Chelydra s. serpentina		S,P	U	PO	O	O	U	PO	U	PO	PO
Eastern Painted Turtle	Chrysemys p. picta		S,P	U	PO	O	O	U	PO	U	PO	PO
Spotted Turtle	Clemmys guttata	S3	S,V	U	U	U	U	U	PO	N	N	N
Bog Turtle	Clemmys muhlenbergii	S1,FT	S,V	N	PO	U	PO	U	PO	N	N	N
Eastern Mud Turtle	Kinosternon s. subrubrum		S,P	U	PO	PO	PO	U	PO	U	N	N
Redbelly Turtle	Pseudemys rubriventris		P	U	PO	O	U	U	U	U	U	U
Common Musk Turtle	Sternotherus odoratus		S,P	U	PO	O	O	PO	PO	U	U	U
Eastern Box Turtle	Terrapene c. carolina		W,F	O	PR	U	PO	PR	PO	PO	PO	PO
Northern Copperhead	Agkistrodon contortrix mokasen	S1	W	U	U	N	N	N	N	U	U	U
Northern Black Racer	Coluber c. constrictor		W,F	PR	PO	U	U	PO	U	PR	PO	PO
Ringneck Snake	Diadophis punctatus		W,F	PR	PO	U	U	PO	U	PO	O*	PO
Black Rat Snake	Elaphe o. obsoleta		W,E,F	PR	PR	U	U	U	U	PR	PR	PO
Eastern Milk Snake	Lampropeltis t. triangulum	S2	W	PR	PO	U	U	U	U	PR	PR	PO
Northern Water Snake	Nerodia s. sipedon		S,V,P	PO	PO	O	O	PO	PR	U	PO	PO
Queen Snake	Regina septemvittata	S1	S	U	U	PO	O	U	U	U	U	N
Northern Brown Snake	Storeria d. decayi	S3	W	PO	PO	N	N	U	N	PO	PO	U
Eastern Ribbon Snake	Thamnophis s. sauritus	S2	S,V,P	PO	PO	PO	U	PO	PO	PO	PO	U
Eastern Garter Snake	Thamnophis s. sirtalis		W,F,S,V	O	PR	PR	O	PO	PR	PR	PR	PR

Notes:
Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*
Habitats listed are those that are preferred by a given species across its range.
Occurrence listings are specific to the Winterthur Museum property.

STATUS
T = state threatened
E = state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank

FE = federally endangered
FT = federally threatened

HABITAT
W = woodlands
F = fields
P = ponds
S = stream
V = vernal pool
SP = spring
E = edge

OCCURRENCE
O = observed
PR = probably occurs in area
PO = possibly occurs in area
U = unlikely to occur in area
N = does not occur

TABLE 3
LIST OF BIRDS
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Common Loon	Gavia immer		P	W	X	X	PO	X	X	X	X
Pied-billed Grebe	Podilymbus podiceps	S1B, S3N	P	,F,W,S	X	X	PR	X	X	X	X
American Bittern	Botaurus lentiginosus	S1B,S2N	S,P	S,F	X	X	PO	PO	X	X	X
Great Blue Heron	Ardea herodias	S2B	S,P	Y,N?	PO	O	O	O	X	X	X
Great Egret	Casmerodius albus	S1B	S,P	F,S,SU,NB	X	O	O	O	X	X	X
Snowy Egret	Egretta thula	S1B	S.P	S,SU,F,NB	X	X	U	U	X	X	X
Little Blue Heron	Egretta caerulea	S1B	S,P	S,SU,F,NB	X	X	PO	U	X	X	X
Tricolored Heron	Egretta tricolor	S1B	S,P	S,SU,F,NB	X	X	PO	U	X	X	X
Cattle Egret	Bubulcus ibis	S1B	F,P	S,SU,NB	X	X	PO	U	X	X	X
Green Heron	Butorides striatus		W,S,P	F,S,SU,N	PR	U	O	O	PO	X	X
Black-crowned Night Heron	Nycticorax nycticorax	S1B	S,P	S,SU,NB	X	X	PO	PO	X	X	X
Glossy Ibis	Plegadis falcinellus	S1B	F,P	S,SU,NB	X	PO	PO	U	X	X	X
Tundra Swan	Cygnus columbianus	S3N	F,P	F,W	X	PO	PO	X	X	X	X
Mute Swan	Cygnus olor		F,P	Y,N	X	X	O	O	X	X	X
Snow Goose	Chen caerulescens		F,P	F,W	X	PO	PO	X	X	X	X
Canada Goose	Branta canadensis		P,S,F	Y,B	X	O	O	O	X	O	O
Wood Duck	Aix sponsa		S,P	S,SU,F,B	O	U	O	O	X	X	X
Green-winged Teal	Anas crecca		P	F,W,S	X	U	PO	X	X	X	X
American Black Duck	Anas ribripes		P,S,F	Y,N	X	O	O	PO	X	X	X
Mallard	Anas platyrhynchos		P,S,F	Y,B	X	O	O	O	X	PO	PO
Northern Pintail	Anas acuta		P	F,W,S	X	U	PO	X	X	X	X
Blue-winged Teal	Anas discors	S3B	P	F,W,S	X	U	PO	U	X	X	X
Northern Shoveler	Anas clypeata	SHB	P	F,W,S	X	U	PO	X	X	X	X
Gadwall	Anas strepera	S3B	P	F,W,S	X	U	PO	X	X	X	X
American Widgeon	Anas americana		P	F,W,S	X	U	PO	X	X	X	X
Canvasback	Aythya valisineria	S2N	P	F,W,S	X	X	U	X	X	X	X
Redhead	Aythya americana	S2N	P	F,W,S	X	X	PO	X	X	X	X
Ring-necked Duck	Aythya collaris		P	F,W,S	X	X	PR	X	X	X	X
Lesser Scaup	Aythya affinus		P	F,W,S	X	X	PO	X	X	X	X
Bufflehead	Bucephala albeola		P	W	X	X	U	X	X	X	X
Hooded Merganser	Lophodytes cucullatus	S1B	P	F,W,S	X	X	PO	U	X	X	X
Common Merganser	Mergus merganser		P	W	X	X	PO	X	X	X	X

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Ruddy Duck	Oxyura dominica		P	F,W,S	X	X	O	X	X	X	X
Black Vulture	Coragyps atratus	S2B	W,F	Y,N?	O	O	X	X	X	PR	O
Turkey Vulture	Cathartes aura		W,F	Y,NB	O	O	X	X	X	PR	O
Osprey	Pandion haliaetus	S3B	P	S,F	U	U	O	PO	X	X	X
Bald Eagle	Haliaeetus leucocephalus	S2B, S3N, FE	W,P	Y,NB	O	PO	PR	PO	X	X	X
Northern Harrier	Circus cyaneus	S1B	F	F,W,S	U	O	X	X	PO	U	PO
Sharp-shinned Hawk	Accipiter striatus		W,F	F,W,S	O	O	X	X	O	O	O
Cooper's Hawk	Accipiter cooperii	S1B	W,F	Y,B?	O	O	X	X	O	O	O
Northern Goshawk	Accipiter gentilis		W,F	F,W	PO	U	X	X	U	PO	PO
Red-shouldered Hawk	Buteo lineatus	S2B	W,F	Y,N	PO	PO	X	X	PO	PO	PO
Broad-winged Hawk	Buteo platypterus	S1B	W,F	F,S,SU,N	O	O	X	X	PO	PO	PO
Red-tailed Hawk	Buteo jamaicensis		W,F	Y,B	O	O	X	X	O	O	O
Rough-legged Hawk	Buteo lagopus		F	W	U	PO	X	X	X	U	U
Golden Eagle	Aquila chrysaetos		W,F	F,W	PO	PO	X	X	U	U	U
American Kestrel	Falco sparverius	S3B	E,F	Y,N	PO	O	X	X	O	O	O
Merlin	Falco columbarius		F	F,W,S	X	U	X	X	X	X	X
Peregrine Falcon	Falco peregrinus	S1N, FE	F	F,W,S	X	PO	X	X	X	X	U
Ring-necked Pheasant	Phasianus colchicus		E,F	Y,N	PO	PR	X	X	PR	PO	PO
Northern Bobwhite	Colinus virginianus		E,F	Y,B	PR	O	X	X	PR	PO	U
Virginia Rail	Rallus limicola		S,P	S	X	X	U	PO	X	X	X
Sora	Porzana carolina	S2	S,P	S	X	X	U	PO	X	X	X
Common Moorhen	Galllinula chloropus	S3B	P	SU	X	X	U	X	X	X	X
American Coot	Fulica americana	S1B	P	Y,NB	X	X	PO	U	X	X	X
Killdeer	Charadrius vociferus		F	Y,B	X	O	O	U	X	X	X
Lesser Yellowlegs	Tringa flavipes		S,P	S,F	X	PO	PO	X	X	X	X
Solitary Sandpiper	Tringa solitaria		S,P	S	X	PO	O	PO	X	X	X
Spotted Sandpiper	Actitus macularia	SU	S,P	S,SU,N?	X	X	PR	PR	X	X	X
Upland Sandpiper	Bartramia longicauda	SHB	F	F	X	PO	X	X	X	X	X
American Woodcock	Scolopax rusticola		W,F	Y,N	PR	PR	X	X	PO	U	PO
Laughing Gull	Larus atricilla		P,F	S,SU,F,NB	X	U	U	X	X	X	U
Ring-billed Gull	Larus delawarensis		P,F	Y,NB	X	O	O	U	X	X	PO
Herring Gull	Larus argentatus	S3B	P,F	Y,NB	X	O	PO	X	X	X	X
Rock Dove	Columbia livia		F,A	Y,B	U	O	PO	PO	O	O	O
Mourning Dove	Zenaida macroura		F,E	Y,B	O	O	PR	PO	O	O	O
Black-billed Cuckoo	Coccyzus erythropthalmus	S1B	W,E	S,F	PR	X	X	X	PR	PO	U
Yellow-billed Cuckoo	Coccyzus americanus		W,E	S,SU,F,N	PR	X	X	X	PR	PO	PO
Barn Owl	Tyto alba	S3	W,F	Y,N?	U	PO	X	X	X	PO	PO

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Eastern Screech Owl	Otus asio		W,E,F	Y,B	O	PR	X	PO	O	PR	PO
Great Horned Owl	Bubo virginianus		W,E,F	Y,B	O	PR	X	X	PR	PR	PO
Barred Owl	Strix varia	S2	W,F	Y,N?	PO	U	U	PO	U	U	U
Long-eared Owl	Asio otus	S1N	W,F	W	PO	PO	X	X	PO	PO	PO
Short-eared Owl	Asio flammeus	SHB, S2N	F	W	X	U	X	X	X	X	U
Northern Saw-whet Owl	Aegolius acadicus		W,E	W	PO	PO	X	PO	PO	PO	PO
Common Nighthawk	Chordeiles minor	S2B	F	S,F	X	O	X	X	X	X	X
Chimney Swift	Chaetura pelagica		W,F	S,SU,F,N	PO	O	U	U	U	PO	PO
Ruby-throated Hummingbird	Archilochus colubris		W,E	S,SU,F,B	PR	O	X	X	O	O	PR
Belted Kingfisher	Caryle alcyon		P,S	Y,N	X	X	O	O	X	X	X
Red-headed Woodpecker	Melanerpes erythrocephalus	S1	W	Y,NB	PO	X	X	X	PO	PO	PO
Red-bellied Woodpecker	Melanerpes carolinus		W,E	Y,N	O	U	X	X	O	O	PR
Yellow-bellied Sapsucker	Sphyrapicus varius		W,E	F,W,S	O	U	X	X	PR	PR	PO
Downy Woodpecker	Picoides pubescens		W,E	Y,B	O	PR	X	X	O	O	O
Hairy Woodpecker	Picoides villosus	S3	W,E	Y,B	O	X	X	X	PR	O	PO
Northern Flicker	Colaptes auratus		W,F,E	Y,N	O	O	X	X	O	O	O
Pileated Woodpecker	Dryocopus pileatus	S3	W	Y,N	O	U	X	X	PO	PO	U
Olive-sided Flycatcher	Contopus borealis		W,E	F	U	O	X	X	O	PO	PO
Eastern Wood-Pewee	Contopus virens		W,E	S,SU,F,B	O	O	X	X	O	O	PO
Yellow-bellied Flycatcher	Empidonax flaviventris		W	S,F	PO	PO	X	X	PO	PO	U
Acadian Flycatcher	Empidonax virescens		W,E	S,SU,F,B	O	U	X	X	O	PR	U
Willow Flycatcher	Empidonax trailii	S3B	E	S,SU,N	U	PO	X	X	PO	U	U
Least Flycatcher	Sayornis phoebe		W,E	S,SU,F,N?	U	X	X	X	PO	U	U
Great Crested Flycatcher	Myiarshus crinitus		W,E	S,SU,F,N	O	U	X	X	O	PR	PO
Eastern Kingbird	Tyrannus tyrannus		E,F	S,SU,B	U	O	X	X	O	O	PR
Purple Martin	Progne subis		F	S,SU,F,N?	X	O	X	X	X	X	O
Tree Swallow	Tachycineta bicolor		F,P	S,SU,F,B	X	O	O	X	X	O	O
N. Rough-winged Swallow	Corvus ossifragus		S,P,F	S,SU,F,B	X	O	O	O	X	U	PO
Bank Swallow	Corvus ossifragus	S2B	P,F	F	X	PO	PO	PO	X	U	U
Barn Swallow	Hirundo rustica		P,F	S,SU,F,B	X	O	O	O	X	O	O
Blue Jay	Cyanocitta cristata		W,F,E	Y,B	O	O	X	X	O	O	O
American Crow	Corvus brachyrhychos		ALL	Y,B	O	O	X	PO	O	O	O
Fish Crow	Corvus ossifragus		ALL	Y,N	PR	O	X	PO	PR	PO	PO
Black-capped Chickadee	Parus atricapillus		W,E	W	PO	PO	X	X	PO	PO	U
Carolina Chickadee	Parus carolinensis		W,F,E	Y,B	O	O	X	X	O	O	O
Tufted Titmouse	Rarus bicolor		W,F,E	Y,B	O	O	X	X	O	O	O
Red-breasted Nuthatch	Sitta canadensis		W,E	F,W,S	O	U	X	X	O	O	O

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
White-breasted Nuthatch	Sitta carolinensis	S3	W,E	Y,B	O	U	X	X	O	O	PR
Brown Creeper	Certhia americana	S1B	W,E	F,W	O	X	X	X	PR	O	PO
Carolina Wren	Thryothorus ludovicianus		W,E,F	Y,B	O	O	X	X	O	O	O
House Wren	Troglodytes aedon		W,E,F	S,SU,F,B	O	PR	X	X	O	O	PR
Winter Wren	Troglodytes troglodytes		W,E,S	F,W	PR	PR	X	X	PR	PO	U
Marsh Wren	Cistothorus palustris		S	S,F	X	PO	X	X	PO	U	U
Golden-crowned Kinglet	Regulus satrapa		W,E	S,F,W	O	PO	X	X	O	O	PO
Ruby-crowned Kinglet	Regulus calendula		W,E	S,F	O	PR	X	X	O	O	PR
Blue-gray Gnatcatcher	Polioptila caerulea		W,E	S,SU,F,B	O	U	X	X	O	PO	U
Eastern Bluebird	Sialia sialis		W,F,E	Y,B	O	O	X	X	O	O	O
Veery	Catharus fuscescens	S2B	W	S,SU,F,B	O	U	X	X	PR	PO	X
Swainson's Thrush	Catharus ustulatus		W	S,F	O	U	X	X	PO	PO	X
Hermit Thrush	Catharus guttatus		W,E	F,W,S	O	U	X	X	O	O	U
Wood Thrush	Hylocichia mustelina		W,E	S,SU,F,B	O	U	X	X	PO	PO	U
American Robin	Turdus migratorius		W,F,E	Y,B	O	O	X	X	O	O	O
Gray Catbird	Dumetella carolinensis		W,F,E	S,SU,F,B	O	O	X	X	O	O	PO
Northern Mockingbird	Mimus polygottos		F,E	Y,B	PO	O	X	X	O	O	O
Brown Thrasher	Toxostoma rufrum		W,E	Y,B	O	PO	X	X	O	PR	PO
Water Pipit	Anthus spinoletta		F	F,W,S	X	PO	X	X	X	X	PO
Cedar Waxwing	Bombycilla garrulus		W,E	Y,N	O	PO	X	X	O	PR	PO
European Starling	Sturnus vulgaris		ALL	Y,B	O	O	X	X	O	O	O
White-eyed Vireo	Vireo griseus		W,E	S,SU,F,B	O	U	X	X	O	PO	U
Blue-backed Vireo	Vireo solitarius		W,E	S,F	O	U	X	X	PR	PO	U
Yellow-throated Vireo	Vireo flavifrons	S3B	W,E	S	PO	U	X	X	PO	U	U
Warbling Vireo	Vireo gilvus	S2B	W,E	S,SU,F,B	O	U	X	X	O	PO	U
Philadelphia Vireo	Vireo philadelphicus		W,E	S,F	PO	U	X	X	PO	PO	U
Red-eyed Vireo	Vireo olivaceus		W,E	S,SU,F,B	O	PO	X	X	O	O	PO
Blue-winged Warbler	Vermivora pinus	S1B	E	S,SU,F,N?	U	PO	X	X	PO	U	U
Golden-winged Warbler	Vermivora chrysoptera		W,E	S,F	PO	U	X	X	PO	PO	U
Tennessee Warbler	Vermivora peregrina		W,E	S,F	PR	U	X	X	PR	PO	U
Orange-crowned Warbler	Vermivora celata		E	F,W	U	PO	X	X	PO	U	U
Nashville Warbler	Vermivora ruficapilla		W,E	S,F	O	U	X	X	O	PR	U
Northern Parula	Parula americana	S1B	W,E	S,SU,F,N?	O	U	X	X	O	PR	U
Yellow Warbler	Dendroica petechia		E	S,SU,N	PO	PO	X	X	PO	PO	U
Chestnut-sided Warbler	Dendroica pensylvanica	S1B	W,E	S,F	O	U	X	X	O	PR	U
Magnolia Warbler	Dendroica magnolia		W,E	S,F	O	U	X	X	O	O	U
Cape May Warbler	Dendroica tigrina		W,E	S,F	PR	U	X	X	PR	PO	U

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Black-throated Blue Warbler	Dendroica caerulescens		W,E	S,F	O	U	X	X	PR	PR	U
Yellow-rumped Warbler	Dendroica coronata		W,E	S,F,W	O	O	X	X	O	O	PO
Black-throated Green Warbler	Dendroica virens		W,E	S,F	O	U	X	X	O	O	U
Blackburnian Warbler	Dendroica fusca		W,E	S,F	PR	X	X	X	PO	PO	U
Yellow-throated Warbler	Dendroica dominica	S2B	W,E	S,F,N?	PO	X	X	X	U	U	X
Pine Warbler	Dendroica pinus		W,E	S,F	PO	X	X	X	PO	PO	PO
Prairie Warbler	Dendroica discolor		E	S,SU,N?	PR	PO	X	X	PR	PO	U
Palm Warbler	Dendroica palmarum		W,F,E	S,F	O	O	X	X	PR	PR	PO
Bay-breasted Warbler	Dendroica castanea		W,E	S,F	PO	U	X	X	PO	PO	U
Blackpoll Warbler	Dendroica striata		W,E	S,F	O	U	X	X	PR	PR	U
Cerulean Warbler	Dendroica cerulea	S1B	W	S,SU,N?	PO	X	X	X	U	X	X
Black-and-white Warbler	Minotilta varia	S3B	W,E	S,SU,F,N?	O	PO	X	X	O	PR	U
American Redstart	Setophaga ruticilla	S1B	W,E	S,SU,F,N?	O	PO	X	X	O	PR	U
Prothonotary Warbler	Protonotaria citera		W,E	S,F	U	X	X	X	U	X	X
Worm-eating Warbler	Helmitheros vermivorus	S3B	W,E	S,SU,N?	PR	X	X	X	PO	U	U
Ovenbird	Seiurus aurocapillus		W,E	S,SU,F,B	O	U	X	X	PO	PO	U
Northern Waterthrush	Seriurus noveboracensis		W,E,S	S,F	PR	U	X	PR	PO	PO	U
Louisiana Waterthrush	Seriurus montacilla	S3B	W,S	S,SU,F,N	PR	U	X	PR	PO	PO	U
Kentucky Warbler	Oporornis formosus	S3B	W	S,SU,B	O	X	X	X	PO	PO	X
Connecticut Warbler	Oporornis agilis		E	S,F	PO	U	X	X	PO	PO	X
Mourning Warbler	Oporornis philadelphia		E	S,F	PO	U	X	X	PO	PO	X
Common Yellowthroat	Geothlypis trichas		F,E	S,SU,F,N	PO	O	X	X	O	O	PO
Hooded Warbler	Wilsonia citrina	S1B	W	S,SU,N?	O	X	X	X	PO	U	X
Wilson's Warbler	Wilsonia pusilla		W,E	S,F	PR	U	X	X	PR	PR	U
Canada Warbler	Wilsonia canadensis		W,E	S,F	O	PO	X	X	PR	PO	U
Yellow-breasted Chat	Icteria virens	S3B	E	S,SU,F,N	U	PO	X	X	O	U	U
Scarlet Tanager	Piranga olivacea		W,E	S,SU,F,B	O	U	X	X	O	PO	U
Northern Cardinal	Cardinalis cardinalis		W,F,E	Y,B	O	O	X	X	O	O	O
Rose-breasted Grosbeak	Pheucticus ludovicianus		W,E	S,F	O	U	X	X	PR	PR	U
Blue Grosbeak	Guiraca caerulea		E	S,SU,N	PO	PO	X	X	PO	PO	U
Indigo Bunting	Passerina cyanea		W,F,E	S,SU,F,B	O	O	X	X	O	PO	U
Eastern Towhee	Pipilo erythrophythalmus		F,E	Y,B	O	O	X	X	O	PR	PO
American Tree Sparrow	Spizella arborea		F,E	W	U	PR	X	X	PR	PO	PO
Chipping Sparrow	Spizella passerina	S3N	W,F,E	Y,B	PO	O	X	X	O	O	PO
Field Sparrow	Spizella pusilla		F,E	Y,B	U	O	X	X	O	PO	PO
Savannah Sparrow	Passerculus sandwichensis		F,E	S,F	U	PR	X	X	PO	PO	PO
Grasshopper Sparrow	Ammodramus savannarum	S3B	F	S,SU,F,N?	X	PO	X	X	U	X	PO

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Fox Sparrow	Passerella iliaca		W,F,E	S,F,W	PR	PR	X	X	O	O	U
Song Sparrow	Melospiza melodia		F,E	Y,B	O	O	X	X	O	O	O
Lincoln's Sparrow	Melospiza lincolnii		F,E	F	U	PR	X	X	PR	U	PO
Swamp Sparrow	Melospiza georgiana	S3B	E,S	S,F,W	U	PO	X	X	PO	U	U
White-throated Sparrow	Zonotrichia albicollis		W,E	S,F,W	O	O	X	X	O	O	O
White-crowned Sparrow	Zonotrichia leucophrys		E	S,F,W	PO	PR	X	X	PR	PO	U
Dark-eyed Junco	Junco hyemalis		F,E	S,F,W	O	O	X	X	O	O	O
Bobolink	Dolichonyx oryzivorus	SU	F	S,F	X	PR	X	X	PO	U	PO
Red-winged Blackbird	Agelaius phoeniceus		W,F,E	Y,B	O	O	X	X	O	O	O
Eastern Meadowlark	Sturnella magna	S3	F	Y,B	X	O	X	X	X	X	PO
Rusty Blackbird	Euphagus carolinus		W,E,S	S,F,W	PO	PO	X	X	PO	PO	U
Common Grackle	Quiscalus quiscula		W,F,E	Y,N	O	O	X	X	O	O	PR
Brown-headed Cowbird	Molothrus ater		W,F,E	Y,N	O	O	X	X	O	O	O
Orchard Oriole	Icterus spurius		E	S,SU,B	P	PO	X	X	PO	PO	PO
Baltimore Oriole	Icterus galbula		W,E	S,SU,B	O	PO	X	X	PR	PR	PO
Purple Finch	Carpodacus purpureus		W,F,E	F,W	O	PR	X	X	PR	O	PO
House Finch	Carpodacus mexicanus		W,F,E	Y,B	O	O	X	X	O	O	O
Red Crossbill	Loxia curvirostra		W	W	U	X	X	X	U	U	U
White-winged Crossbill	Loxia leucoptera		W	W	U	X	X	X	U	U	U
Common Redpoll	Carduelis flammea		W,E	W	U	X	X	X	U	U	U
Pine Siskin	Carduelis pinus		W,E	S,F,W	PR	PO	X	X	PR	PO	U
American Goldfinch	Carduelis tristis		W,F,E	Y,B	O	O	X	X	O	O	O
Evening Grosbeak	Coccothraustes vespertinus		W,E	W	PO	U	X	X	PO	PO	U
House Sparrow	Passer domesticus		F,E	YN	U	PO	X	X	O	O	PR

Notes:

STATUS
T = state threatened
E = state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
SH = species historically known from the state
SU = species status uncertain within the state
FE = federally endangered
FT = federally threatened
"B" and "N" qualifiers indicate breeding and nonbreeding status, respectively

HABITAT
W = woodlands
F = fields
P = ponds
S = stream
E = edge

RESIDENCE
F = fall
W = winter
S = spring
Su = summer
Y = all year
B =breeding
N= nesting habitat available
N? = nesting habitat marginal
NB = non-breeding

OCCURRENCE
O = observed
PR = probably occurs in area
PO = possibly occurs in area
U = unlikely to occur in area
X =does not occur in area

Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*

TABLE 4
LIST OF MAMMALS
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA							
					WOOD	FIELD	POND	STREAM	SPRING	EDGE	GARDEN	GOLF C
Opossum	Didelphis marsupialis		ALL	R	O	O	PR	O	PR	O	O	PR
Eastern Mole	Scalopus aquaticus		W,F	R	PO	O	N	N	PR	PR	PO	PO
Starnose Mole	Condylura cristata		W,F,S,SP	R	PO	PR	U	U	PR	PO	PO	U
N. Short-tailed Shrew	Blarina brevicauda		W,F,SP	R	O	O	U	U	PO	PR	PR	PO
Masked Shrew	Sorex cinereus		W,F,SP	R	PO	PO	N	N	PO	PO	U	U
Least Shrew	Cryptotis parva	SU	F	R	U	PO	N	N	N	PO	PO	U
Little Brown Myotis	Myotis lucifugus		ALL	SB	O	O	O	PR	PO	PO	PR	O
Eastern Pipistrelle	Pipistrellus subflavus		ALL	SB	PR	PR	PR	PR	PO	PO	PR	PO
Keen's Myotis	Myotis keenii		ALL	M	?	?	?	?	?	?	?	?
Evening Bat	Nycticeius humeralis	SU	ALL	M	?	?	?	?	?	?	?	?
Silver-haired Bat	Lasionycteris noctivagans	SU	ALL	M	?	?	?	?	?	?	?	?
Big Brown Bat	Eptesicus fuscus		ALL	R	O	O	O	O	PO	PO	PR	PR
Red Bat	Lasiurus borealis	SU	ALL	SB	O	PO	PR	PO	PO	PO	PR	PO
Hoary Bat	Lasiurus cinereus	SU	ALL	M	?	?	?	?	?	?	?	?
Eastern Cottontail	Sylvilagus floridanus		W,F,E	R	PO	O	N	N	N	O	O	O
Eastern Gray Squirrel	Sciurus carolinensis		W,F,E	R	O	O	N	N	N	O	O	O
Eastern Chipmunk	Tamias striatus		W	R	O	U	N	N	N	O	O	PO
Southern Flying Squirrel	Glaucomys volans		W	R	PR	PO	N	N	N	PR	PR	U
Red Squirrel	Tamiasciurus hudsonicus	S3	W	R	O	U	N	N	N	O	PR	PO
Beaver	Castor canadensis	S3	W,P,S	R	PO	U	PO	PO	U	PO	U	U
Woodchuck	Marmota monax		W,F,E	R	O	O	N	N	N	O	O	O
Meadow Jumping Mouse	Zapus hudsonius		W,F,E	R	U	PR	U	U	U	PO	U	U
White-footed Mouse	Peromyscus leucopus		W,E	R	O	PR	N	N	N	O	PR	PR
Southern Bog Lemming	Synaptomys cooperi		W,F	R	U	PO	N	N	PO	PO	U	U
House Mouse	Mus musculus		W,E	R	PO	PR	N	N	N	PO	PR	PO
Meadow Vole	Microtus pennsylvanicus		W,F,E	R	PR	O	N	N	N	PR	PR	PR
Norway Rat	Rattus norvegicus		F	R	PO	PO	PO	PO	PO	PO	PR	PO
Black Rat	Rattus rattus		F	R	U	U	U	U	U	U	U	U
Muskrat	Ondatra zibethicus		P,S	R	N	O	O	O	P	U	U	U
Raccoon	Procyon lotor		ALL	R	O	O	O	O	PR	O	O	O

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA							
					WOOD	FIELD	POND	STREAM	SPRING	EDGE	GARDEN	GOLF C
Long-tail Weasel	Mustela frenata		W,E	R	PR	PO	N	PO	PO	PR	PO	PO
Mink	Mustela vison	S3	P,S,SP	R	PO	U	PO	PO	PO	PO	U	U
Striped Skunk	Mephitis mephitis		W,F,F	R	PR	PR	U	PO	PO	PR	PO	PO
Red Fox	Vulpes fulva		W,F,E	R	O	O	N	PR	PR	O	O	O
Gray Fox	Urocyon cinereogonteus		W,F	R	?	?	N	?	?	?	?	?
White-tailed Deer	Odocoileus virginiana		W,F,E	R	O	O	N	PR	PO	O	O	O
Coyote	Canis latrans	SU	W,F,E	R	?	?	N	?	?	?	?	?

NOTES:

Status	**Habitat**	**Residence**	**Occurrence**
T=state threatened	W = woodlands	R=resident all year	O=species observed during field survey
E=state endangered	F = field	SB= summer breeding	PR=species likely to occur; habitat suitable
S1 = DE heritage 1st priority rank	P = pond	M= migrates through area	PO=species possibly occurs; habitat marginal
S2 = DE heritage 2nd priority rank	S = stream		U=species unlikely to occur
S3 = DE heritage 3rd priority rank	SP = spring		N=species not occurring
SU = species status uncertain within the state	E = edge		?=occurrence unknown

Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*

TABLE 5
LIST OF ODONATA
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE		
				FIELD	POND	STREAM
Dragonflies	**Anisoptera**					
Darners	*Aeschnidae*					
Fawn Darner	Boyeria vinosa		F,S	PR	U	PO
Swamp Darner	Epiaeschna heros		S,WP	PO	PO	PO
Cyrano Darner	Nasiaeschna pentacantha	S3	S,WP	PO	PO	PO
Shadow Darner	Aeshna umbrosa	S3	S,WP	PO	PO	PO
Green Darner	Anax junius		F,WP,OP	O	O	O
Spiketails	*Cordulegasteridea*					
Tiger Spiketail	Cordulegaster erronea	S2	S	U	U	PO
Twin-spotted Spiketail	Cordulegaster maculata	S3	F,S	O	U	O
Clubtails	*Gomphidae*					
Least Clubtail	Stylogomphus albistylus	S2	?	?	?	?
Lancet Clubtail	Gomphus exilis		S,WP,OP	U	PO	PO
a common clubtail	Gomphus lividus		S,WP,OP	?	?	?
a pond clubtail	Agrogomphis villosipes		S,WP,OP	?	?	?
Russet-tipped Clubtail	Gomphus plagiatus	S2	S,WP,OP	?	?	?
Arrow Clubtail	Gomphus spiniceps	S1	S,OP	?	?	?
River Cruisers	*Macromiidae*					
Swift River Cruiser	Macromia illinoiensis	S2	OP	PO	PO	U
Emeralds	*Corduliidae*					
an emerald	Tetragoneuria cynosura		OP	PO	PR	PO

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE		
				FIELD	POND	STREAM
Skimmers	*Libellulidae*					
Spangled Skimmer	Libellula cyanea		S,OP	PO	PO	PO
Slaty Skimmer	Libellula incesta		S,WP,OP	PO	PO	PO
The Widow	Libellula luctuosa		F,WP,OP	PO	PO	U
Common Whitetail	Libellula lydia		F,WP,OP	O	O	PO
Ten Spotted Dragonfly	Libellula pulchella	S3	F,WP,OP	O	O	U
Great Blue Skimmer	Libellula vibrans	S3	F,WP,S	O	O	PR
Eastern Amberwing	Perithemis tenera		OP	PO	O	U
Eastern Pondhawk	Erythemis simplicicollis		F,WP,OP,S	O	O	PR
a Skimmer	Sympetrum janeae		F,WP,OP,S	?	?	?
Ruby Meadowhawk	Sympetrum rubicundulum		F,WP,OP	O	O	PO
Yellow-legged Meadowhawk	Sympetrum vicinum		F,WP,OP	PO	PO	U
Blue Pirate	Pachydiplax longipennis		WP,OP		O	U
Halloween Pennant	Celithemis eponina		F,WP,OP	O	O	PO
Wandering Glider	Pantala flavescens		F, OP	O	O	U
Black-mantled Glider	Tramea lacerata	S3	F,WP,OP,S	O	O	PO
Damselflies	**Zygoptera**					
Broad-winged Damselflies	*Calopterigidae*					
Ebony Jewelwingy	Calopteryx maculata		WP,S	U	O	O
American Rubyspot	Hetaerina americana		WP,S	U	?	?
Spreadwings	*Lestidae*					
Common Spreadwing	Lestes disjunctus australis	S3	WP,OP	PO	O	PO
Sweetflag Spreadwing	Lestes forcipatus	S3	WP,OP	U	?	?
Elegant Spreadwing	Lestes inaequalis		WP	U	PO	U
Slender Spreadwing	Lestes rectangularis		WP	U	PO	U
Narrow-winged Damselflies	*Coenagrionidae*					
Eastern Red Damsel	Amphiagrion saucium		S	U	U	PO
Variable Dancer	Argia fumipennis violacea		S,WP,OP	U	PO	PO
Powdered Dancer	Agria moesta		S	U	U	PO

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE		
				FIELD	POND	STREAM
Blue-tipped Darner	Agria tibialis		S	U	U	PO
Azure Bluet	Enallagma aspersum	S3	S	U	?	?
Familiar Bluet	Enallagma civile		OP	U	PO	U
Stream Bluet	Enallagma exsulans		S	U	?	?
Fragile Forktail	Ischnura posita		WP	U	PO	U
Rambur's Forktail	Ischnura ramburi		WP,OP	U	PO	U
Eastern Forktail	Ischnura verticalis		OP	U	PO	U

Notes:

Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*
Habitats listed are those that are preferred by a given species across its range.
Occurrence listings are specific to the Winterthur Museum property.

STATUS
T = state threatened
E = state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
FE = federally endangered
FT = federally threatened

HABITAT
F = fields
WP = wooded ponds
OP = open ponds
S = stream

OCCURRENCE
O = observed
PR = probably occurs in area
PO = possibly occurs in area
U = unlikely to occur in area

TABLE 6
LIST OF LEPIDOPTERANS
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997-1998

COMMON NAME	SCIENTIFIC NAME	STATUS	OCCURRENCE BY AREA		
			WOODLANDS	FIELDS	GARDENS
	Family: Papilionidae				
Pipevine Swallowtail	Battus philenor		U	PO	PO
Zebra Swallowtail	Eurytides marcellus		PO	PO	PO
Black Swallowtail	Papilio polyxenes		PO	O	O
Eastern Tiger Swallowtail	Papilio glaucus		PR	O	O
Spicebush Swallowtail	Papilio troilus		PR	O	O
	Family: Pieridae				
Checkered White	Pontia protodice	SU	?	?	?
Cabbage	Pieris rapae		PO	O	O
Falcate Orangetip	Paramidia midea		PO	PO	PO
Clouded Sulfur	Colias philodice		PO	O	O
Orange Sulfur	Colias eurytheme		PO	O	O
Cloudless Sulfur	Phoebis sennae		U	O	O
	Family: Lycaenidae				
American Copper	Lycaena phlaeas		U	PR	PR
Bronze Copper	Lycaena hyllus	S2	U	U	U
Banded Hairstreak	Satyrium calanus		PO	PR	PR
Gray Hairstreak	Strymon melinus		PO	O	O

COMMON NAME	SCIENTIFIC NAME	STATUS	OCCURRENCE BY AREA		
			WOODLANDS	FIELDS	GARDENS
Olive Hairstreak	Mitoura grynea	S2	U	?	?
EasternTailed-blue	Everes comyntas		PO	O	O
Spring Azure	Celastrina ladon		PR	O	O
Appalachian Azure	Celastrina neglectamajor		PR	U	O
	Family: Nymphalidae				
American Snout	Libytheana bachmanii		S	S	S
Variegated Fritillary	Euptoieta claudia		U	O	O
Great Spangled Frilillary	Speyeria cybele		PO	O	O
Meadow Fritillary	Boloria bellona	SU	U	O	O
Pearl Crescent	Phycoides tharos		U	O	O
Baltimore Checkerspot	Euphydryas phaeton	S1	U	PO	PO
Question Mark	Polygonia interrogationis		O	O	O
Eastern Comma	Polygonia comma		O	O	O
Mourning Cloak	Nymphalis antiopa		O	PO	O
American Lady	Vanessa virginiensis		U	PR	PR
Painted Lady	Vanessa cardui		U	O	PR
Red Admiral	Vanessa atalanta		PO	O	O
Common Buckeye	Junonia coenia		U	O	O
Red-spotted Purple	Limenitis arthemis		O	O	O
White Admiral	Limenitis arthemis		S	S	S
Viceroy	Limenitis archippus		PO	O	O
Appalachian Brown	Satyrodes eurydice		O	PO	O
Little Wood-satyr	Megisto cymela		PO	PO	PO
Common Wood Nymph	Cercyonis pegala		PO	PO	PO
Monarch	Danaus plexippus		PO	O	O

COMMON NAME	SCIENTIFIC NAME	STATUS	OCCURRENCE BY AREA		
			WOODLANDS	FIELDS	GARDENS
	Family:Hesperiidae				
Silver-spotted Skipper	Epargyreus clarus		U	O	O
Southern Cloudywing	Thorybes bathyllus		U	?	?
Northern Cloudywing	Thorybes pylades		U	?	?
Confused Cloudy Wing	Thorybes confusis	SH	U	?	?
Hayhurst's Scallopwing	Staphylus hayhurstii		U	?	?
Dreamy Duskywing	Erynnis icelus		U	?	?
Juvenal's Duskywing	Erynnis juvenalis		U	?	?
Wild Indigo Duskywing	Erynnis baptisiae	SU	U	?	?
Zarucco Dusky Wing	Erynnis zarucco	SR	U	?	?
Common Duskywing	Pyrgus communis		U	?	?
Common Sootywing	Pholisora catullus		U	O	O
Swarthy Skipper	Nastra lherminier		U	?	?
Least Skipper	Ancyloxypha numitor		U	O	O
European Skipper	Thymelicus lineola		U	O	O
Peck's Skipper	Polites peckius		U	PR	PR
Tawny-edged Skipper	Polites themistocles		U	?	?
Crossline Skipper	Polites origenes		U	?	?
Long Dash	Polites mystic		U	PR	PR
Northern Broken Dash	Wallengrenia egeremet		U	PR	PR
Little Glassywing	Pompeius verna		U	?	?
Delaware Skipper	Anatrytone logon	SU	U	PO	PO
Hobomok Skipper	Poanes hobomok		U	O	O
Zabulon Skipper	Poanes zabulon		U	O	O
Broad-winged Skipper	Poanes viator		U	PO	PO
Dun Skipper	Euphyes ruricola		U	?	?

Notes:
Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*
Occurrence listings are specific to the Witherthur Museum property.

STATUS
T = state threatened
E = state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
SH= Species historically known from the state
SR= Species reported from the state, but no evidence exists for accepting or rejecting the report
SU= Species status uncertain within the state
FE = federally endangered
FT = federally threatened

OCCURRENCE
O = observed
PR = probably occurs in area, habitat suitable
PO = possibly occurs in area, habitat marginal
U = unlikely to occur in area, habitat poor
S = stray
? = occurrence unknown

TABLE 7
FISH SPECIES OF SPECIAL CONCERN
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE	
				POND	STREAM
Spotfin Shiner	Cyprinella spiloptera	S3	S	U	PO
River Chub	Nocomis micropogon	SR	S	U	PO
Comely Shiner	Notropis amoenus	S2	S	U	PO
Swallowtail Shiner	Notropis procne	SU	S	U	PR

Notes:

STATUS
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S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
SR= Species reported from the state, but no evidence exists for accepting or rejecting the report
SU= Species status uncertain within the state.
FE = federally endangered
FT = federally threatened

HABITAT
P = ponds
S = stream

OCCURRENCE
O = observed
PR = probably occurs in area
PO = possibly occurs in area
U = unlikely to occur in area

Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*

TABLE 8
AMPHIBIAN AND REPTILE SPECIES OF SPECIAL CONCERN
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	OCCURRENCE BY AREA								
				WOOD	FIELD	POND	STREAM	SPRING	VERNAL P	EDGE	GARDEN	GOLF C
Amphibians												
Spotted Salamander	Ambystoma maculatum	S2	W,V	PO	N	U	U	U	PO	U	U	N
Longtail Salamander	Eurycea l. longicauda	S1	W,S,SP	PR	N	U	PR	PR	U	U	U	N
Four-toed Salamander	Hemidactylium scutatum	S1	W,V	PO	N	U	U	PO	PO	U	U	N
N. Red Salamander	Pseudotriton r. ruber	S3	S	PR	N	U	O	PR	PO	U	U	N
Reptiles												
Spotted Turtle	Clemmys guttata	S3	S,V	U	U	U	U	U	PO	N	N	N
Bog Turtle	Clemmys muhlenbergii	S1, FT	S,V	N	PO	U	PO	U	PO	N	N	N
Northern Copperhead	Agkistrodon contortrix mokasen	S1	W	U	U	N	N	N	N	U	U	U
Eastern Milk Snake	Lampropeltis t. triangulum	S2	W	PR	PO	U	U	U	U	PR	PR	PO
Queen Snake	Regina septemvittata	S1	S	U	U	PO	O	U	U	U	U	N
Northern Brown Snake	Storeria d. decayi	S3	W	PO	PO	N	N	U	N	PO	PO	U
Eastern Ribbon Snake	Thamnophis s. sauritus	S2	S,V,P	PO	PO	PO	U	PO	PO	PO	PO	U

Notes:
Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*
Habitats listed are those that are preferred by a given species across its range.
Occurrence listings are specific to the Winterthur Museum property.

STATUS
T = state threatened
E = state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
FE = federally endangered
FT = federally threatened

HABITAT
W = woodlands
F = fields
P = ponds
S = stream
V = vernal pool
SP = spring
E = edge

OCCURRENCE
O = observed
PR = probably occurs in area
PO = possibly occurs in area
U = unlikely to occur in area
N = does not occur

TABLE 9
BIRD SPECIES OF SPECIAL CONCERN
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Pied-billed Grebe	Podilymbus podiceps	S1B, S3N	P	F,W,S	X	X	PR	X	X	X	X
American Bittern	Botaurus lentiginosus	S1B,S2N	S,P	S,F	X	X	PO	PO	X	X	X
Great Blue Heron	Ardea herodias	S2B	S,P	Y,N?	PO	O	O	O	X	X	X
Great Egret	Casmerodius albus	S1B	S,P	F,S,SU,NB	X	O	O	O	X	X	X
Snowy Egret	Egretta thula	S1B	S.P	S,SU,F,NB	X	X	U	U	X	X	X
Little Blue Heron	Egretta caerulea	S1B	S,P	S,SU,F,NB	X	X	PO	U	X	X	X
Tricolored Heron	Egretta tricolor	S1B	S,P	S,SU,F,NB	X	X	PO	U	X	X	X
Cattle Egret	Bubulcus ibis	S1B	F,P	S,SU,NB	X	X	PO	U	X	X	X
Black-crowned Night Heron	Nycticorax nycticorax	S1B	S,P	S,SU,NB	X	X	PO	PO	X	X	X
Glossy Ibis	Plegadis falcinellus	S1B	F,P	S,SU,NB	X	PO	PO	U	X	X	X
Tundra Swan	Cygnus columbianus	S3N	F,P	F,W	X	PO	PO	X	X	X	X
Blue-winged Teal	Anas discors	S3B	P	F,W,S	X	U	PO	U	X	X	X
Northern Shoveler	Anas clypeata	SHB	P	F,W,S	X	U	PO	X	X	X	X
Gadwall	Anas strepera	S3B	P	F,W,S	X	U	PO	X	X	X	X
Canvasback	Aythya valisineria	S2N	P	F,W,S	X	X	U	X	X	X	X
Redhead	Aythya americana	S2N	P	F,W,S	X	X	PO	X	X	X	X
Hooded Merganser	Lophodytes cucullatus	S1B	P	F,W,S	X	X	PO	U	X	X	X
Black Vulture	Coragyps atratus	S2B	W,F	Y,N?	O	O	X	X	X	PR	O
Osprey	Pandion haliaetus	S3B	P	S,F	U	U	O	PO	X	X	X
Bald Eagle	Haliaeetus leucocephalus	S2B, S3N, FE	W,P	Y,NB	O	PO	PR	PO	X	X	X
Northern Harrier	Circus cyaneus	S1B	F	F,W,S	U	O	X	X	PO	U	PO
Cooper's Hawk	Accipiter cooperii	S1B	W,F	Y,B?	O	O	X	X	O	O	O
Red-shouldered Hawk	Buteo lineatus	S2B	W,F	Y,N	PO	PO	X	X	PO	PO	PO
Broad-winged Hawk	Buteo platypterus	S1B	W,F	F,S,SU,N	O	O	X	X	PO	PO	PO
American Kestrel	Falco sparverius	S3B	E,F	Y,N	PO	O	X	X	O	O	O
Peregrine Falcon	Falco peregrinus	S1N, FE	F	F,W,S	X	PO	X	X	X	X	U
Sora	Porzana carolina	S2	S,P	S	X	X	U	PO	X	X	X
Common Moorhen	Galllinula chloropus	S3B	P	SU	X	X	U	X	X	X	X
American Coot	Fulica americana	S1B	P	Y,NB	X	X	PO	U	X	X	X
Spotted Sandpiper	Actitus macularia	SU	S,P	S,SU,N?	X	X	PR	PR	X	X	X

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA						
					WOOD	FIELD	POND	STREAM	EDGE	GARDEN	GOLF C
Upland Sandpiper	Bartramia longicauda	SHB	F	F	X	PO	X	X	X	X	X
Herring Gull	Larus argentatus	S3B	P,F	Y,NB	X	O	PO	X	X	X	X
Black-billed Cuckoo	Coccyzus erythropthalmus	S1B	W,E	S,F	PR	X	X	X	PR	PO	U
Barn Owl	Tyto alba	S3	W,F	Y,N?	U	PO	X	X	X	PO	PO
Barred Owl	Strix varia	S2	W,F	Y,N?	PO	U	U	PO	U	U	U
Long-eared Owl	Asio otus	S1N	W,F	W	PO	PO	X	X	PO	PO	PO
Short-eared Owl	Asio flammeus	SHB, S2N	F	W	X	U	X	X	X	X	U
Common Nighthawk	Chordeiles minor	S2B	F	S,F	X	O	X	X	X	X	X
Red-headed Woodpecker	Melanerpes erythrocephalus	S1	W	Y,NB	PO	X	X	X	PO	PO	PO
Hairy Woodpecker	Picoides villosus	S3	W,E	Y,B	O	X	X	X	PR	O	PO
Pileated Woodpecker	Dryocopus pileatus	S3	W	Y,N	O	U	X	X	PO	PO	U
Willow Flycatcher	Empidonax trailii	S3B	E	S,SU,N	U	PO	X	X	PO	U	U
Bank Swallow	Corvus ossifragus	S2B	P,F	F	X	PO	PO	PO	X	U	U
White-breasted Nuthatch	Sitta carolinensis	S3	W,E	Y,B	O	U	X	X	O	O	PR
Brown Creeper	Certhia americana	S1B	W,E	F,W	O	X	X	X	PR	O	PO
Veery	Catharus fuscescens	S2B	W	S,SU,F,B	O	U	X	X	PR	PO	X
Yellow-throated Vireo	Vireo flavifrons	S3B	W,E	S	PO	U	X	X	PO	U	U
Warbling Vireo	Vireo gilvus	S2B	W,E	S,SU,F,B	O	U	X	X	O	PO	U
Blue-winged Warbler	Vermivora pinus	S1B	E	S,SU,F,N?	U	PO	X	X	PO	U	U
Northern Parula	Parula americana	S1B	W,E	S,SU,F,N?	O	U	X	X	O	PR	U
Chestnut-sided Warbler	Dendroica pensylvanica	S1B	W,E	S,F	O	U	X	X	O	PR	U
Yellow-throated Warbler	Dendroica dominica	S2B	W,E	S,F,N?	PO	X	X	X	U	U	X
Cerulean Warbler	Dendroica cerulea	S1B	W	S,SU,N?	PO	X	X	X	U	X	X
Black-and-white Warbler	Minotilta varia	S3B	W,E	S,SU,F,N?	O	PO	X	X	O	PR	U
American Redstart	Setophaga ruticilla	S1B	W,E	S,SU,F,N?	O	PO	X	X	O	PR	U
Worm-eating Warbler	Helmitheros vermivorus	S3B	W,E	S,SU,N?	PR	X	X	X	PO	U	U
Louisiana Waterthrush	Seriurus montacilla	S3B	W,S	S,SU,F,N	PR	U	X	PR	PO	PO	U
Kentucky Warbler	Oporornis formosus	S3B	W	S,SU,B	O	X	X	X	PO	PO	X
Hooded Warbler	Wilsonia citrina	S1B	W	S,SU,N?	O	X	X	X	PO	U	X
Yellow-breasted Chat	Icteria virens	S3B	E	S,SU,F,N	U	PO	X	X	O	U	U
Chipping Sparrow	Spizella passerina	S3N	W,F,E	Y,B	PO	O	X	X	O	O	PO
Grasshopper Sparrow	Ammodramus savannarum	S3B	F	S,SU,F,N?	X	PO	X	X	U	X	PO
Swamp Sparrow	Melospiza georgiana	S3B	E,S	S,F,W	U	PO	X	X	PO	U	U
Bobolink	Dolichonyx oryzivorus	SU	F	S,F	X	PR	X	X	PO	U	PO
Eastern Meadowlark	Sturnella magna	S3	F	Y,B	X	O	X	X	X	X	PO

Notes:
Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*
Habitats listed are those that are preferred by a given species across its range.
Occurrence listings are specific to the Winterthur Museum property.

STATUS	**HABITAT**	**RESIDENCE**	**OCCURRENCE**
T = state threatened	W = woodlands	F = fall	O = observed
E = state endangered	F = fields	W = winter	PR = probably occurs in area
S1 = DE heritage 1st priority rank	P = ponds	S = spring	PO = possibly occurs in area
S2 = DE heritage 2nd priority rank	S = stream	Su = summer	U = unlikely to occur in area
S3 = DE heritage 3rd priority rank	E = edge	Y = all year	X =does not occur in area
SH = species historically known from the state		B =breeding	
SU = species status uncertain within the state		N= nesting habitat available	
FE = federally endangered		N? = nesting habitat marginal	
FT = federally threatened		NB = non-breeding	
"B" and "N" qualifiers indicate breeding and nonbreeding status, respectively			

TABLE 10
MAMMAL SPECIES OF SPECIAL CONCERN
WINTERTHUR MUSEUM
NEW CASTLE COUNTY, DELAWARE
1997 - 1998

COMMON NAME	SCIENTIFIC NAME	STATUS	HABITAT	RESIDENCE	OCCURRENCE BY AREA							
					WOOD	FIELD	POND	STREAM	SPRING	EDGE	GARDEN	GOLF C
Least Shrew	Cryptotis parva	SU	F	R	U	PO	N	N	N	PO	PO	U
Evening Bat	Nycticeius humeralis	SU	ALL	M	?	?	?	?	?	?	?	?
Silver-haired Bat	Lasionycteris noctivagans	SU	ALL	M	?	?	?	?	?	?	?	?
Red Bat	Lasiurus borealis	SU	ALL	SB	O	PO	PR	PO	PO	PO	PR	PO
Hoary Bat	Lasiurus cinereus	SU	ALL	M	?	?	?	?	?	?	?	?
Red Squirrel	Tamiasciurus hudsonicus	S3	W	R	O	U	N	N	N	O	PR	PO
Beaver	Castor canadensis	S3	W,P,S	R	PO	U	PO	PO	U	PO	U	U
Mink	Mustela vison	S3	P,S,SP	R	PO	U	PO	PO	PO	PO	U	U
Coyote	Canis latrans	SU	W,F,E	R	?	?	N	?	?	?	?	?

NOTES:

Status
T=state threatened
E=state endangered
S1 = DE heritage 1st priority rank
S2 = DE heritage 2nd priority rank
S3 = DE heritage 3rd priority rank
SU = species status uncertain within the state

Habitat
W = woodlands
F = field
P = pond
S = stream
SP = spring
E = edge

Residence
R=resident all year
SB= summer breeding
M= migrates through area

Occurrence
O=species observed during field survey
PR=species likely to occur; habitat suitable
PO=species possibly occurs; habitat marginal
U=species unlikely to occur
N=species not occurring
?=occurrence unknown

Status listings are in accordance with the Delaware Natural Heritage Program August 1997 *Delaware's Rare Animal Species of Conservation Interest.*

APPENDIX D

Master Species List of Plants Occurring in Sampled Wetlands

TREE

Acer rubrum	red maple	native	FAC
Acer saccharinum	silver maple	native	FACW
Carpinus caroliniana	hornbeam	native	FAC
Fagus grandifolia	American beech	native	FACU
Fraxinus americana var. *americana*	white ash	native	FACU
Fraxinus nigra	black ash	native	FACW
Liriodendron tulipifera	tuliptree	native	FACU
Nyssa sylvatica	black-gum	native	FAC
Platanus occidentalis	sycamore	native	FACW–
Prunus serotina	wild black cherry	native	FACU
Salix sp.	willow	—	—
Salix nigra	black willow	native	FACW+
Ulmus americana	American elm	native	FACW–

SHRUB

Alnus sp.	alder	—	—
Alnus incana	speckled alder	native	FACW+
Berberis thunbergii	Japanese barberry	introduced	FACU
Euonymus alatus	winged euonymus	introduced	NL
Ligustrum vulgare	common privet	introduced	FACU
Lindera benzoin	spicebush	native	FACW–
Lonicera sp.	honeysuckle	introduced	—
Rosa multiflora	multiflora rose	introduced	FACU
Rubus sp.	bramble	—	—
Rubus phoenicolasius	wineberry	introduced	NL
Sambucus canadensis	American elder	native	FACW–
Viburnum sp.	viburnum	—	—
Viburnum dentatum	southern arrow-wood	native	FAC

VINE

Celastrus orbiculatus	Oriental bittersweet	introduced	NL
Cuscuta gronovii	dodder	—	—
Lonicera japonica	Japanese honeysuckle	introduced	FAC–
Toxicodendron radicans	poison-ivy	native	FAC
Vitis sp.	grape vine	—	—

HERBACEOUS

Acorus calamus	sweetflag	introduced	OBL
Alisma plantago-aquatica	southern water-plantain	native	OBL
Alliaria petiolata	garlic-mustard	introduced	FACU–
Andropogon virginicus	broom-sedge	native	FACU
Apocynum sp.	dogbane	native	—
Arisaema triphyllum	Jack-in-the-pulpit	native	FACW–
Asclepias incarnata ssp. *incarnata*	swamp milkweed	native	OBL
Aster sp.	aster	—	—
Aster puniceus	purple-stemmed aster	native	OBL
Bidens sp.	beggar-ticks	—	—
Boehmeria cylindrica	bog-hemp	native	FACW+
Carex sp.	sedge	native	—
Carex lurida	sedge	native	OBL
Carex stricta	tussock sedge	native	OBL
Chelone glabra	turtlehead	native	OBL
Chrysosplenium americanum	golden saxifrage	native	OBL
Cirsium sp.	thistle	—	—
Cirsium arvense	Canada thistle	introduced	FACU
Conium maculatum	poison hemlock	introduced	FACW
Cyperus sp.	umbrella-sedge	—	—
Daucus carota	Queen-Anne's-lace	introduced	NL
Duchesnea indica	Indian strawberry	introduced	FACU–
Echinochloa crusgalli	barnyard grass	introduced	FACU
Eclipta prostata	yerba-de-tajo	native	FAC
Eleocharis sp.	spike-rush	native	—
Epilobium coloratum	purple-leaved willow-herb	native	OBL
Eupatorium fistulosum	Joe-pye-weed	native	FACW
Euthamia graminifolia	grass-leaved goldenrod	native	FAC
Galium sp.	bedstraw	—	—
Glyceria striata	fowl mannagrass	native	OBL
Hedera helix	English ivy	introduced	NL
Hemerocallis sp.	daylily	introduced	—
Heteranthera reniformis	mud-plantain	native	OBL
Hibiscus moscheutos	rose-mallow	native	OBL

Hosta sp.	hosta	introduced	—
Hypericum mutilum	dwarf St.-John's-wort	native	FACW
Hypericum sp.	St.-John's-wort	—	—
Impatiens capensis	jewelweed	native	FACW
Iris sp.	iris	—	—
Juncus effusus	soft rush	native	FACW+
Laportea canadensis	wood-nettle	native	FACW
Leersia oryzoides	rice cutgrass	native	OBL
Lobelia cardinalis	cardinal-flower	native	FACW+
Lobelia siphilitica	great lobelia	native	FACW+
Ludwigia alternifolia	false loosestrife	native	FACW+
Ludwigia palustris	marsh-purslane	introduced	OBL
Ludwigia peploides	primrose-willow	native	OBL
Lycopus sp.	water-horehound	—	—
Lysimachia nummularia	creeping-charlie	introduced	OBL
Mentha arvensis	field mint	native	FACW
Microstegium vimineum	stilt grass	introduced	FAC
Mimulus ringens	Allegheny monkey-flower	native	OBL
Myosotis scorpioides	forget-me-not	introduced	OBL
Nasturtium officinale	watercress	introduced	OBL
Onoclea sensibilis	sensitive fern	native	FACW
Osmunda cinnamomea	cinnamon fern	native	FACW
Pachysandra sp.	Japanese spurge	introduced	—
Panicum clandestinum	deer-tongue grass	native	FAC+
Paspalum sp.	beadgrass	—	—
Phalaris arundinacea	reed canary-grass	native	FACW+
Phragmites australis	common reed	native	FACW
Pilea pumila	clearweed	native	FACW
Plantago lanceolata	English plantain	introduced	NL
Polygonum sp.	smartweed	—	—
Polygonum arifolium	halberd-leaved tearthumb	native	OBL
Polygonum caespitosum	smartweed	introduced	FACU–
Polygonum cuspidatum	Japanese knotweed	introduced	FACU–
Polygonum hydropiperoides	mild water-pepper	native	OBL
Polygonum persicaria	lady's-thumb	introduced	FACW

Polygonum sagittatum	arrow-leaved tearthumb	native	OBL
Polygonum virginianum	jumpseed	native	FAC
Primula sp.	primrose	introduced	—
Pycnanthemum sp.	mountain-mint	native	—
Rumex crispus	curly dock	introduced	FACU
Sagittaria latifolia	arrowhead	native	OBL
Scirpus sp.	bulrush	native	—
Scirpus atrovirens	black bulrush	native	OBL
Setaria pumila	yellow foxtail	introduced	FAC
Silphium perfoliatum	cup-plant	introduced	FACU
Solanum dulcamara	trailing nightshade	introduced	FAC–
Solidago sp.	goldenrod	native	—
Solidago canadensis var. *hargeri*	Canada goldenrod	native	FACU
Solidago patula	spreading goldenrod	native	OBL
Solidago uliginosa	bog goldenrod	native	OBL
Sparganium sp.	bur-reed	native	—
Symplocarpus foetidus	skunk-cabbage	native	OBL
Thelypteris noveboracensis	New York fern	native	FAC
Typha latifolia	common cat-tail	native	OBL
Verbena hastata	blue vervain	native	FACW+
Vernonia noveboracensis	New York ironweed	native	FACW+
Viola sp.	violet	—	—

APPENDIX E

Wildlife Habitat Boxes

Making Birdhouses and Feeders

Charles R. Self
Sterling Publishing Co., Inc., New York

Birdhouse Size Requirements

Types	Floor Size in Inches	Entry-Hole Size in Inches	Hole above Floor in Inches	Interior Depth in Inches	Nest above Ground in Feet
Bluebirds					
Eastern and Western	5 x 5	1½	6	8	5–10
Chickadees					
black-capped, Carolina, gray-headed Boreal & chestnut-backed	4 x 4	1⅛	6–8	8–10	6–15
Finch					
house	6 x 6	2	4	6	8–12
Flycatchers					
great-crested, olivaceous, Western	6 x 6	2	6–8	8–10	8–20
Nuthatches					
white-breasted, red-breasted	4 x 4	1¼	6–8	8–10	5–20
brown-headed	2 x 3	1	6–8	8–10	5–20
Owls					
barn	10 x 18	6	4	15–18	12–18
screech	8 x 8	3	9–12	12–15	10–30
barred	13 x 15	8	—	16	10–30
Phoebes					
Eastern & black	6 x 6	open, one side	—	6	8–12
Sparrows					
song	6 x 6	open, all sides	—	6	1–3
house	4 x 4	1½	6–8	8–10	4–12
Swallows					
barn		open, one side	—	6	8–12
purple martin	6 x 6	2½	1	6	15–20
tree	5 x 5	1½	1–5	6	10–15
Thrushes					
(American robin)	6 x 8	open, one side	—	8	6–15

Types	Floor Size in Inches	Entry-Hole Size in Inches	Hole above Floor in Inches	Interior Depth in Inches	Nest above Ground in Feet
Titmice					
plain, tufted, & bridled	4 x 4	1¼	6–8	8–10	6–15
Warbler					
prothonary	4 x 4	1½	5	8	4–7
Woodpeckers					
downy	4 x 4	1¼	6–8	8–10	6–20
flicker	7 x 7	2½	14–16	16–18	6–20
hairy	6 x 6	1½	9–12	12–15	12–20
redheaded	6 x 6	2	9–12	12–15	12–20
pileated	8 x 8	3–4	10–12	12–30	12–60
red-bellied	6 x 6	2½	10–12	12–14	12–20
Wrens					
brown-throated	4 x 4	1	1–6	6–8	6–10
Carolina	4 x 4	1⅛	1–6	6–8	6–10
house	4 x 4	1	1–6	6–8	6–10
winter	4 x 4	1 x 2½	4–6	6–8	5–10

APPENDIX F

Contacts

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www.dnrec.state.de.us

Division of Water Resources
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Delaware Natural Heritage Program

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New Castle Field Service Center
6 Peoples Plaza
Newark, DE 19720

tel: 302-832-3100
fax: 302-834-0783

New Castle County Land Use Department

87 Reads Way
New Castle Corporate Commons
New Castle, DE 19720

tel: 302-395-5400

Delaware Riverkeeper Network

P.O. Box 326
Washington Crossing, PA 18977

tel: 215-369-1188
www.delawareriverkeeper.org

Estuary Field Office
tel: 609-854-5108

Delaware Nature Society

P.O. Box 700
3511 Barley Mill Road
Hockessin, DE 19707

tel: 302-239-2334
fax: 302-239-2473

Brandywine Conservancy

P.O. Box 141
Chadds Ford, PA 19317

tel: 610-388-2700
fax: 610-388-1575