

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

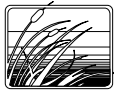
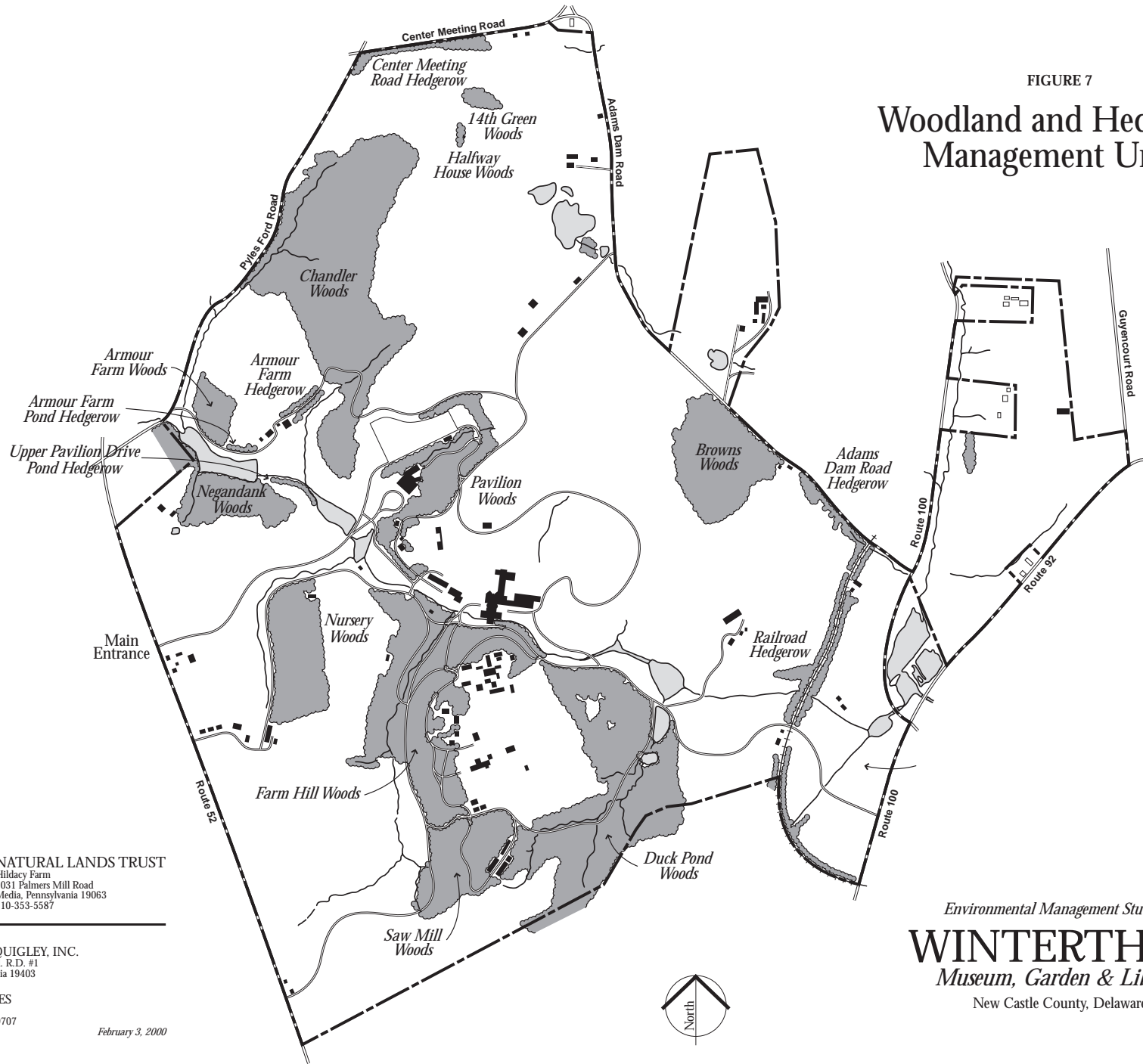
- Use existing old road network for trail system (see 3.2.4 Trails). Install restoration measures such as waterbars (see 4.5 Trail Design and Maintenance).

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 enclosure 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 enclosure 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/gullyng of stream in Duck Pond Woods. Recommend approaching them about ways to ameliorate the problem (see 4.3 Aquatic Resources).
- Scouring/gullyng 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 versus 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:

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

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

LAND STEWARDSHIP

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:

<i>Acer platanoides</i>	Norway maple
<i>Ailanthus altissima</i>	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 enclosure around their 100-acre property and effectively protected its wildflower collection. It should be remembered that the enclosure 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**

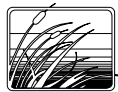
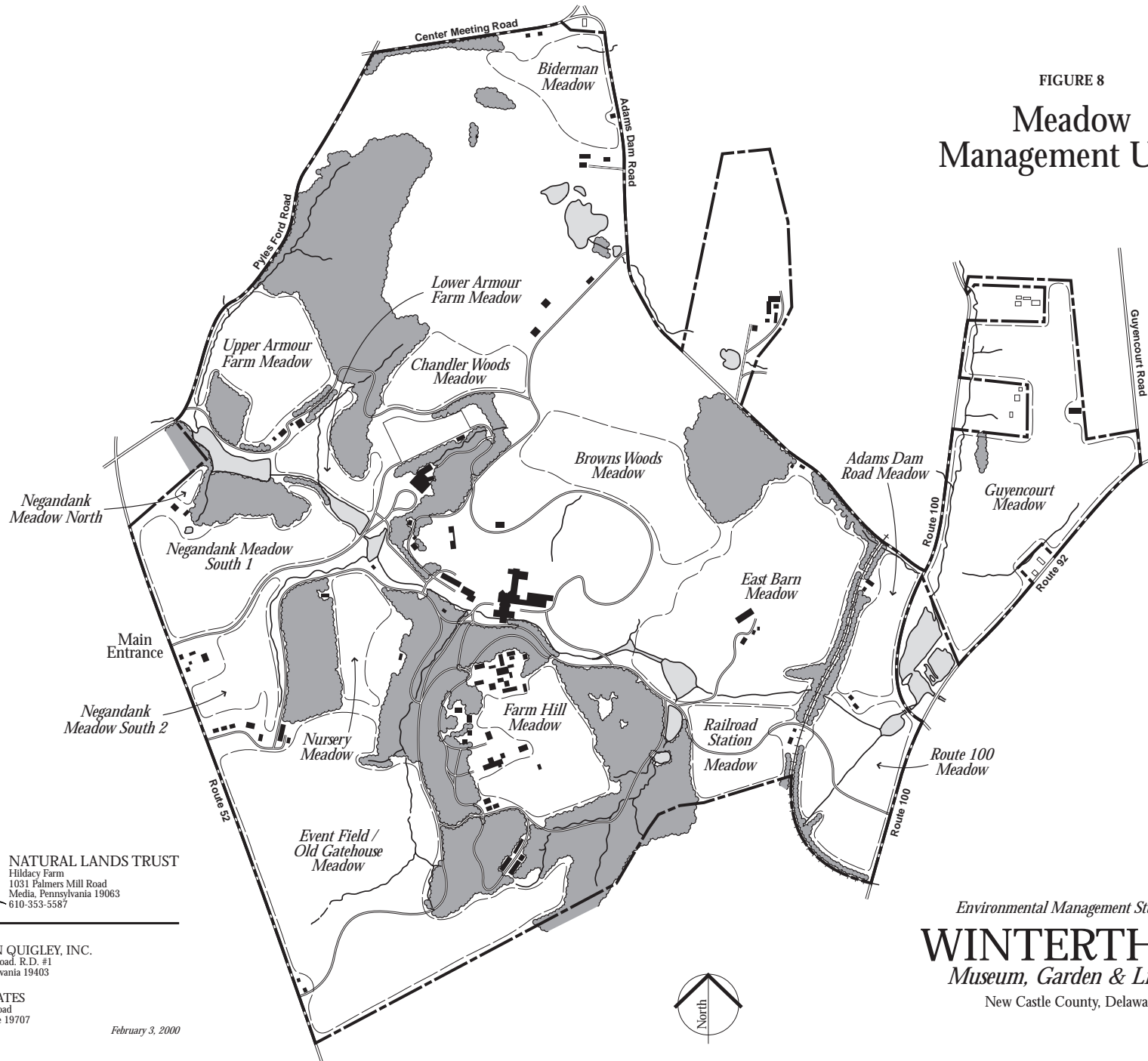
Meadow Health

INVASIVE VEGETATION IMPACT: Moderate to heavy

Vegetation Management / Restoration

- Monitor for and control invasive plants.

FIGURE 8
**Meadow
 Management Units**



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
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 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 its 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

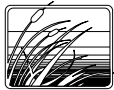
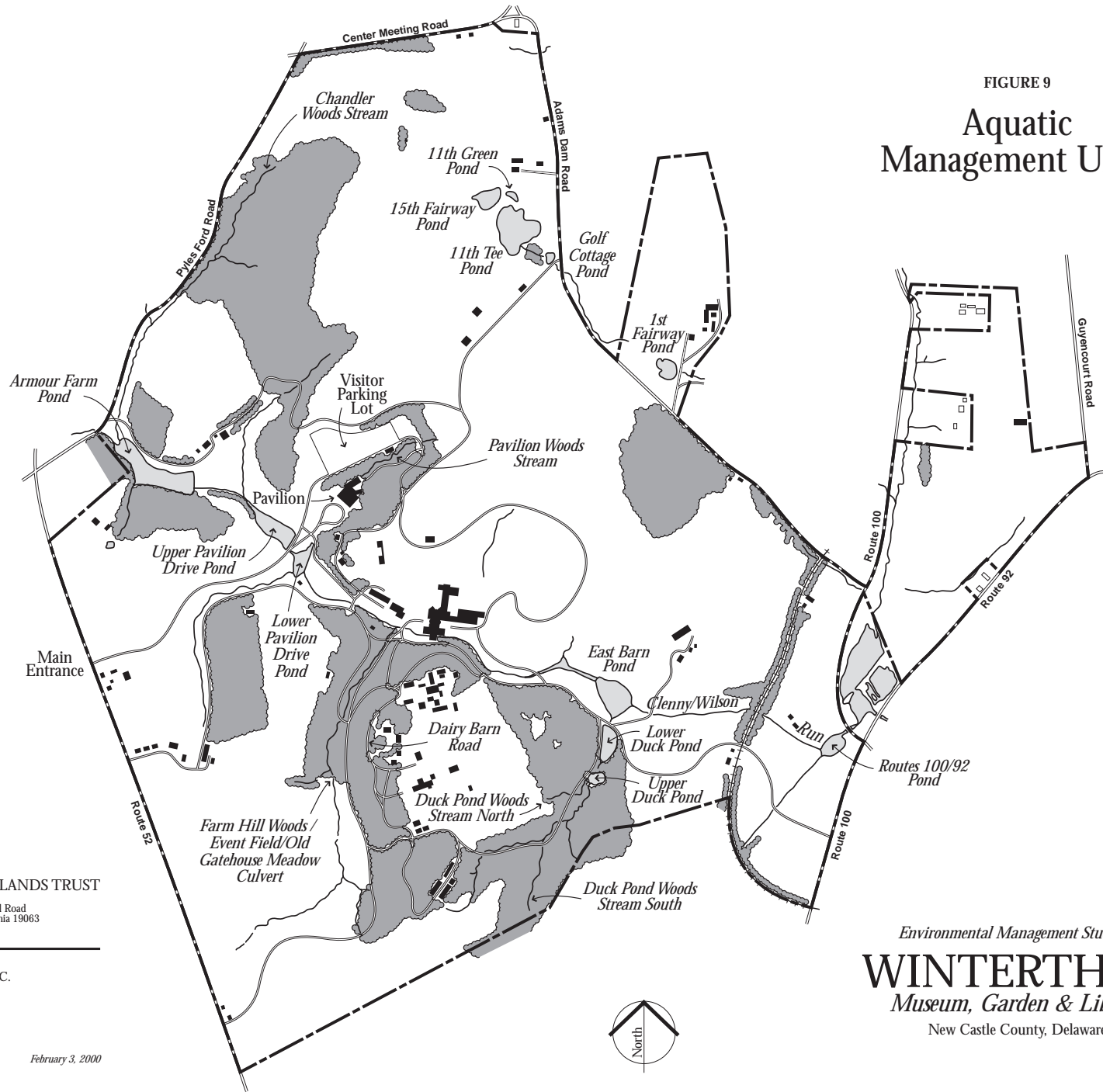
Refer to Figure 9 and the Management Recommendations plan.

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

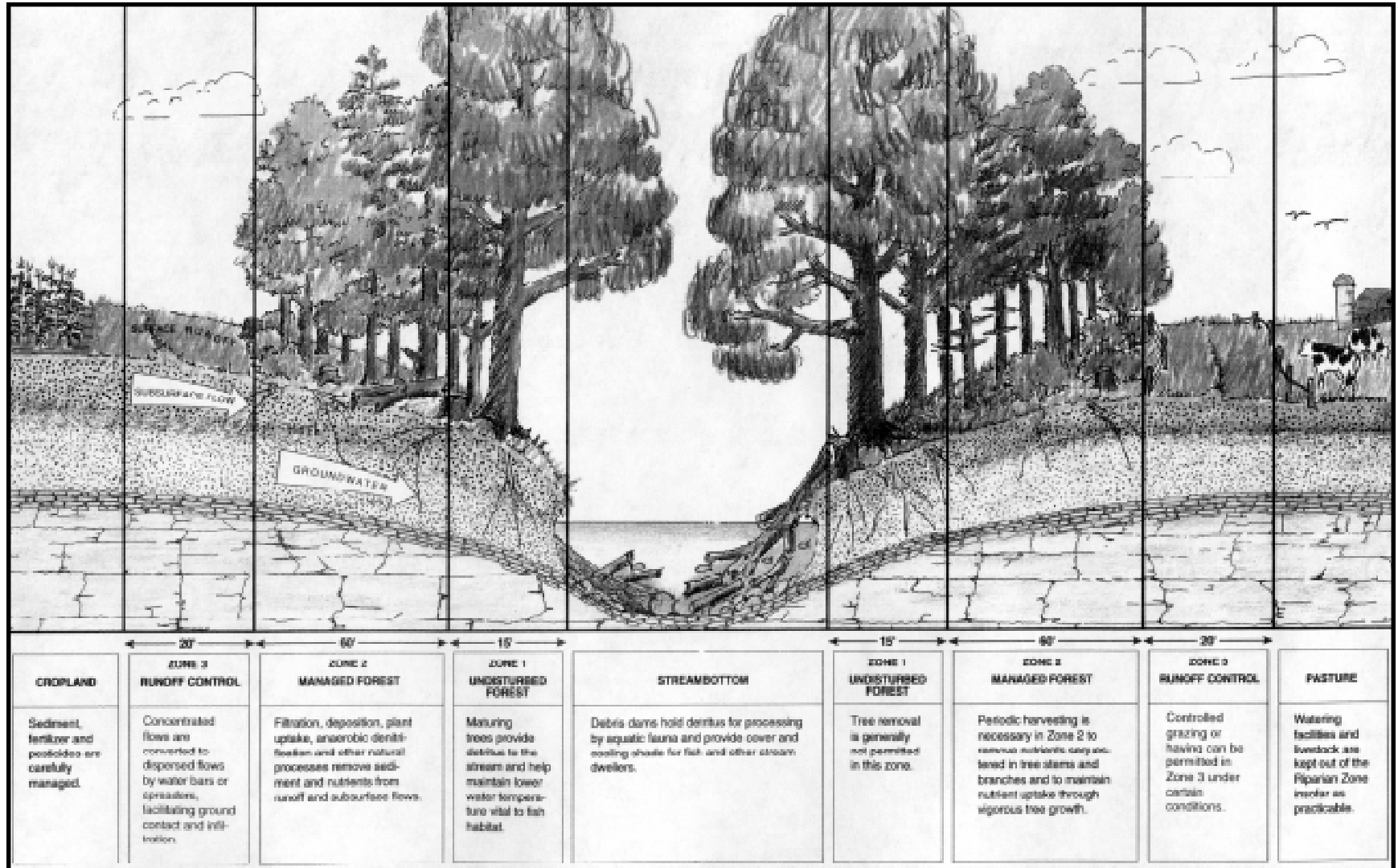
There are many management activities that can increase the wildlife benefits of aquatic areas. Basking logs can be installed along the edge or anchored in open water to provide basking areas for aquatic turtles. Leave dead or dying trees (snags) standing along the edge of wetlands (provided that they 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 gulying 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.

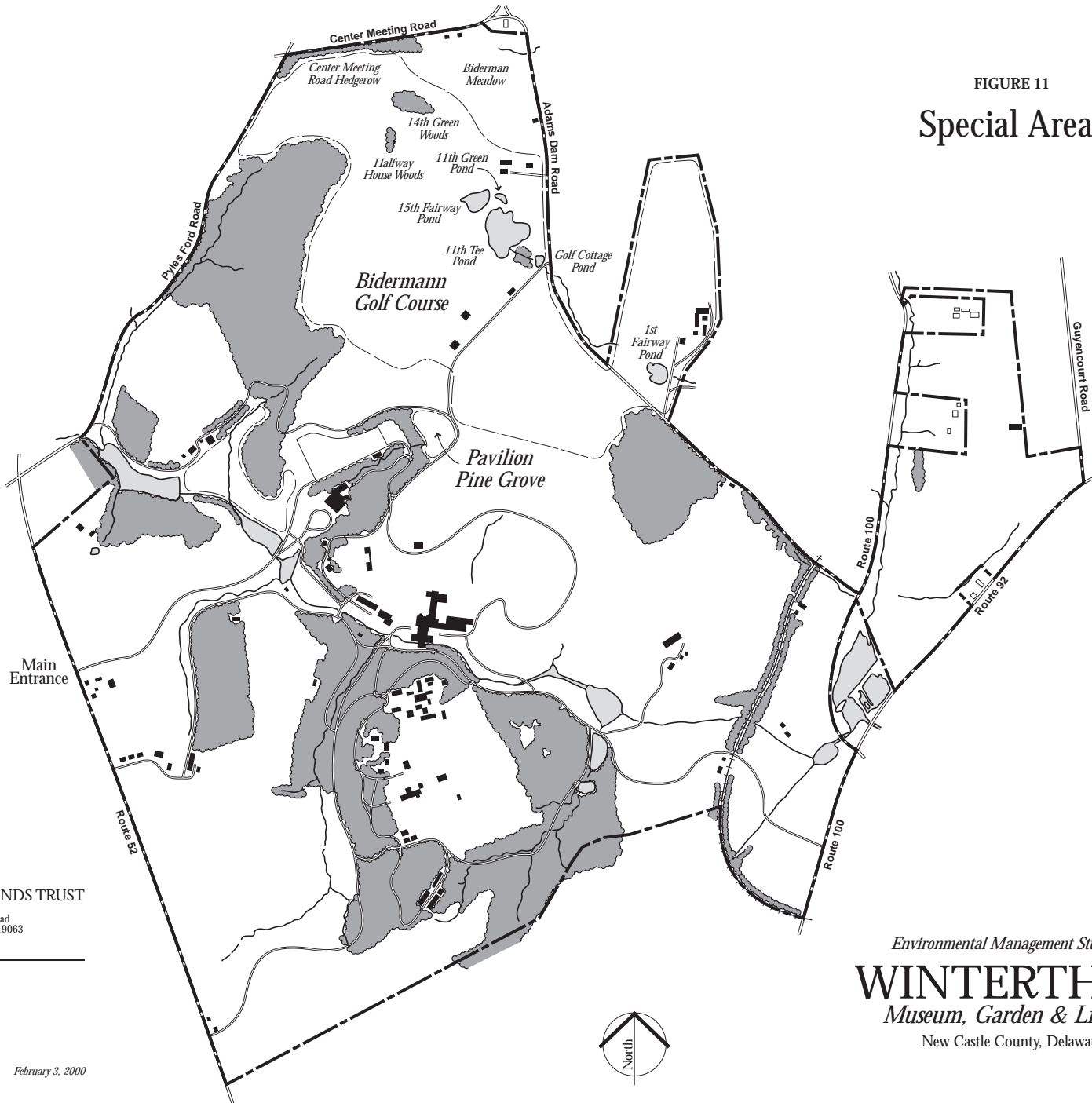
4.4.1 Pavilion Pine Grove

- ± 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.

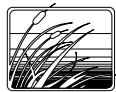
4.4.2 Bidermann Golf Course

- ± 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.

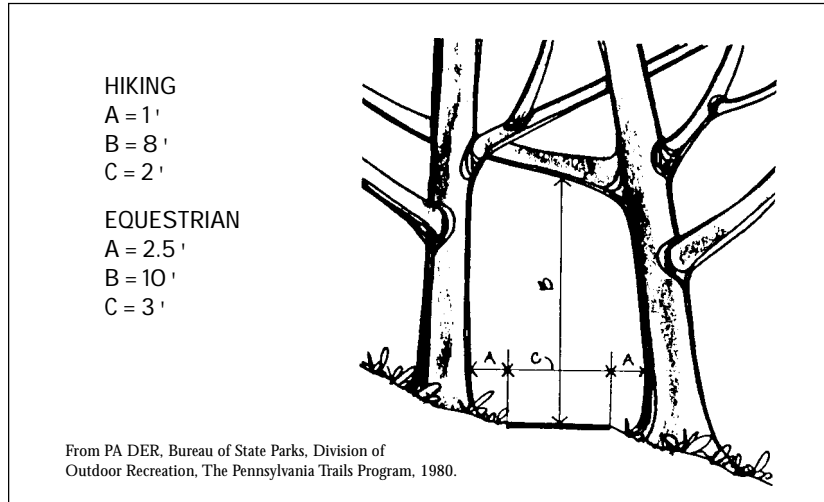
4.5.2 Trail Construction

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*



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.

FIGURE 13: *Trail Vegetation Removal*

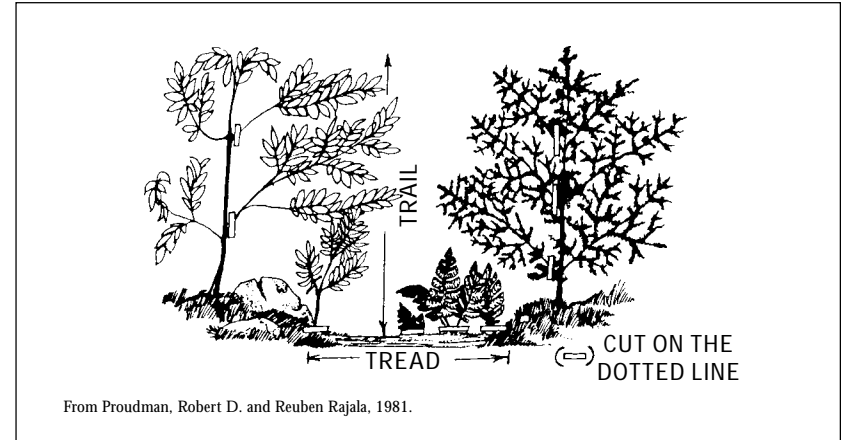
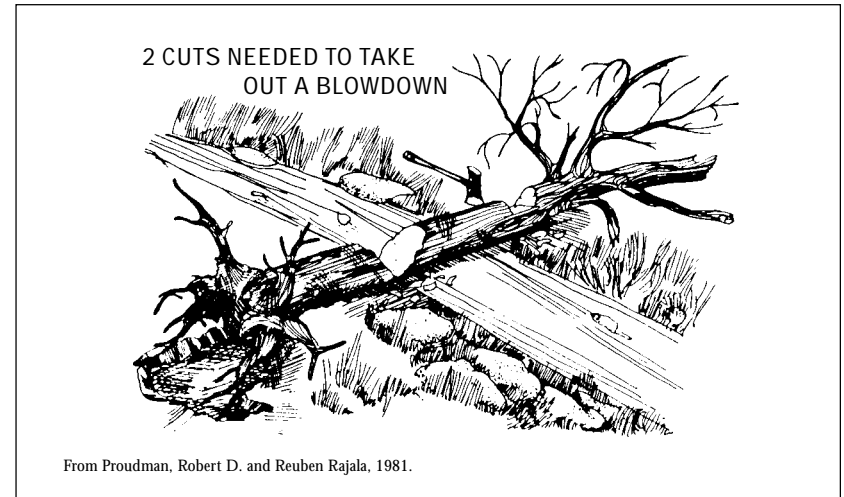


FIGURE 14: *Blowdowns*



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.

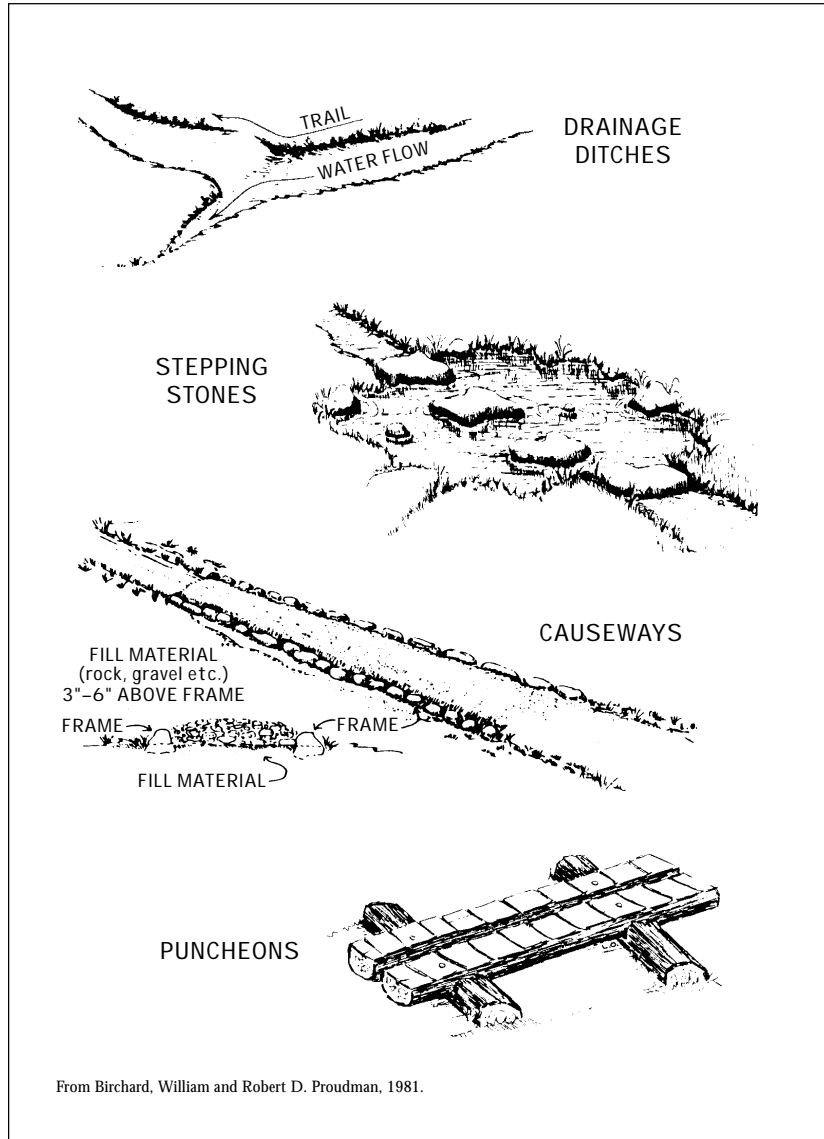
- *Causeways*

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).

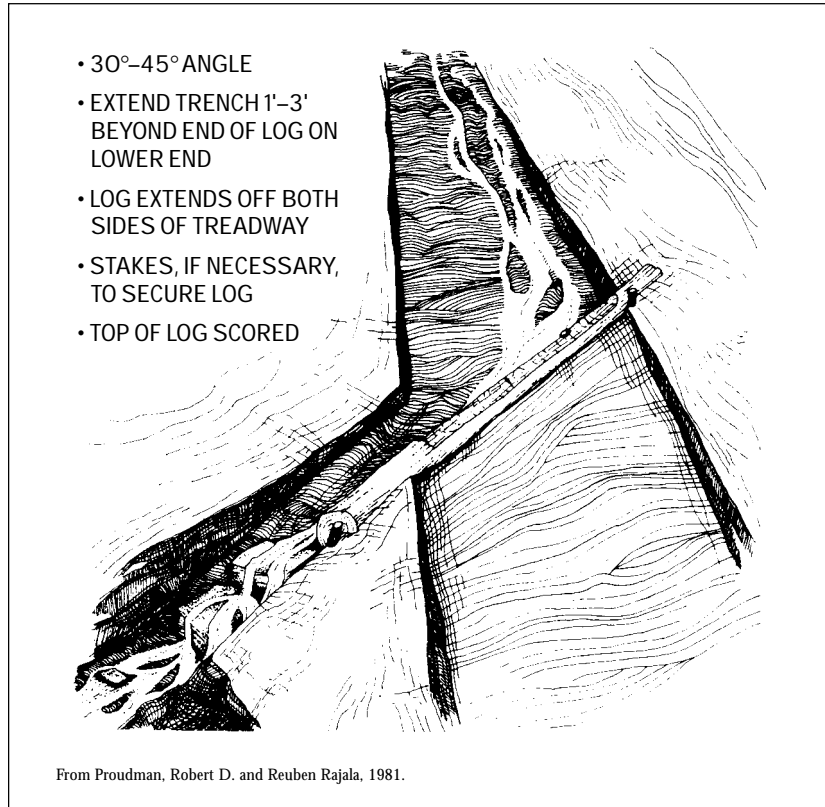
WATERBARS

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 $\pm 75'$ when the slope is 3–8%, every $\pm 50'$ when the slope is 8–15%, and every $\pm 25'$ 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.

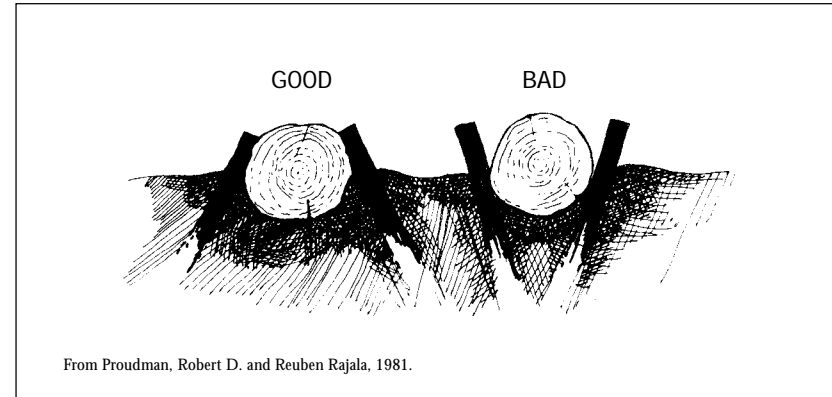
Dig a trench across the trail at a 30°–45° angle (Figure 16). The depth of the trench should be about the same as the diameter of

FIGURE 16: *Waterbars*



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*



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.

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,

FIGURE 18: *Waterbar Cross Section*

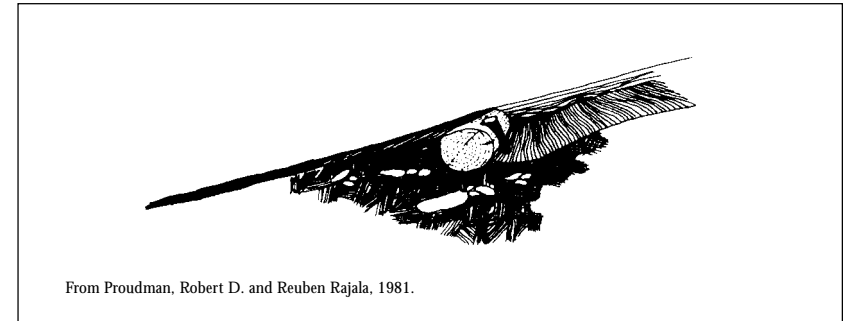
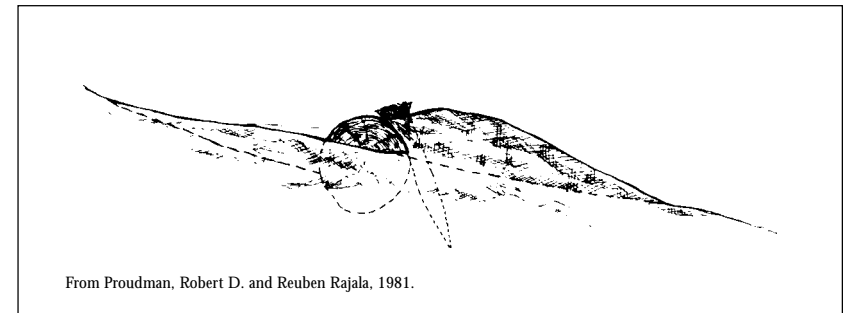


FIGURE 19: *Waterbar Maintenance*



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*

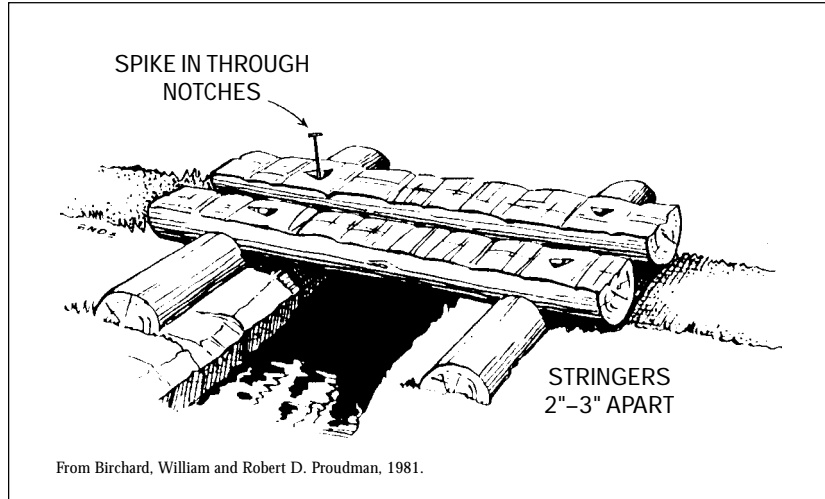


FIGURE 22: *Two Stringer Bridge with Handrail*

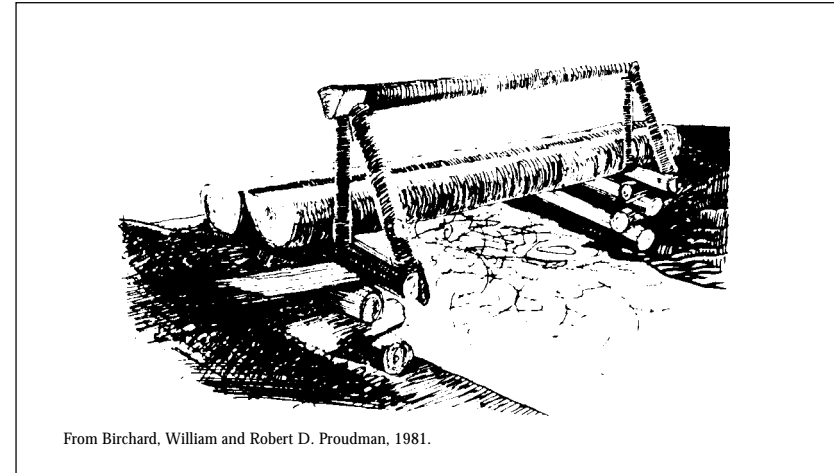
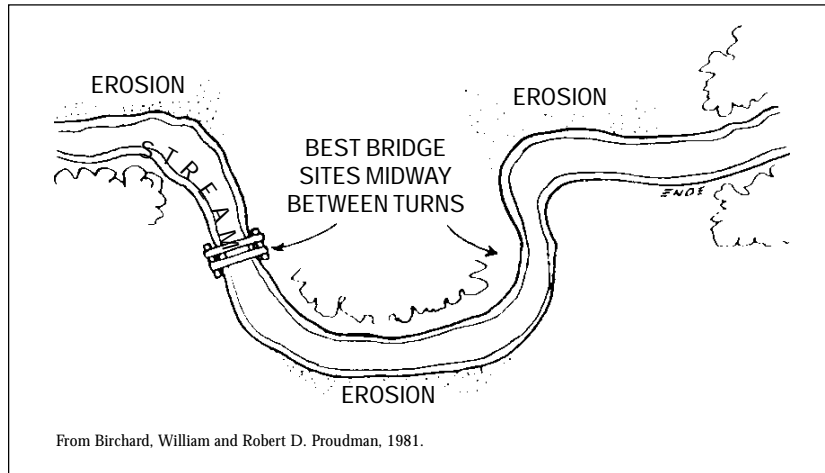


FIGURE 21: *Bridge Siting*



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.

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,

FIGURE 23: *Trail Markers*



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.

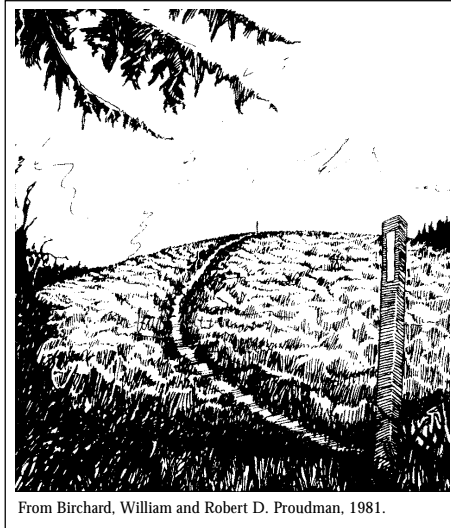
POSTS

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.

