Stewardship Handbook

for Natural Lands in
Southeastern Pennsylvania

Natural Lands Trust

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Natural Lands Trust

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Natural Lands Trust is the region's largest land conservation organization, saving thousands of acres of forests, fields, streams, and wetlands each year. Since 1953, we have worked to protect landscapes in eastern Pennsylvania and southern New Jersey by preserving and caring for natural lands, healthy habitats, and clean watersheds for the benefit of native plants, wildlife, and current and future generations. Our comprehensive and practical approach to conservation includes:

- Land protection through acquisition and development restrictions;
- Leadership in managing natural landscapes;
- State-of-the-art planning and regulatory tools to help growing communities preserve more of their land; and
- Providing an opportunity for people to connect with and learn from nature on our preserves.

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The *Stewardship Handbook* took its first steps in 1993 as the *Design and Management Handbook for Preservation Areas* in Lower Merion Township, Montgomery County, Pennsylvania. The township had recently passed an ordinance requiring creation of open space, or Preservation Areas, on every new development over five acres in size. To ensure perpetual stewardship of these areas, the ordinance required the preparation and submission of "Maintenance and Operations Plans." Natural Lands Trust was engaged to prepare a handbook for developers and landowners on the design of Preservation Areas, the setting of management goals and objectives for different types of resources, and detailed and specific recommendations for restoration and maintenance of natural resources.

Over the last 15 years, the Natural Lands Trust has prepared stewardship plans for a wide range of clients—Hawk Mountain Sanctuary, Winterthur Museum and Garden, Swarthmore College, Kennett Area Park Authority, and numerous private landowners—helping them to better understand their natural lands and develop goals and a management program to achieve those goals. The many recurring challenges and opportunities associated with these properties highlighted the need for a more detailed reference to guide the stewardship of natural lands in our region.

The *Stewardship Handbook* also draws heavily from Natural Lands Trust's 50 years of experience stewarding natural lands, which has resulted from our Board of Trustees' steadfast commitment to better stewardship and the support of our many donors and members. The *Handbook* has also been informed by the findings of the numerous local colleges and research organizations that have used our preserves. They include Academy of Natural Sciences, Albright College, American Chestnut Foundation, Antioch College, Bryn Mawr College, Columbia University, Cornell University, Delaware Valley College, Dickinson College, Environmental Defense Fund, Lafayette College, Pennsylvania Audubon, Pennsylvania State University, Philadelphia University, Rutgers University, Stroud Water Research Center, The Nature Conservancy, US Army Corps of Engineers, USDA Natural Resource Conservation Service, University of Pennsylvania, West Chester University, and Widener University.

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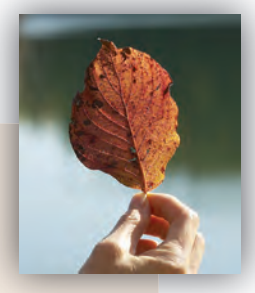


To YOU the land steward...

This *Handbook* is for ***you***. You are faced with a daunting task: to take care of natural lands. Natural lands don't take care of themselves. Not here, not now. They need ***your*** help to be the natural lands they were meant to be, in the face of accelerating change, unrelenting pressure on dwindling resources, and never-ending competition for your time and your funds.

You are absolutely necessary to the future of natural lands. Good land stewardship can turn degraded, barren lands into rich sources of diverse life. Good land stewardship can serve as an example to other land managers, building on itself to create a network of high quality natural lands. Good land stewardship can make a better future.

To be a good land steward you need to do two things: develop a stewardship plan for your land, and then implement the plan by managing your land.

Take your time. Look at this *Stewardship Handbook* not as a single resource but as many. Read this Introduction first to understand the basics of land stewardship. Then read the parts of the *Handbook* that you need to develop your plan. There are many other information resources available, to help with specifics of your plan. The *Handbook* includes references to these too.

The *Handbook* will give you the understanding of land stewardship principles that you need to develop your plan. But it cannot tell you about your land itself. That is up to you. Know your land. Watch it, listen to it, breathe it in, taste it, walk it forwards and backwards. Know the rocks, the water, the soil, the plants, and the wildlife. Know how it got to where it is. Then, only then, can you decide where it ought to be.

And one more thing.

Thank you.

Introduction

The need to protect and steward remaining natural lands has grown along with the wave of suburban development in southeastern Pennsylvania. In response, public agencies and private foundations are helping municipalities and land conservancies protect critical natural lands within the region through fee acquisition and conservation easements. Some municipalities, through Smart Growth practices, now require that new developments contain a percentage of open space. In addition, public agencies and private conservation organizations are working to inform landowners about the "best management practices" for the remaining—both protected and unprotected—natural lands.

Natural lands provide many environmental, ecological, and recreational benefits including protection of soil and water resources, habitat for local and migratory wildlife, and areas for hiking and nature study. In order to maximize the ecological and community benefits of natural lands, landowners and land managers must establish an effective long-term land stewardship program.

Holly Harper

Why stewardship?

In order to maximize the ecological and community benefits of natural lands, landowners and land managers must establish an effective long-term land stewardship program.

natural lands **are areas that are dominated by vegetative cover types native to our region (e.g., forest, meadow, marsh, barrens) and typically require less maintenance to perpetuate than lands outside this category, such as formal landscapes and agricultural fields.**

What is land stewardship?

Taking care of natural lands to achieve conservation objectives.

Stewardship is an active process of engagement with your land to direct it toward (or keep it at) a desired state. Because natural processes in the region have been and continue to be significantly altered by human activity, natural lands left to themselves will—in most cases—become degraded and dysfunctional. It is not good enough to let natural lands go.

Defining stewardship goals for individual properties and understanding the existing resources and various issues and opportunities associated with each site are critical to sustaining healthy ecosystems beneficial to wildlife and safe and enjoyable recreational areas for human visitors.

What this *Handbook* will do for you

The *Stewardship Handbook* provides a framework in which to make decisions on the stewardship of natural lands. It will assist the owner or manager of existing or potential natural lands in developing ***stewardship goals*** and a regimen to implement ***stewardship practices***. The *Handbook*:

- *Provides information on the options available for stewarding natural lands and the challenges and opportunities associated with each option;*
- *Guides you through a "decision tree" to determine which stewardship option is appropriate for the existing or potential natural lands based on the existing conditions and your goals; and*
- *Provides a list of additional resources on major stewardship topics.*

The *Stewardship Handbook* is written primarily for those involved with natural lands planning and stewardship within the five counties surrounding Philadelphia (Bucks, Chester, Delaware, Montgomery, and Philadelphia counties). This includes owners and managers of natural lands (conservancies, homeowners' associations caring for open space in conservation subdivisions, officials responsible for park and greenway maintenance) and planning professionals (including developers required to create a stewardship plan for open space within a development) engaged in the design, layout, and preparation of stewardship plans. However, most of the planning concepts and stewardship issues and recommendations are applicable to natural lands throughout the greater southeastern Pennsylvania region and beyond.

The *Handbook* employs current best management practices and is intended to help the land steward gain a greater understanding of the importance of protecting and restoring a broad range of native ecosystems including forests, grasslands, wetlands, and riparian areas. It can be used for properties of any size and type—from large parcels of unbroken forest to small open space parcels within conservation subdivisions.

Ultimately, it is hoped that the *Handbook* will help to improve the stewardship of the growing "nature network" of protected public and private lands in the region.

How to steward natural lands

Your *stewardship objective* is to take the land *from* its current state *to* a desired future state (or keep it in the same state).

Your *stewardship plan* [p. 44] helps you identify...

What are the current **resources** on your land?

- Geology and soils **[p. 9]**
- Water **[p. 13]**
- Vegetation cover type(s) **[p. 14]**
- Cultural (scenic locations, trails, etc.)

What are the stewardship **issues** that affect the health of these resources?

- The four most common:
  - ~ Overabundant deer **[p. 20]** severely affect the sustainability of native plant communities, especially forests
  - ~ Fragmentation and edge effects **[p. 23]** encourage invasive plants and reduce plant/wildlife diversity
  - ~ Invasive plants **[p. 26]** replace native plants and reduce plant/wildlife diversity
  - ~ Disrupted water cycle **[p. 29]** depletes groundwater and causes flooding

What are your stewardship **conservation priorities [p. 56]** and **goals [p. 59]**?

- Preserve and enhance the most important conservation value(s) of the site

What are your stewardship **strategies** to achieve the goals **[p. 59]**?

- What you need to do over time (years, in fact)

Your *stewardship practices* implement the plan [p. 104].

Use the best management practices and techniques for your site, such as:

- Decrease deer abundance **[p. 104]**
- Reduce forest fragmentation **[p. 122]**
- Control invasive plants **[p. 125]**
- Establish and sustain meadows **[p. 138]**
- Recharge groundwater **[p. 149]**
- Design and maintain trails **[p. 155]**
- Monitor and remove hazard trees **[p. 165]**
- Plant native trees, shrubs and flowers **[p. 168, 172]**

Adapt! Monitor results, change practices or even goals if it is not working. Keep up with new management techniques.

The *Stewardship Handbook* first introduces you to the types and composition of natural lands in southeastern Pennsylvania and the current stewardship issues affecting these areas that should be addressed within a stewardship plan.

It then walks you through the process of developing a stewardship plan, a multistep process:

Step 1: Inventory existing natural resources to identify and better understand the natural resources within the property and current stewardship issues.

Step 2: Delineate natural lands from remainder of the property.

Step 3: Establish stewardship units to delineate areas with similar vegetation and past management.

Step 4: Establish the conservation priority for the natural lands.

Step 5: Establish the stewardship goals for the natural lands.

Step 6: Determine appropriate strategies for each stewardship unit.

Step 7: Prioritize and schedule tasks for each stewardship unit.

Step 8: Establish a monitoring program to determine if goals are being met within each stewardship unit.

Step 9: Assemble the Stewardship Plan to record information gathered and decisions made.

Human intervention, while necessary, should be minimized and should, as much as possible, support the natural processes inherent to the area.

The *Handbook* specifically assists you in determining the driving consideration, or "conservation priority," for conserving and maintaining your natural lands. ***Your most important decision as a land steward is whether to maintain, restore or convert the current cover type(s) on your site to protect and enhance the conservation priority.*** This will depend on site conditions, resources on adjacent properties, historical site use, and available funding. The major cover types addressed in the *Handbook* are forests, hedgerows, shrublands, meadows/grasslands, pasture/cropland, wetlands, streambanks/riparian areas, ponds, lawns/landscaped areas, and traditional stormwater management areas.

The *Handbook* provides perspective and guidelines for converting and maintaining the current cover types as natural lands. In general, the *Handbook* is written from the perspective that human intervention, while necessary, should be minimized and should, as much as possible, support the natural processes inherent to the area. The **Stewardship Techniques and Procedures** *(page 104)* section gives additional detail on the major stewardship issues and recommendations. Finally, the main body of the *Stewardship Handbook* is followed by a glossary and a list of resources from which you can find additional information.

Stewardship challenges, stewardship opportunities

As a land steward you will face numerous challenges in implementing your goals. The good news is that you are not alone. Your land is unique, but the problems are common to many other land stewards. That means that there is a wealth of learning out there about what works and what doesn't. This *Handbook* will help

you meet these challenges by formulating appropriate goals and strategies.

There are ***four major challenges*** to land stewards in southeastern Pennsylvania today.

Fragmentation/edge effects

Removal of native vegetation from large areas of the region—through conversion to agriculture and followed by residential and commercial development—have left the remaining natural lands as primarily fragmented "edge" type forest habitat. Edges are dominated by light-loving plants (often invasive non-natives) and they support much less diverse wildlife than large, contiguous forests.

For the land steward the challenge is to either reduce fragmentation through restoring links between forest patches, or to minimize edge effects by management of the invasive plants.

Deer overabundance

Deer are a natural part of the region's ecosystem, but long ago lost their primary natural predators (other than humans). A lack of natural controls coupled with a highly successful Pennsylvania Game Commission policy (originally implemented to save the species from extinction in the 19th century) focused on maximizing the sustained yield for hunters has resulted in populations much greater than natural lands can sustainably support. Although deer thrive on the edge habitat that a fragmented, suburbanized landscape provides, in overabundant numbers they consume the young trees, shrubs, and wildflowers that make a forest healthy, beneficial to wildlife, and self-sustaining. They can also cause significant damage to agricultural crops and ornamental plantings, and contribute to the spread of Lyme disease and vehicular accidents.

For the land steward the challenge is to manage the deer population at a density that restores and sustains native plant communities.

Invasive plants

Invasive plants—almost all of which are exotic (non-native) plants introduced for horticultural or agricultural purposes—can spread rapidly and aggressively into natural areas and effectively displace native plants and lower biodiversity. Not only do they alter the makeup of the plant communities on a site, but they also may affect soil chemistry and hydrology. Exotic invasive plants are usually less beneficial to wildlife than the native plants they replace, contributing further to loss of biodiversity.

For the land steward the challenge is to manage invasive plants (eliminating them is highly unlikely) to a level that protects and sustains diverse native plant and animal communities.

Water quality (stormwater management)

The natural hydrologic cycle returns stormwater to the ground through infiltration: as rain falls, most of it percolates down through the soil into the groundwater table. Groundwater replenishes not only the underground aquifers that supply drinking water for much of the region but also wetlands and waterways. Suburban development, particularly the huge amounts of paved (impervious) surface that comes with it, as well as old-style stormwater management that pipes runoff into streams, has so altered this cycle that groundwater is depleted and flooding is common.

For the land steward the challenge is to restore, as much as possible, the natural hydrologic cycle on the stewarded land.

Before you go out

A few last words are offered about using the *Handbook* (or any other land management resource) and stewarding natural lands. First, ***today's stewardship recommendations are based on current knowledge and technology***. You should use the *Stewardship Handbook* knowing that plant communities will evolve, resource information and technology will change, and new impacts to natural lands are inevitable that may require

Stewardship recommendations will evolve over time.

new strategies to address. In addition, our knowledge of natural systems will grow and new techniques and technologies will be developed to address stewardship issues. To illustrate this point, remember that within the past twenty years, best management practices have included maximizing edge and habitat diversity on every property and the planting of invasive plant species for erosion control and wildlife food. Both ideas are strongly discouraged today.

Holly Harper

Second, ***every property has a unique combination of inherent environmental conditions (geology, soils, slope, aspect, hydrology, climate) and management history***. Every parcel of land will require a stewardship plan tailored to its particular conditions and history. It is extremely

Every property is unique.

important to be patient, observant, and not afraid to modify your original stewardship plan if you are not meeting your stewardship goals (a process that scientists call "adaptive management"). It also does not hurt to question any recommendation from this or any other source if it does not fit into the reality that you experience on a particular land parcel.

Finally, ***managing natural lands in our region is truly a relationship that benefits from mental flexibility, a light approach, and more humor and humility than hubris***. History is littered with evidence—failed projects and civilizations—that testifies to the human capacity for stubbornly mismanaging natural systems. This capacity is painfully

Stewardship is a relationship.

evident in the human origins of the most serious issues facing land stewards today (overabundant deer, invasive plants, water quality degradation). Like other relationships, the stewardship of natural lands requires an ongoing commitment to understand (which will take many years) and respect your "partner" and it is guaranteed to provide you with unexpected surprises (good and bad) along the way.

Land Stewardship in Southeastern Pennsylvania

OVERVIEW

Natural lands in southeastern Pennsylvania consist of forests, meadows, shrublands, streams, and wetlands that support a diverse assortment of plant and wildlife species. They have been shaped by human use and management for thousands of years—from agricultural clearings and the extensive use of fire by Native Americans to wholesale clearing of forests by European settlers for agriculture and wood products to the suburban development of the late 20th and early 21st centuries. As a result of human influences and random environmental stresses (high wind, drought, flooding, ice) natural lands have shifted back and forth from open ground to forest cover over the centuries.

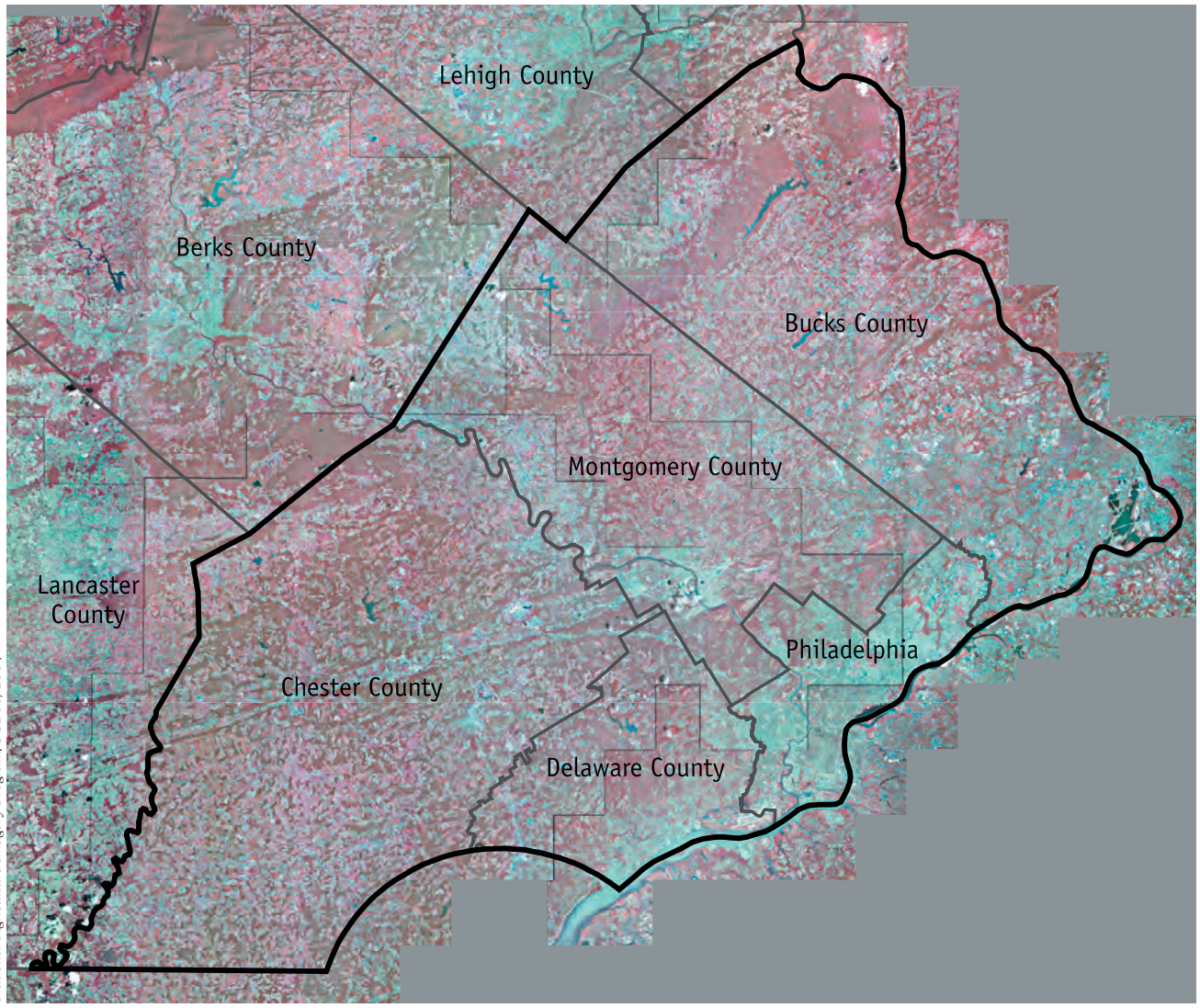
Today, natural lands are an important component of the regional landscape. Natural lands harbor rare plant species and communities, and supply habitat (food, water, shelter) for local and migratory wildlife. They benefit human communities by protecting water supplies, filtering air and noise pollution, and moderating climate. They are also valuable locations for recreation and contemplation, observation of nature, and education. And they provide a welcome visual change from shopping malls and concrete highways.

Unfortunately, humans are placing new and more permanent stresses (sprawl development, the introduction of exotic plants and animals) on natural lands while at the same time placing more demands on an ever-decreasing amount of natural land within the region. Stewarding natural lands is becoming an increasingly complex task of trying to maintain the environmental and ecological benefits of natural lands and accommodating human recreational needs.

We have so disrupted natural processes within the region, that we have made ourselves indispensable in the protection and restoration of natural lands.

Active stewardship of natural lands in our region is critical, ironically because of the anthropogenic (human created) impacts affecting these areas now. Based on our past record of poor stewardship, the argument could be made that natural lands would be better off without further human intervention. While this may be true in some areas of the world, we have so disrupted natural processes within the region that we have made ourselves indispensable in the protection and restoration of natural lands. Our challenge going forward is to steward natural lands in a manner that carefully considers the long-term impact of stewardship activities and recreational uses prior to implementation.

IN THIS SECTION



National Agriculture Imagery Program/USDA, 2004

This composite infrared satellite image showing forested lands in dark red, open areas in light red, and developed areas in gray, illustrates how, with few exceptions, the region's natural lands are small, disconnected and knitted into the dense fabric of developed areas.

The stewardship of natural lands mainly involves the manipulation of resources at and above ground level. In our region this mostly means manipulating plant resources within forested and open areas, and to a lesser extent (due to far less surface area and current regulations) surface water resources. Understanding the different types of plant and water resources, their characteristics and requirements, is critical to the development of a stewardship plan.

This section will provide an introduction to the different plant and water resources that dominate southeastern Pennsylvania and the local geology and soils that largely determine the types and extent of these resources. It will also detail the numerous issues involved in managing plant and water resources and will highlight the main subjects of a stewardship plan and the concerns that need to be addressed within it.

MAJOR NATURAL RESOURCES

Geology and Soils

The types of rock formations that form the foundation of southeastern Pennsylvania are quite diverse. A long history of folding, compression and intrusion of volcanic material has left us a legacy of rock types ranging from soft limestones and shales to very durable gneisses, diabase and quartzite *(see map on page 10)*. Typically, hard rocks form the high lands and soft rocks the lower-lying areas. Different rock formations vary in porosity; each formation will allow groundwater to pass through rapidly or slowly (or not at all) to feed streams and rivers through springs and seeps. Generally, softer rocks are more porous.

Differences in chemical composition of rocks also have a strong influence on soil quality. Taken together, soil wetness and soil chemical composition tend to be the strongest influences on soil fertility.

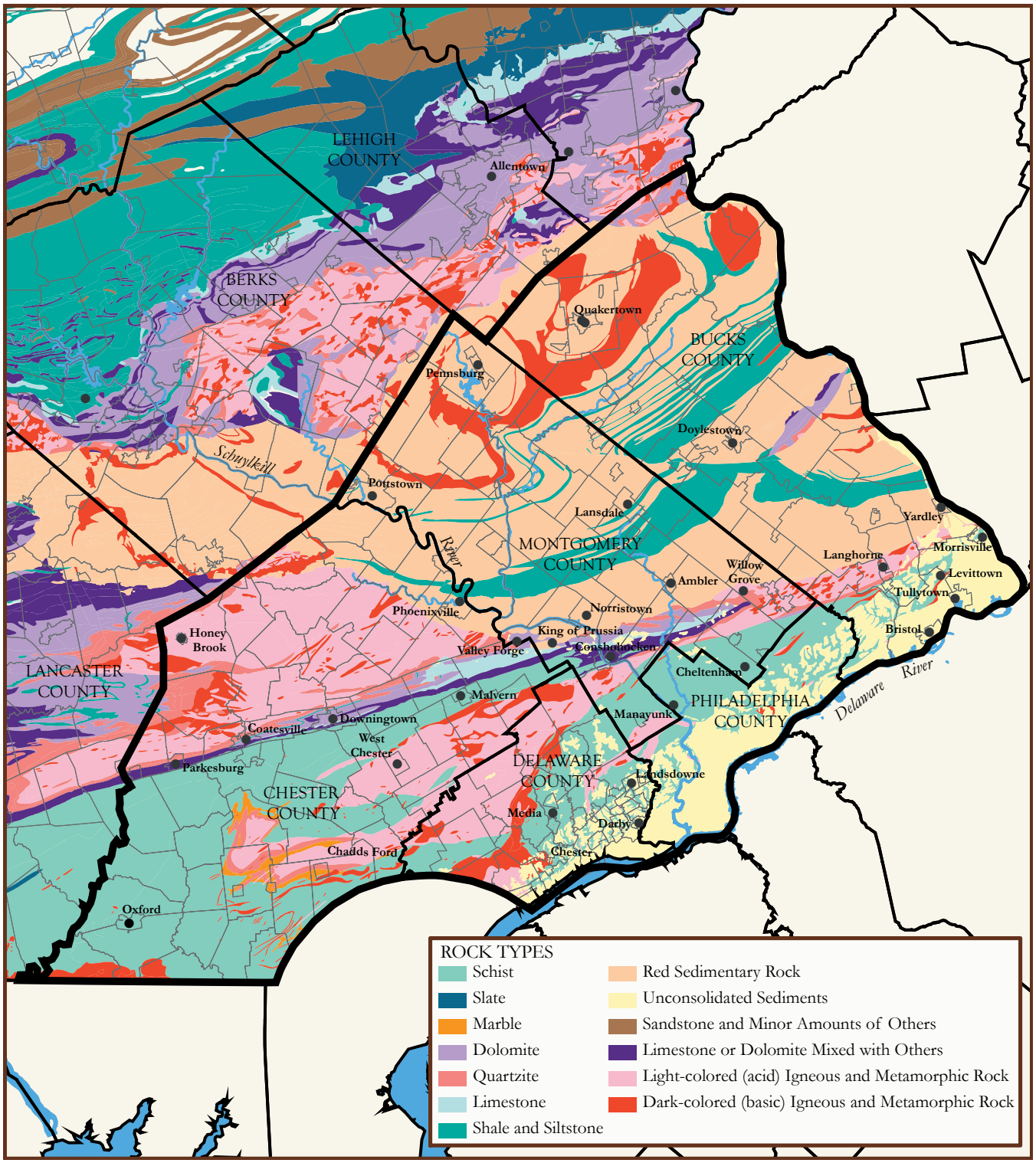
Much can be predicted about the types of plants that will grow on a site by understanding the type of soil occurring there. Extreme wetness or dryness in soils creates stress for plants and so specialized floras typically grow in these locations. In between the harsh conditions imposed by wetness or dryness, plant growth is more strongly determined by soil fertility. Descriptions of soils in County Soil Surveys can be very useful in determining whether a soil is extremely wet or dry and fertile or infertile. Fertility can be related back to geology, with quartzite and many sandstones and shales producing lower fertility soils and gneiss, limestone, diabase, schist, and some shales and sandstones producing richer soils. Most native plant communities are highly tolerant of low soil fertility and are often outcompeted on high-fertility soils by exotic invasive species.

Southeastern Pennsylvania also has one very unusual soil type based on geology. The serpentine soils derived from serpentine rock can be very toxic to most plants where the soils are thin and where organic material has not accumulated sufficiently to buffer the effects of the serpentine bedrock. Because of this unique soil characteristic, the plant communities that grow on serpentine harbor many state and globally rare species, which require special stewardship practices, such as prescribed fire.

The complex geology of the region places parts of southeastern Pennsylvania within four physiographic provinces *(see map on page 11)*—the Coastal Plain encompassing most of Philadelphia County and the southeastern sections of Delaware and Bucks Counties; the Piedmont encompassing all of Chester and Montgomery Counties, the remainder of Delaware and Philadelphia Counties, and most of Bucks County; and the New England and Ridge and Valley provinces sharing the very northern tip of Bucks County.

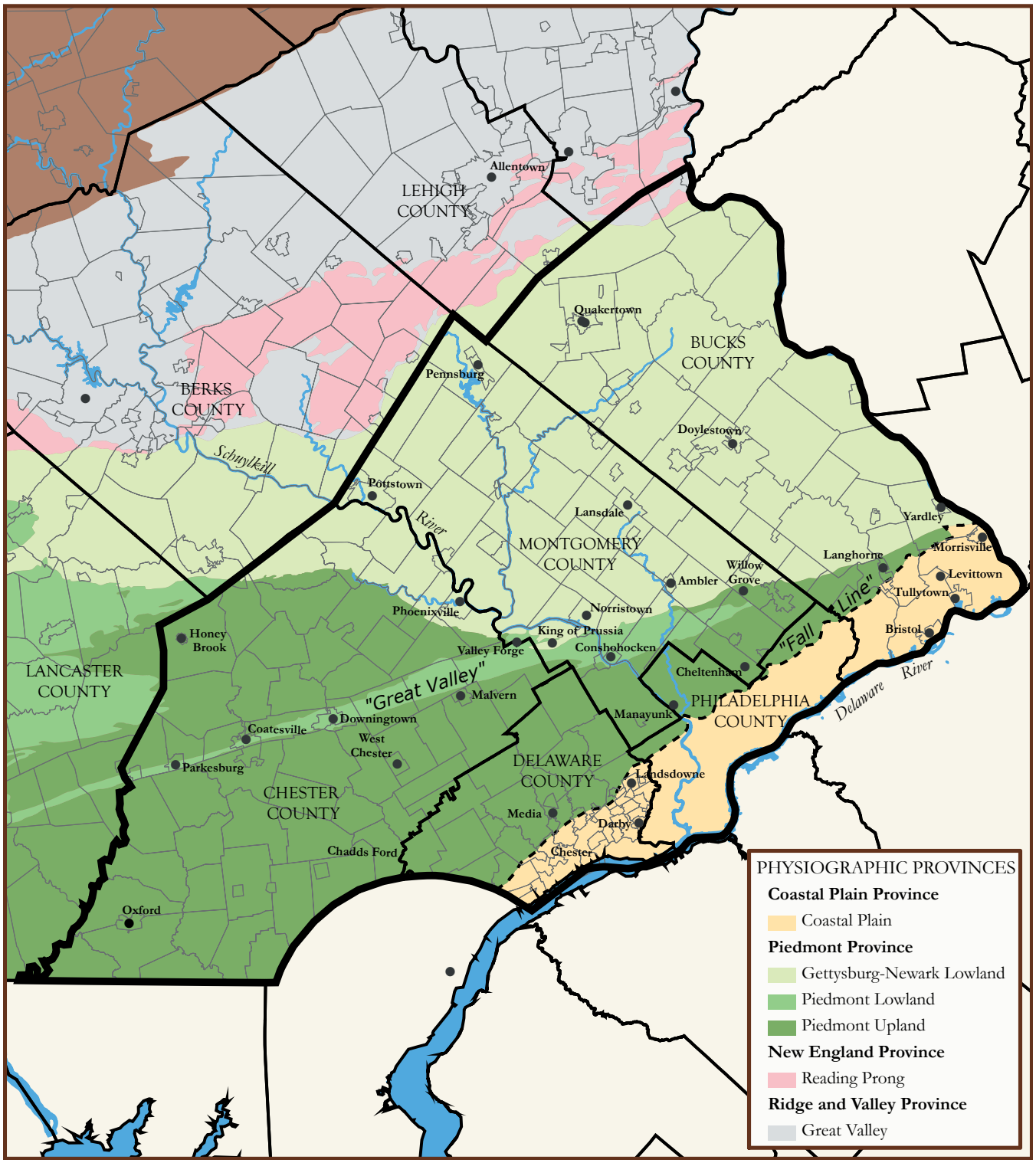
The ***Coastal Plain*** is a thin strip of land—roughly paralleling the Delaware River along the southeastern edge of the region—with no hard bedrock near the surface and soils composed of ancient sand, gravel, silt, and clay deposits. These soils can be very wet or very dry, depending on how close the water table is to the surface. Moving north and west from the Delaware River, the Coastal Plain transitions to the Piedmont province containing hard bedrock near the surface. This transitional area, known as the Fall Line or Fall Zone, is most noticeable in streams and rivers as the location of rapids or waterfalls. Because the Fall Line interrupted navigation of the major rivers by early European settlers and provided water power for mills, it is where many

Geology *determines* **soil type** *which determines* **plant type**.



Michael McGeehin

In addition to affecting large- and small-scale patterns of development in the region, major rock types are the major determinant of soil type, which in turn is the primary influence on the types of vegetative cover plants that thrive best on a site.



Michael McGeehin

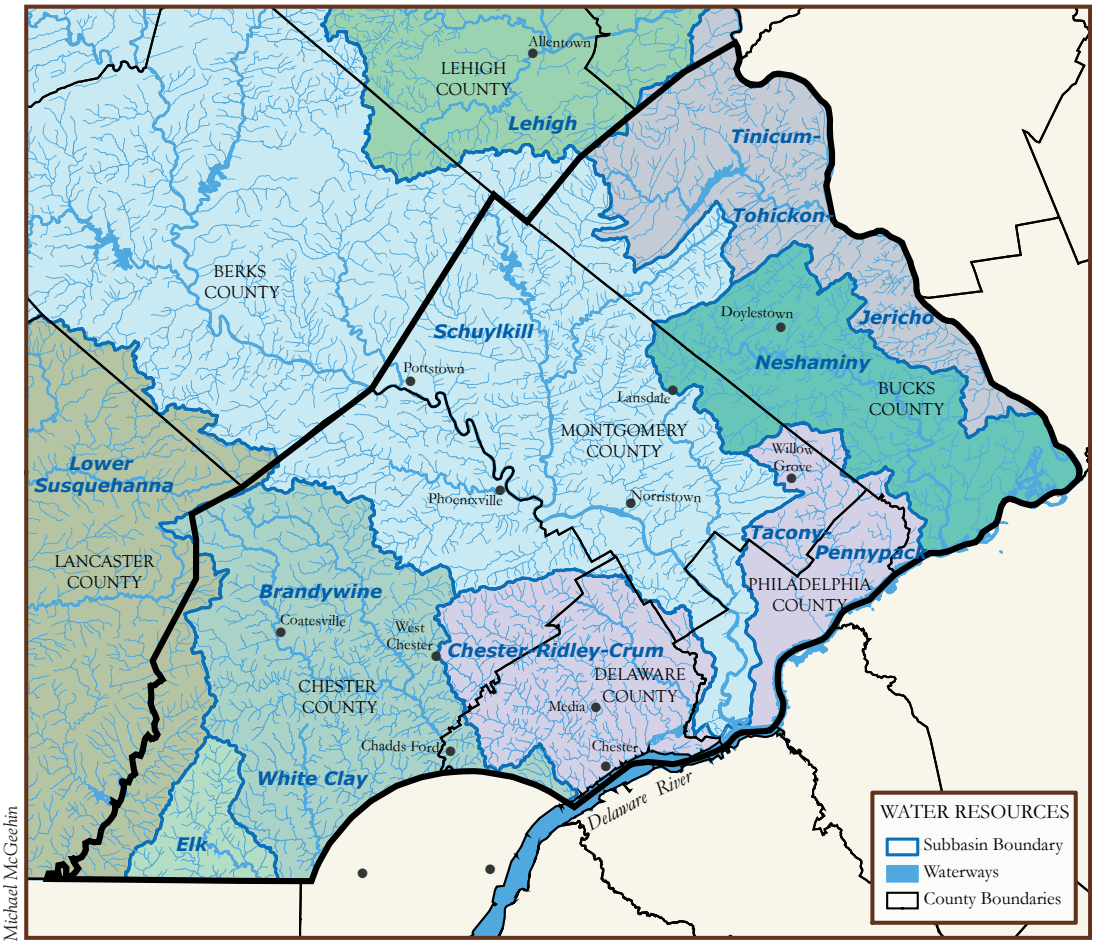
Most of the southeastern Pennsylvania region is part of the Piedmont physiographic province, with slow-draining moderately acidic clay soils, and hardwood-dominated forests. A small portion is coastal plain, which has sandy, usually well-draining soil; and another small portion is Ridge and Valley province dominated by fertile limestone soils; a tiny section is Reading Prong, with hard, rocky soils.

towns and cities were founded, including Philadelphia on the Schuylkill River and Morrisville on the Delaware River.

The ***Piedmont*** physiographic province is divided into three sections by major rock types. Closest to the Coastal Plain is the Piedmont Upland consisting of rolling hills supported by a foundation of schists and gneisses (relatively hard rocks) with the schists typically weathering to higher-fertility soils than the gneisses. Continuing to the north and west we then find the Piedmont Lowland, a narrow limestone valley within Chester and Montgomery Counties with rich soils that is locally known as the "Great Valley" (not to be confused with the Great Valley section of the Ridge and Valley province to the north in Berks and Lehigh Counties). Much of this area is heavily settled (including the towns of Coatesville, Downingtown, and King of Prussia) with attendant industry, commerce, and roadways. Following the Piedmont Lowland we encounter the final section of the Piedmont, the Gettysburg–Newark Lowland. The bedrock in this section consists of schists and gneisses in places, but is dominated primarily by thin or thick stretches of red shales, sandstones and conglomerates, punctuated by hills underlain by a volcanic rock known as diabase.

The remaining two physiographic provinces of southeastern Pennsylvania intermingle in a narrow band in northern Bucks County. The ***Ridge and Valley***

Watersheds (drainage areas) cross political boundaries, tying the landscape together by virtue of shared geographical features. The southeastern Pennsylvania region is located almost entirely within the Delaware River watershed, and is made up of smaller watersheds of the many creeks and streams in the region.



Michael McGeehin

province (also called the Valley and Ridge province) is characterized by parallel, forested ridges divided by long, continuous valleys with fertile limestone soils. The northern tip of Bucks County includes a portion of the Great Valley section of this province. Adjoining the Great Valley section is the southernmost section of the ***New England*** province, called the Reading Prong, which consists of rounded ridges of granitic gneiss and quartzite that are highly resistant to erosion.

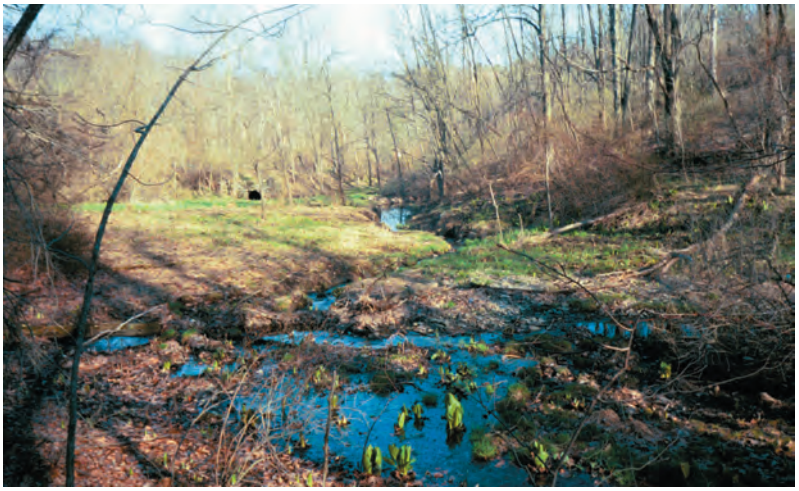
Water

Water resources are generally divided into ***groundwater*** and ***surface water***. As the names imply, groundwater is that reservoir of water that occurs in fissures and aquifers located below the soil surface, whereas surface waters are visible above ground and typically include wetlands, streams and rivers. The land area that drains to and includes an interrelated network of ground and surface water resources is known as a ***watershed***. All watersheds eventually drain into a major river basin.

The southeastern Pennsylvania region *(outlined in bold on the Water Resources map at left)* is located almost entirely within the Delaware River Basin. The exception is the southwest corner of Chester County, which lies within the Octoraro watershed of the Susquehanna River basin. The largest watershed within the region is the Schuylkill River watershed, which drains much of the central half of the region before entering the Delaware River at Philadelphia.

The majority of streams in the region are small, first order or second order headwater streams that are high in the watershed. Unless they lie in a highly developed part of a watershed, these streams are generally not prone to severe flooding as they only drain at most several hundred acres. Small streams have a more acute reaction to local land use change than larger streams and rivers. In particular, they are more vulnerable to pollution from adjacent land use activities such as construction, agriculture, lawn care practices, and paved areas such as roads and parking lots because of their much lower volume of water. Although less affected by local land use change, larger streams such as French Creek, Brandywine Creek, and Neshaminy Creek are still vulnerable to water quality degradation and must also endure excessive flood flows due to the cumulative effects of land use changes over a very large watershed.

Wetlands in the region typically follow stream networks and can be found at the source of small tributaries, along the bases of slopes, and in floodplains. The National Wetland Inventory (NWI) *(see* **Additional Information Sources**, *page 217)* provides general mapping of more pronounced wetlands; however, many potential wetland areas are better indicated by hydric soils where the depth



David Steckel

A headwater seep feeding a first order stream. These small streams create networks of larger streams that eventually flow into larger creeks and rivers. Because of their low volume of water, small streams are very sensitive to pollution from stormwater runoff and to groundwater depletion.

to the seasonal high water table is less than 2 feet at certain times of year.

Groundwater quantity is locally determined by geologic formations (see above) and is everywhere vulnerable to contamination from failing septic systems, livestock, pesticides and herbicides, and leaks and spills of toxic substances. The County Conservation District or Natural Resources Conservation Service can provide you with groundwater information for specific areas.

Maintaining and enhancing the health of local watersheds requires a focused strategy including:

- Retaining and restoring broad, natural, vegetated buffers along streams
- Retaining and restoring wetlands and wetland buffers
- Requiring effective stormwater management practices to promote groundwater recharge and filter stormwater runoff
- Identifying and protecting critical groundwater recharge zones and wellheads for community drinking water systems
- Minimizing use and proper handling of potential pollutants

Plant species tend to sort themselves out in a pattern of roughly repeated assemblages or "communities."

- **Palustrine (wetland) communities are typically found along streams and rivers and in areas with a shallow water table**
- **Terrestrial (upland) communities are found everywhere else**

Plant Communities

Ecologists have noted for centuries that plant species tend to sort themselves out in a pattern of roughly repeated assemblages or "communities" across the landscape and have developed numerous classification systems for cataloging this phenomenon. The *Stewardship Handbook* uses the classifications presented in *Terrestrial and Palustrine Plant Communities of Pennsylvania* (Fike 1999) to describe the various plant communities that are found within southeastern Pennsylvania.

In general, plant communities are divided into two major groups—***terrestrial*** and ***palustrine***—depending on the hydrologic characteristics of the site where they occur. A third group, ***aquatic*** communities, including the underwater and emergent plants of streams, lakes, and ponds, is not covered in this *Handbook*. In this context, terrestrial corresponds closely with "upland" and palustrine is synonymous with "wetland." Palustrine communities are typically found along streams and rivers and in areas with a shallow water table. These two categories are each broken down further into ***forest***, ***woodland***, ***shrubland***, and ***herbaceous openings***. Forests, which cover the majority of the region's natural lands, are dominated by trees where the leaf canopy is closed or nearly closed and the majority of tree crowns are overlapping, typically with between 60% and 100% tree cover. Woodlands are also tree dominated, but are more open in character and have between 25% and 60% tree canopy cover. Shrublands are dominated by shrubs and small trees, with herbaceous plants present in more open areas. Herbaceous openings are communities dominated by plants with no persistent woody stem such as grasses, sedges, and wildflowers. Palustrine forests, woodlands, and shrublands are often

called swamps, forest seeps, or floodplain forests and thickets. Palustrine herbaceous openings are marshes, open seeps, and wet meadows; their terrestrial counterparts are meadows and grasslands.

The next differentiation in community types is based on the dominant species within the community. Which species dominate a forest is generally the result of the site's physical characteristics (soil, slope, aspect, soil moisture) and how past stewardship activities and environmental stresses (wind, ice, flood, drought) have affected the trees and the amount of shade they cast on the forest floor. Some species (often referred to as pioneer species) are shade-intolerant and require full sun conditions to colonize a site. Examples of shade-intolerant species in our region include sweet birch, eastern red-cedar, and quaking aspen. Species with intermediate shade tolerance include tuliptree, ash, oaks, hickories, and red maple. These species can colonize both open areas and forest gaps that are not open enough for pioneer species. Shade-tolerant species such as sugar maple, eastern hemlock, and American beech have the ability to survive in low light conditions and can persist in the understory until canopy trees die. Because seedlings of shade-tolerant species are best adapted to grow under low light conditions, these species are often able to maintain dominance until the site suffers a significant disturbance (high winds, extensive logging) that increases the amount of light reaching the forest floor, favoring intermediate or shade-intolerant species.

In southeastern Pennsylvania, most of the natural forest communities are dominated by deciduous broadleaf (hardwood) species. Communities dominated by conifers are limited and typically the result of abandoned plantations established in the middle part of the 20th century, although eastern hemlock and native pines are minor components of some mixed hardwood forests in the region. Currently, communities dominated by oak species are the most common plant communities in the region and elsewhere in the southern two-thirds of the state. This is largely the result of two factors. One is the decline of the American chestnut between 1910 and 1950 due to an introduced fungus.

Examples of common *terrestrial* communities in southeastern Pennsylvania

Red oak – mixed hardwood forest: A broadly defined community type that includes most of Pennsylvania's hardwood-dominated forests occurring on fairly mesic sites and is therefore quite variable in composition. Typically, this forest type occurs on soils developed from red shales, diabase, serpentine, schist and gneiss. In addition to soil influences, such stands often have had a history of heavy cutting and/or fire disturbance. Northern red oak is usually present, often dominant or codominant, most often with red maple, black and white oak, mockernut and shagbark hickory, sweet and yellow birch, white ash, American beech, and tuliptree.

David Steckel

Examples of common *terrestrial* communities in southeastern Pennsylvania, *cont.*

David Steckel

Tuliptree – beech – maple forest: These forests occur on fairly deep, not strongly acidic soils, at a mid- to lower-slope position. Typically, this forest type occurs on soils developed from limestone, marble, diabase and some shales with higher calcium and magnesium content. The most consistent tree species for this often very mixed type are red maple and tuliptree. American beech is often present and sometimes codominant. In successional, lower slope situations, tuliptree may occur in nearly pure stands. The long list of possible associates includes various oaks, mostly northern red oak, as well as black-gum, sugar maple, mockernut and shagbark hickory, sweet birch, and eastern hemlock (less than 25% relative cover).

David Steckel

Red maple (terrestrial) forest: This is generally an early- to mid-successional type that is becoming increasingly common as red maple increases in Pennsylvania's forests. This type is seldom pure, but red maple dominates the tree stratum. Associated species include oaks, sweet birch, tuliptree, hickories, black cherry, ashes, and other hardwoods. This type is not well correlated with soil characteristics, but instead is a common result of release of a site from agriculture and a history of fire exclusion.

Ann Fowler Rhoads

Dry oak – heath forest: A fairly broadly defined community type, these forests occur on xeric (very dry) to moderately dry, acidic sites, often on shallow or sandy soils and/or steep slopes. Typically, this forest type occurs on soils developed from sandstone, conglomerate and quartzite. Soils developed from red shales, schist and gneiss can also support this community type if the area has experienced heavy disturbance from repeated cutting and/or fire. The most characteristic tree species is chestnut oak, usually occurring with a mix of black, scarlet and/or white oak. Other tree species include sassafras, black-gum, sweet birch, red maple, pignut hickory, and pitch, Virginia, and eastern white pine. Total cover by conifers generally does not exceed 25% of the canopy.

Examples of common *palustrine* communities in southeastern Pennsylvania

Red maple palustrine forest: The canopy of this, the most common of our swamp forest communities, is dominated by red maple and/or black-gum. Other trees, e.g., yellow birch, eastern white pine, eastern hemlock, swamp white and pin oak, or black willow, may also occur.

David Steckel

Sycamore – box-elder floodplain forest: This community type occurs along floodplains of larger and mid-size river systems that receive periodic or seasonal flooding. Although typically a palustrine community, there may be examples of this type that are terrestrial. The most characteristic tree species of this type are sycamore and box-elder, often with red and silver maple, American and slippery elm, red ash, and black willow. River birch is a common component of these sites in eastern Pennsylvania.

David Steckel

Skunk-cabbage – golden saxifrage forest seep: These are small communities (usually less than a quarter-acre) that occur where groundwater comes to the surface in a diffuse flow, saturating the soil for most of the growing season. The water chemistry ranges from acidic to strongly calcareous, with only minor accompanying shifts in species composition. These seeps most often occur in a forested context. Canopy cover ranges widely, and may be contributed by woody plants rooted within the seep, or by overhanging foliage of trees in the surrounding uplands. The species composition is highly variable and includes skunk-cabbage, golden saxifrage, cinnamon fern, sedges, goldthread, partridge-berry, jewelweed, Pennsylvania bitter-cress, clearweed, sweet-scented bedstraw, slender mannagrass, swamp saxifrage, New York fern, swamp aster, and sensitive fern.

Claudia Steckel

Examples of common *palustrine* communities in southeastern Pennsylvania, *cont.*

Claudia Steckel

Tussock sedge marsh: These are tussock sedge-dominated marshes. The majority of these systems are influenced by past impoundment. The substrate may be peat, muck, or mineral soil. There is generally standing water between the tussocks for much of the year. Associated species include other sedges, rushes, bluejoint, tall meadow-rue, hairgrass, Joe-Pye weed, wool grass, water parsnip, marsh St.-John's-wort, scattered common cattail and small red maple. The invasive species reed canary-grass, common reed and purple loosestrife are frequently a major problem in these systems.

Claudia Steckel

Herbaceous vernal pond (synonymous with ephemeral or seasonal pool): This community type is characterized by seasonally fluctuating water levels; it may dry out completely in the summer. Species composition is variable between sites, as well as annually and seasonally. Cover may be sparse, species composition is extremely variable, some typical representatives include three-way sedge, mannagrass, rice cut-grass, wool-grass, and a variety of sedges.

David Steckel

Wet meadow: These are open, usually grass-dominated meadows. They are typically flooded early in the growing season, but are generally dry for much of the year. Representative species include rice cut-grass, wool-grass, bugleweed, pale meadow grass and smartweeds.

More detailed descriptions of these and the many other plant communities found within the region and the state can be found in *Terrestrial and Palustrine Plant Communities of Pennsylvania* **(Fike, 1999).**

Oak communities in many natural lands will eventually give way to red maple- and beech-dominated communities after the current canopy trees decline.

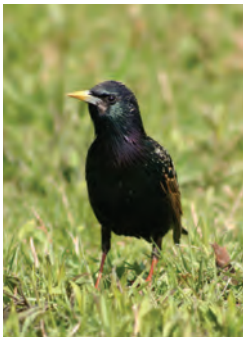
The second is extensive clearcutting that occurred between 1850 and 1920 to increase agricultural production and to supply the growing cities and towns with construction materials and fuel (firewood, charcoal). The high light conditions created by clearcutting and the subsequent wildfires preferentially favored oaks, which can tolerate fire very well. Because there is now a general aversion to clearcutting and fire—although both are considered appropriate management practices when properly used—the conditions required to perpetuate oak dominance occur less often. With overabundant deer consuming much of the annual acorn crop and the few oak seedlings that do sprout, indications are that oak communities on many natural lands will eventually give way to red maple- and beech-dominated communities after the current canopy trees decline. However, any prediction of the future of forests in our region will be challenged by new pests (the Asian long-horned beetle and emerald ash borer are poised to attack our maple and ash species), climate change (warming temperatures will encourage southern species to spread into the region and northern species to decline), and our success with controlling the many invasive species already here.

Wildlife

Because this region has been so fragmented and dominated by human use of the landscape, a good number of wildlife species no longer occur in this part of the state. Those wildlife species that remain are the ones more tolerant of human-dominated landscapes. "Backyard wildlife" species—raccoons, opossums, rabbits, voles, mice, robins, European starlings, catbirds, mourning doves, blue jays, and white-tailed deer—abound under urban and suburban landscape conditions. Less tolerant wildlife, however, still occur in the more rural areas of the region where large blocks of unbroken forest or grasslands create interior habitat, that is, areas sufficiently removed (100 meters or about 300 feet) from all edges between contrasting habitat types. In interior habitat they encounter lower levels of predation and competition from the often abundant "backyard wildlife," which prefer edges. Species in the sensitive category include black bear, bobcat, mink, river otter, and birds of interior forest (e.g., scarlet tanager, ovenbird, various other warblers) and grasslands (e.g., eastern meadowlark, bobolink, vesper sparrow). Typically, these more sensitive species occur in areas of larger, unbroken forest

"Backyard wildlife": white-tailed deer, European starling, raccoon

Bill Moses



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Bill Moses

and grassland tracts of at least hundreds of acres. One notable exception is the federally protected bog turtle *(Clemmys muhlenbergii)*, which inhabits relatively small wetlands throughout the region.

In Pennsylvania, wildlife can only be managed directly through activities approved by the state Game Commission and Fish and Boat Commission. These two agencies regulate hunting, trapping, and fishing within the state and support the protection of declining non-game species. The manager of natural lands can have a strong influence on which animal species use a site through stewardship of the plant and water resources on which wildlife depend. Over the last few decades wildlife management has transitioned from a goal of maximizing habitat diversity to encourage edge-loving game species (deer, rabbit, pheasant) to an approach that also includes creating large blocks of contiguous forest and grassland to protect populations that depend on forest interior and grassland habitat.

Rick Coval

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"Interior habitat wildlife": scarlet tanager, river otter, Eastern meadowlark, bobcat

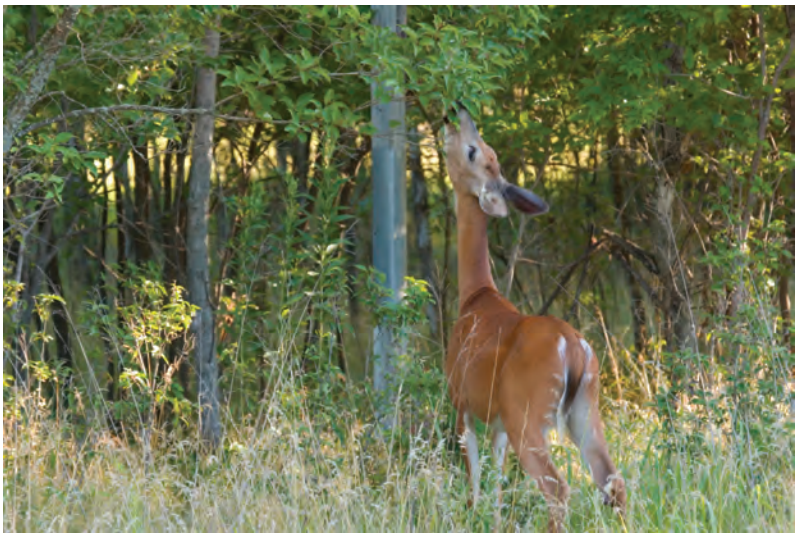
MAJOR STEWARDSHIP ISSUES

The natural lands in southeastern Pennsylvania have been directly and indirectly affected by human activities for many centuries. While humans have benefited from the products of agriculture and forestry (fuel, food, and building materials), many natural lands are now suffering from the residual effects of exploitation and mismanagement. Today, we look to natural lands more and more to provide local environmental and ecological benefits and to fulfill recreational and aesthetic needs. It is important to understand the full range of issues that should be addressed in any stewardship plan to meet and maintain these needs and benefits. Some issues (overabundant deer, invasive plants, hazards) are the result of past human activities. Some (stormwater erosion, adverse uses) result from more recent activities on or near natural lands. Others (recreational use, dead wood management) are more generally related to the restoration and management of natural lands. This section details the common stewardship issues and how they affect the stewardship of natural lands.

Deer Overabundance

Forest fragmentation, the extirpation of large predators, and cultural norms about hunting have resulted in the proliferation of white-tailed deer to unprecedented population densities. Researchers believe that native forests evolved with deer densities of 5–10 per square mile (1 square mile = 640 acres). ***Deer populations are no longer kept at ecologically sustainable levels*** as they were for more than 99% of their existence, first by large predators and more recently by Native Americans, for whom venison was a major source of food.

A diverse array of predators regulated deer populations for millions of years before humans arrived in our region, including the timber wolf, dire wolf, grizzly bear, giant short-faced bear, mountain lion, American cheetah, and jaguar. Human hunters arrived in what is now southeastern Pennsylvania at least 13,000 years ago, forcing out most of the other major predators, but American Indians, timber wolves, and mountain lions continued to regulate deer populations until Europeans arrived and expelled all three. For the first two centuries after William Penn's arrival, the human population grew exponentially and unlimited hunting began eroding the delicate balance between predators and deer that had prevailed for eons. By 1900, white-tailed deer were nearly extinct in Pennsylvania and other eastern states because of over-harvesting. By instituting game laws, state agencies successfully rebuilt the deer population. Unfortunately, these hunting rules, which largely persisted through the 20th century, focused on providing a "maximum sustained yield" of game for recreational hunters and the deer population consequently soared to unprecedented levels in just a few decades. There is general agreement among scientists, resource managers (foresters, wildlife biologists, farmers, hunters) and landowners (rural and suburban) that this strategy has led to the degradation of forests, agricultural lands, and suburban landscaping throughout the state. (A detailed summary of this issue can be found in the 2005 report by the Deer Management Forum, titled Managing White-tailed Deer in Forest Habitat From an Ecosystem Perspective, available at http://pa.audubon.org.) The simple reason for this is that abnormally high deer populations affect all vegetation layers of the forest, including shrubs, herbs, and



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Browsing by overabundant deer populations is the most significant factor in forest decline in Pennsylvania.

the seeds and seedlings that would have become the next generation of canopy trees, if not consumed by deer.

Statewide, the deer density now averages 25 deer per forested square mile, two to five times the desired density of 5–10 per square mile (2003 PA Game Commission census). In some Pennsylvania suburban areas, populations have risen above 100 per square mile. Deer densities at this level threaten the perpetuation of forest communities, which depend on the ongoing establishment of tree seedlings and saplings in sufficient numbers to occupy the gaps that are created by periodic natural or human disturbance. A density of 15–20 deer per forested square mile has been found in some areas to be a maximum level allowing minimal advance tree and shrub regeneration (a sufficient number of

David Steckel

DEGRADED FOREST – There are no young trees to replace the old ones; no shrubs or low trees for birds to find food, nesting sites or cover; and no wildflowers to provide food or cover for ground-nesting birds and small mammals, or nectar for pollinators. Deer overbrowsing, along with stresses on hydrology and the impact of invasive species, can degrade a healthy forest community to the point where it becomes unsustainable.

David Steckel

HEALTHY FOREST – How can you tell you're in a healthy forest? You can't see through it, at least in summer. Lush and three-dimensional, this forest is home to a complex, diverse community of life. It is the natural result of good stewardship. Deer may be present but at a density low enough that the forest can sustain itself. Water and nutrients are available in appropriate amounts, and exotic plants have not displaced the natives.

established seedlings and saplings available to replace existing trees and shrubs following mortality or disturbance of existing vegetation), with a density of 5–10 per square mile needed to sustain a high diversity of native species, including native herbaceous plants.

Deer are browsers, which means their diet consists mainly of newly grown twigs of woody plants, primarily trees and shrubs. When populations are high, deer can consume all of the established seedlings, as well as many tree seeds (particularly acorns) and herbaceous plants. Over 100 species of native wildflowers and other plant species have been extirpated from Pennsylvania; at least some of these losses have been partly a result of overbrowsing by deer, and many more species are known to be in trouble in the state from the same cause. Browsing by overabundant deer dramatically reduces the survival of native flora and has led to the collapse of plant species diversity in the forest understory and the near cessation of tree reproduction in vast areas of Pennsylvania forests. The resulting lack of cover, food, and structural diversity within forests *(see photos at left)* has undoubtedly reduced wildlife populations, particularly of small mammal, bird, and amphibian species. Native oaks, which are highly preferred food for deer, are not regenerating, which means that wildlife-rich oak forests will cease to exist as adult trees age and die. Furthermore, exotic (non-native) invasive plant species are generally avoided by deer and other plant-eating wildlife (which is one of the reasons they are invasive), so deer have contributed to their proliferation by stripping the forests of their native competitors.

Part of the problem in understanding the forest health problem is that it is *too* easy to "see the forest for the trees." Most forests in our region still look healthy, with a canopy of large trees that have

A density of 15–20 deer per forested square mile has been found in some areas to be a maximum level allowing minimal advance tree and shrub regeneration, with a density of 5–10 per square mile needed to sustain a high diversity of native species, including native herbaceous plants.

grown since the last extensive clearing in the late 19th and early 20th centuries. The spread of invasive introduced shrub and understory tree species into natural areas over the last few decades has filled in the vegetation layers vacated by native species as the result of high deer densities. Most forests still look superficially healthy because they are green. Forests with an understory stripped of vegetation have a park-like structure, with tall canopy trees and a uniform low understory or no understory at all. Forests in some parts of our region have looked like this for so long that many people have the impression it is normal and natural.

The best chance for successful regeneration is within forest gaps where more sunlight is available for growth. However, the number of seedlings in a typical forest gap in southeastern Pennsylvania is usually many times less than in a gap in a healthy forest. Successful regeneration in a gap hinges on a few seedlings surviving a host of stresses (buck rubs, invasive vines, drought, insects, windthrow) over the many decades it takes to reach the canopy.

The elimination of tree regeneration not only removes the defining component of the future forest (canopy trees), it greatly amplifies the effects of other stressors by freeing up growing space to invasive plant species and physically creating the disturbed soil conditions to promote their spread. This, in turn, compromises the many benefits—environmental, ecological, and economic (timber production)—that forests provide.

In forests that have been subjected to overbrowsing for many years, the deer density will probably need to be lowered even further than the eventual optimal level for a period of time to allow the forest to regenerate. The section on estimating deer impact under **Wildlife Management** *(page 104)* provides guidelines developed by Penn State University and the US Forest Service for visually assessing deer impact on a forest community.

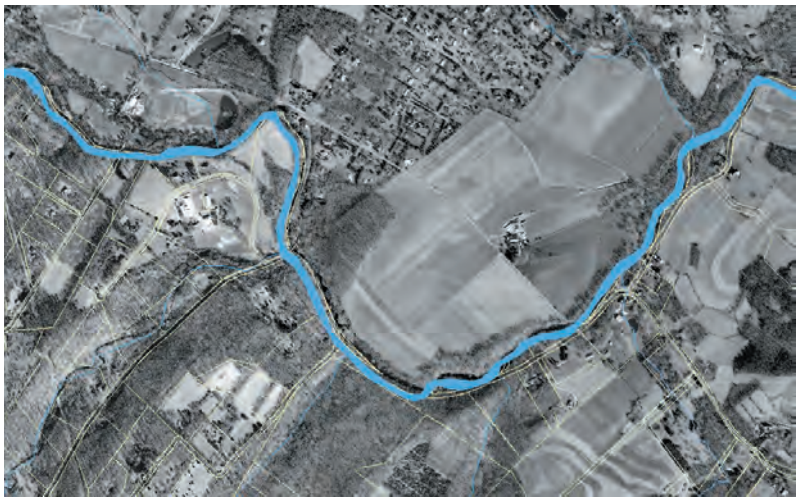
The decision to restore any forest must start with the goal of reducing and maintaining deer density at an appropriate level. Unless this goal is achieved first, the management of other stressors becomes a short-term lesson in futility that ultimately ends with the demise of the current canopy trees—and by definition, the forest itself—through natural decline or the next major wind event.

Fragmentation and Edge Effects

Historically, land use in the region was dominated by agriculture and logging. Those uses, coupled with recent residential and commercial development, have effectively removed or disturbed most of the native vegetation in the region and, through subdivision and clearing, added countless miles of edge (the zone where forest meets a nonforested area) to the fragments of forest that remain. Edges allow light and drying winds to penetrate into

the forest, which fosters the proliferation of aggressive, invasive plants that crowd out native flora. Edges also provide easy access to the forest by predators (feral cats, raccoons) and nest parasites (cowbirds) that consume or displace forest interior animals, especially birds.

Fragmentation of our forests is second only to outright destruction and conversion of forestland to other uses as a cause of degradation of ecosystem function, habitat quality, and biodiversity.



This section of French Creek shows how instead of a large, continuous corridor, the forest is broken up into many small pieces, each of which is another instance of edge habitat. Edge habitat is much less ecologically diverse, and encourages the spread of invasive, non-native plants.

edge = **a zone encompassing the interface between forested and nonforested areas, including the part of the forest that is subject to ecologically significant "edge effects"**

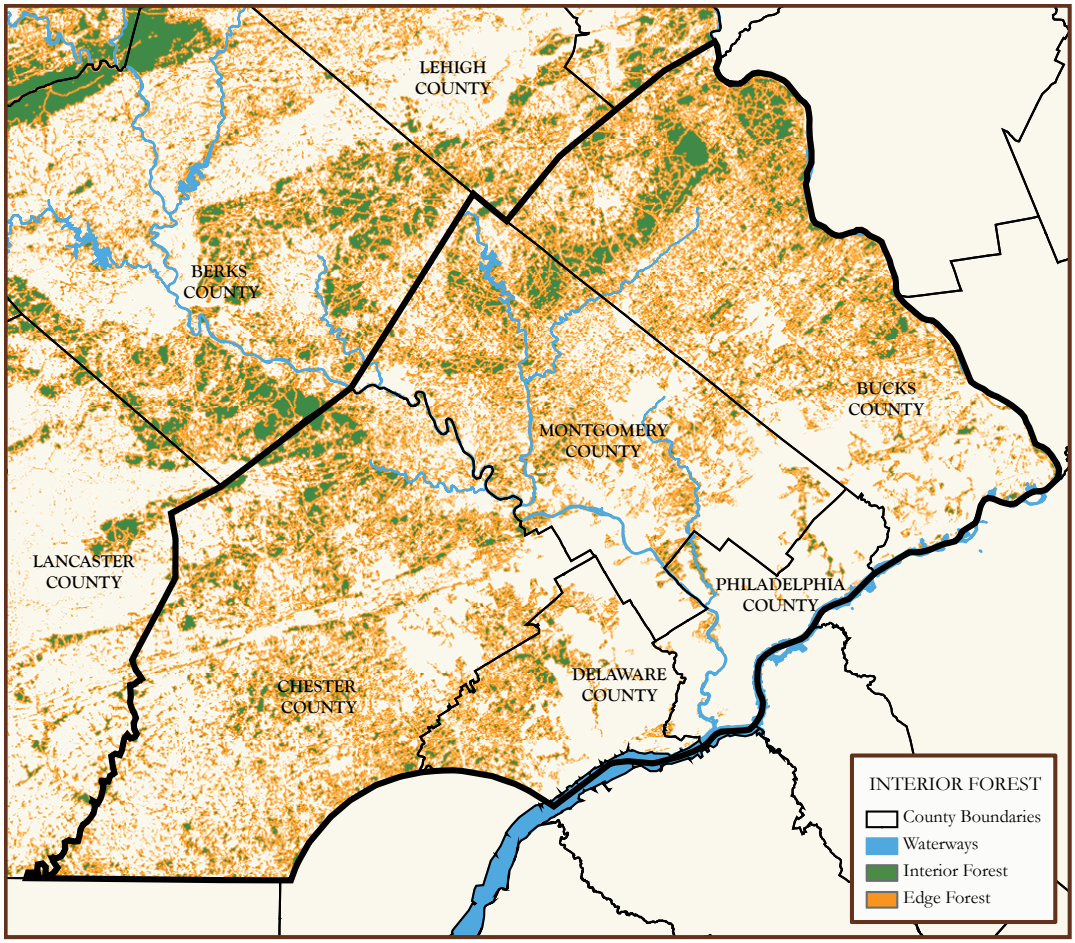
Fragmentation of our forests is second only to outright destruction and conversion of forestland to other uses as a cause of degradation of ecosystem function, habitat quality, and biodiversity. Forest fragmentation results in the local extinction of species and can lead to far lower overall species diversity than would occur if the same total area of forest were to remain as a single contiguous block. The level of impact on the original forest ecosystem depends on the number, size, and shape of resulting forest fragments.

Fragmentation has at least four components:

- reduction in total forest area
- reduction in the area that functions as forest interior
- increase in the edge-to-area ratio
- increased isolation from the nearest large forest blocks

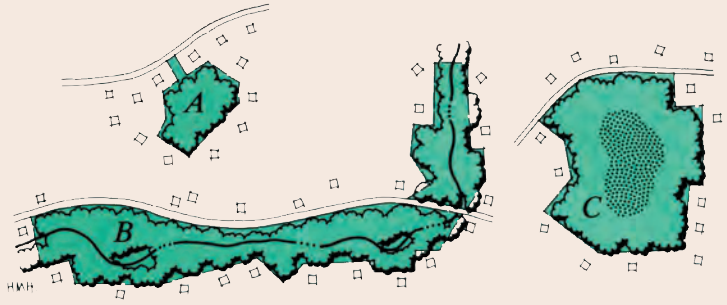
Conventionally, in temperate eastern North America, the part of the forest that lies more than 100 meters (a little over 300 feet) from the closest edge is considered as functional forest interior for most species. It follows that, in two forest blocks with identical areas but different "footprints," the one with the higher edge-to-area ratio (more sinuous edge or narrower overall shape) is more fragmented. A circle is the two-dimensional shape with the lowest edge-to-area ratio and hypothetically the optimal shape for conserving forest diversity in a fragment, but smaller circles have higher edge-to-area ratios than larger circles. Any part of a forest block whose width is 600–700 feet or less has little or no functional interior. Cutting a road or other linear nonforest feature through a forest fragment may not decrease total forest area by much, but the two fragments so created each has a much smaller maximum area, a

forest interior = **the part of the forest that lies more than 100 meters (about 300 feet) from the closest edge**



Michael McGeehin

Interior forests in southeastern Pennsylvania are primarily confined to the northern portions of the region, where topography and geology have disfavored development. Elsewhere in the area, fragmented forests that consist mainly or entirely of edge habitat predominate, with accompanying loss of biodiversity and prevalence of invasive plant species.



EDGE TO AREA RATIO – Preserve A is so small it is all edge. Preserve B is larger, but it is still all edge because of its shape. Preserve C is smaller than B, but because it is circular, it has an area of interior forest.

Holly Harper

much higher edge-to-area ratio, and far less (or no) functional interior.

For many animal species, the area of contiguous habitat in a forest fragment must be above some threshold size for a population to sustain its viability for more than a few individuals. Minimum-area requirements vary greatly among species, but the total area of forest in a fragment is not all that matters. Many plants as well as animals are forest-interior specialists, unable to utilize the outermost zone of forest near the edge as habitat. The area inside a forest but near its edge is vulnerable to a host of detrimental outside influences, including increased wind, light, and heat, decreased humidity, and the influx of seeds of invasive introduced species. In general, ***fragmentation favors invasive species and works against native species***.

Furthermore, the threshold size of a forest block required to sustain a population of a forest-interior species is larger with greater isolation from other forest blocks, because there is less movement of individuals between blocks. Consequently a long-established population in a forest fragment may die out even if the habitat remains intact, if enough nearby forest fragments are further fragmented or destroyed. Put another way, in a neighborhood in which most of the forest is gone, the remaining forest fragment must be larger to sustain the same level of species diversity than if it were near other large forest blocks.

invasive species =
one that rapidly spreads and out-competes multiple native species

Invasive Plant Species

Another anthropogenic (caused by humans) problem encountered in the stewardship of natural lands in southeastern Pennsylvania—and increasingly recognized as a threat worldwide—is the presence of invasive plant species. Even though the occasional immigration of new species into plant communities is a normal process, the current high rate of introduction—fueled by the planting of exotic (non-native) species for horticulture, wildlife management, and erosion control—is threatening the integrity of native plant communities and the survival of native species.

Not all exotic species are invasive. Of the almost 1,000 non-native plant species known to have escaped to the wild in Pennsylvania (there are about 2,000 native species in the state), less than 5%—a few dozen—have become invasive so far. An invasive species is one that rapidly spreads and outcompetes multiple native species, chiefly because of the absence of the predators, pathogens, and herbivores that keep it in check in its native range. An invasive species displays one or more of the following characteristics:

- few predators, herbivores, and diseases
- adaptation to disturbance
- fast germination
- high population growth
- early reproductive maturity
- vegetative as well as sexual reproduction
- pollination by wind or multiple insect species
- wide tolerance to many habitat types
- fast growth rate
- long-range seed dispersal capability
- fruit used by wildlife or humans

Nationally, ***the destructive impact of invasive species on native biodiversity is exceeded only by direct habitat destruction and forest fragmentation***.

Most invasive plants are particularly well adapted to colonize disturbed areas. In southeastern Pennsylvania the division and clearing of land parcels associated with agriculture and more recent sprawl development have created countless miles of edge condition that is highly favorable to the proliferation of invasive species. The misguided promotion of several exotic species for erosion and livestock control and the region's rich horticultural legacy (often using exotic species) have provided plentiful seed sources for regional dispersal of numerous invasive exotic species.

The presence of invasive plant species complicates the goal of maintaining healthy native plant communities because invasive plants compete vigorously with preferred native species for "growing space," the major resources and conditions—light, water, nutrients, temperature, humidity, soil structure, and other factors—that support plant growth in any area. As a result, invasive species have the ability to displace native vegetation, halt or subvert the natural process of succession from field to forest, and homogenize the structural and wildlife food resources of a site. They can also alter nutrient cycling, local hydrology, and fire regimes.

These modifications to native plant communities reduce their habitat value for native fauna, particularly migratory songbirds, which nest within different vegetation layers, and insects, which are vital links in many of the food chains that make up the food web in ecosystems. Most native insect species (terrestrial and aquatic) are specialist feeders on just one native plant species or a narrow range of species. Exotic invasive plants rarely serve as a food resource for native insect species, which is one of the reasons why they are invasive. The higher the cover and species richness of native plants, the higher the total insect biomass is in a given area of land; conversely, the higher the cover of non-native plants, the scarcer insects are as a food resource for other wildlife. Insects are the richest source of fats and protein for birds, fish, and many small animals that, in turn, are food for larger animals. Where non-native plants are abundant, far less of the total plant biomass is converted, via the food chains that make up the food web, into animal biomass. Invasive plants have adverse impacts on virtually all native wildlife populations, both by degrading habitat directly and by reducing the total food supply.

The control of invasive plants will be a perpetual concern of land managers in the region. The extensive edge area and

Why invasives matter

invasives outcompete natives

resulting in

fewer natives in the natural area's species mix

resulting in

- **halting or subverting of natural succession**
- **lower diversity of food sources**

resulting in

- **degraded habitat for wildlife**
- **disruption of nutrient cycling, hydrology, fire regimes, and other vital ecosystem processes**

The most problematic *invasive species* at this time

Oriental bittersweet *(Celastrus orbiculatus)*: A woody vine that aggressively grows along forest edges or in open meadows. Its seeds are dispersed by birds and human collectors (the bright orange seed capsules are used for fall decorations). By growing into the tree canopy, the vine shades the leaves of the host tree and increases wind resistance and snow and ice accumulation, making it vulnerable to windthrow.

Dan Barringer

Autumn-olive *(Elaeagnus umbellata)*: Once promoted as a wildlife food along with its relative, Russian-olive *(E. angustifolia)*, this shrub can rapidly invade abandoned fields and open canopy forests to the exclusion of all other plants.

David Steckel

Japanese stiltgrass *(Microstegium vimineum)*: A warm-season grass dispersed by deer and human walkers that quickly spreads to the detriment of native herbs and tree and shrub seedlings.

Norway maple *(Acer platanoides)*: A shade-tolerant tree that is invading many forests throughout the region. Once established, its dense shade prevents virtually all plants from growing around it.

Multiflora rose *(Rosa multiflora)*: An upright shrub that was promoted as a "living fence," its proponents failed to understand its ability to spread rapidly via bird droppings.

Dan Barringer

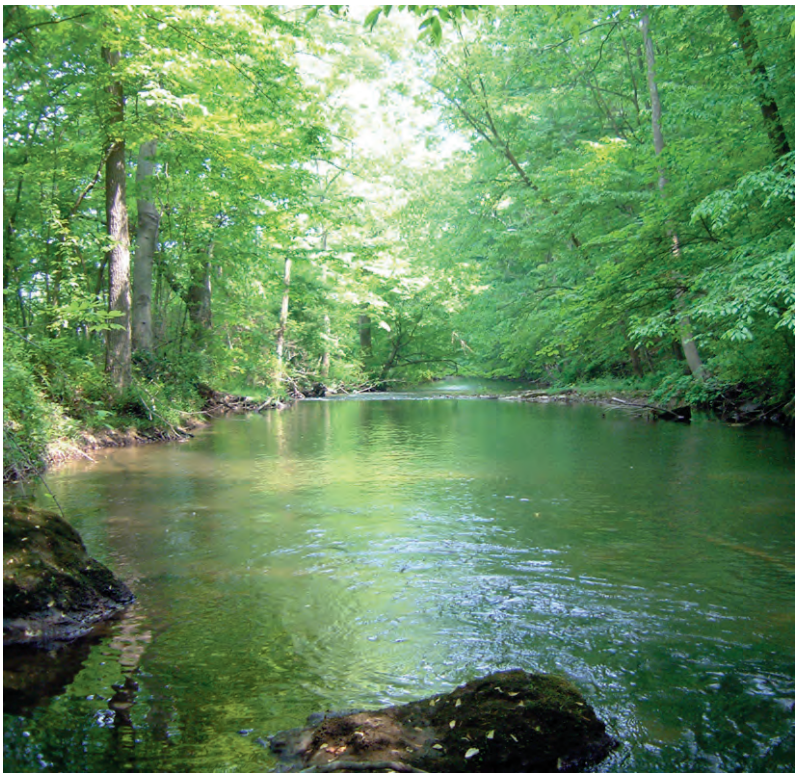
Japanese honeysuckle *(Lonicera japonica)*: A perennial vine initially used for erosion control, its greatest impact is on forest tree seedlings and shrubs.

A more complete list of the invasive plants that have the most severe impacts on natural lands in the region can be found under **Invasive Vegetation Management** *(page 125)*. Photos and detailed descriptions of individual plants are available at **www.nps.gov/plants/alien/index** and from other sources listed under **Additional Information Sources** *(page 217)*.

seed sources in our region and the prolific nature of these plants guarantee that ***even with complete eradication on a given property, invasive species can quickly reestablish themselves as a serious stewardship problem if not monitored and addressed on a regular basis***. A strategy for coexisting with these plants is needed—one that will minimize their effects on the aesthetics and ecological stability of a property, with a minimum of management effort. **Invasive Vegetation Management** *(page 125)* provides information on controlling invasive plants.

Water Resources

Our natural lands directly influence the quality and quantity of water that constitutes the system of streams, wetlands, and groundwater in the region. In general, streams in southeastern Pennsylvania developed (and their aquatic biota evolved) within forested landscapes. Forest cover moderates stream flow throughout the year by maximizing infiltration and groundwater recharge, shades the water surface (helping to maintain cool water temperatures for native fish and aquatic insects) and provides food (leaves) and structural debris (branches, trunks) for aquatic organisms. Streams in forested areas tend to be shallow and wide with rocky beds that serve as breeding and nesting sites for aquatic organisms. Removing forest cover along streams exposes the water surface to sunlight and eliminates preferred food resources. If the dominant cover type along the stream becomes sod-forming grasses (typical in agricultural landscapes) or impervious material, the stream loses the flexibility to wander; with increased surface water inputs during storm events, the stream begins to deepen and narrow its channel. As a result, the rocky streambed, so vital to aquatic organisms, is drastically reduced in surface area and often covered with silt.



Holly Harper

Broad flat areas adjacent to streams with flood-tolerant plants slow down and temporarily hold seasonal and storm-produced floodwaters. Floodplains serve as natural shock absorbers for the dynamic expansion and contraction of a waterway over time. With increased volume of runoff (due to upstream clearing for cultivation and paving for development, and resulting diminished groundwater recharge), streams erode their banks, cut deeper channels, and lose their floodplains, becoming more "flashy" (undergoing wider and more frequent swings in volume) and flooding more often downstream.

The agricultural, suburban, and urban land-use pattern of the region has altered the natural balance of ground and surface water that defined the forested landscape prior to William Penn's arrival in 1682. Almost the entire region has been cleared of forest, plowed and grazed for agriculture, bulldozed for urban and suburban development, planted in lawns, or paved. Each of these actions generates unnatural rates and amounts of stormwater

Why water matters

WATER QUALITY

degraded by

contaminants from lawns and agricultural fields running off into streams

solve by

- **installing/maintaining riparian buffers**
- **reducing use of contaminants**
- **managing goose populations**
- **controlling livestock/pet waste**
- **managing first flush through stormwater management**

WATER QUANTITY

degraded by

lack of recharge due to impervious surface depleting groundwater

resulting in

drying up of wetlands and streams

solve by

- **installing/maintaining riparian buffers**
- **infiltrating stormwater using BMPs**

runoff, particularly in the wettest periods of the year. Water that once infiltrated soil and recharged aquifers to gradually feed wetlands and streams during periods of drought is now lost downstream to the Chesapeake and Delaware Bays and Atlantic Ocean. As a result, the frequency and extent of flooding is artificially high, and the water table that allows groundwater to feed wetlands and supply the base flow of streams is artificially reduced to unnaturally low levels during the driest periods of late summer.

Decreased groundwater levels are manifest in wetlands and small streams that become drier earlier in the year and in the resulting changes in the local plant and wildlife populations. For example, invasive species such as Japanese honeysuckle and multiflora rose have become dominant in many former wetland areas, and salamander populations reliant on wetland pools (small areas of standing water, normal in springtime) for breeding have declined or disappeared for lack of habitat.

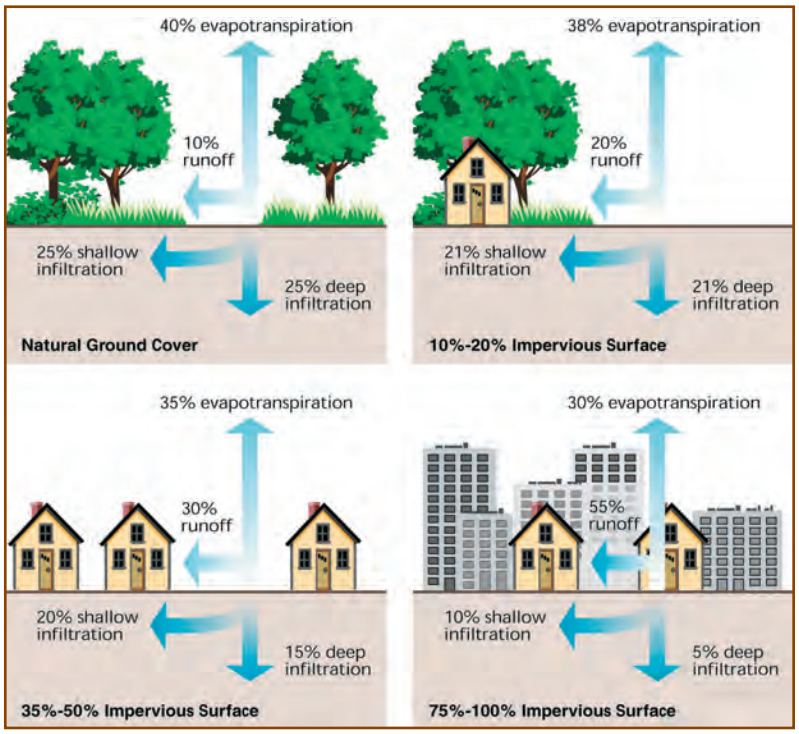
Ongoing threats to the quality and quantity of water represent potential threats to the natural lands in the region. With the advance of technology, humans have the ability to alter the landscape more rapidly and at a broader scale than ever before. The more we clear native vegetation, excavate and compact soil, and construct impervious surfaces such as rooftops and parking lots, the more we "short-circuit" the natural hydrologic cycle that recharges aquifers, regulates flooding, maintains diverse aquatic plant and animal communities, and feeds wetlands and streams with clean, plentiful water to support plant, animal, and human needs (including vital drinking water supplies).

The primary threats to water quality and quantity in our region are modifications to hydrology caused by changes in land use. In natural conditions,

of the approximately 45 inches of rain that falls in southeastern Pennsylvania each year, 12 inches infiltrate into the groundwater, 25 inches are evapotranspired into the air, and 8 inches run off as surface water. However, once the landscape is urbanized, these proportions change with four main effects:

- ***Non-point-source pollution*** results when excessive stormwater runoff volume carries pollutants from residential, commercial, and agricultural areas and sediment from erosion caused by an excessive runoff rate. *(Note: point-source pollution is discharged from pipes at industrial facilities or sewage treatment plants.)*
- ***Flooding*** results from excessive runoff volume.
- ***Groundwater is depleted*** by reduced infiltration.
- ***Streambanks are destabilized*** by increased stormwater flows.

Overall, land development in a watershed results in the amplification of both the high and lows of the natural hydrologic cycle.



Federal Interagency Stream Restoration Working Group

DEVELOPMENT AND THE HYDROLOGIC CYCLE
Stormwater naturally percolates through the soil, recharging groundwater. In undeveloped conditions *(top left)*, **5 times more rainfall is infiltrated into the ground than runs off the surface. Land development modifies this natural hydrology, significantly reducing groundwater recharge and increasing stormwater runoff.**

Non-point-source Pollution

The following issues are associated with non-point-source pollution facing streams in the region:

- *Loss and Degradation of Streamside Forested Areas and Wetlands*

Under natural conditions, the areas adjoining rivers, streams, lakes, and ponds are protected by forested "riparian buffers." A riparian buffer made up of a mixture of native plant types—herbs, shrubs, and trees—filters out sediment and pollutants, stabilizes banks, mitigates stormwater flows, reduces water temperatures, and provides food for aquatic organisms. It also provides a protected habitat for wildlife to obtain water and other vital resources without being exposed to predators. Because these riparian areas are crucial to the protection and enhancement of water resources, a lack of riparian buffer has an adverse effect on the quality of water and aquatic habitats, and limits the overall wildlife benefits of a site.

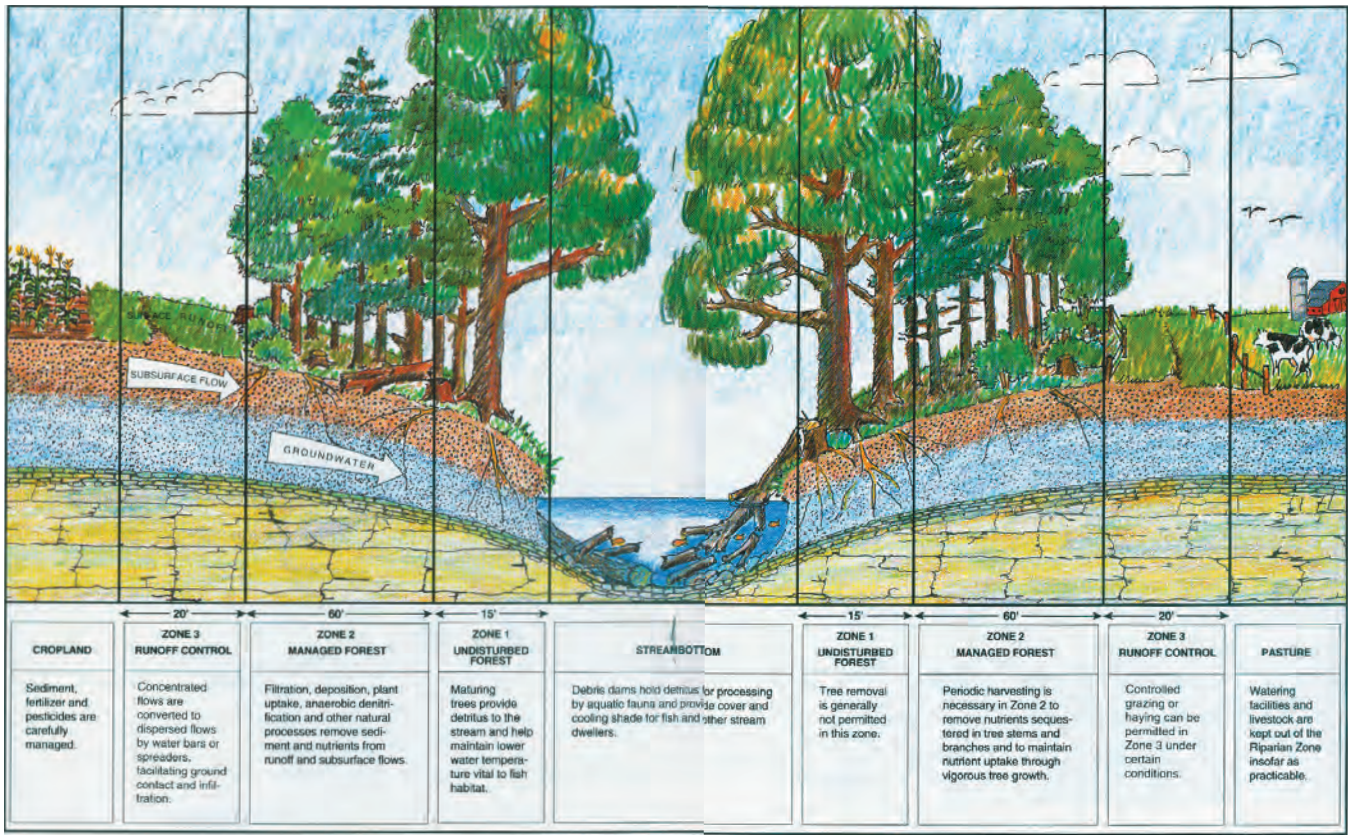
Decades of deforestation, agricultural expansion, and increasing suburban development have drastically reduced the extent of water edge protected by forest in southeastern Pennsylvania. (However, in some watersheds, the combination of less acres in agriculture and better management practices promoted by the

David Steckel

Without vegetation adjacent to a stream, stormwater runoff flows at greatly increased volume into the waterway. This brings not only flooding and bank erosion, but also increased pollution as the runoff carries sediment, nutrients and chemicals from the surface runoff that would be filtered if a riparian buffer were present. Ideally at least a 95-foot-wide zone on both sides of a stream should be vegetated.

Natural Resources Conservation Service have increased riparian buffers.) Without the protective canopy and filtering and stabilizing root systems of riparian vegetation, streams can be degraded by thermal pollution and higher levels of total suspended solids, nutrients, and bacteria from stormwater runoff and nearby farms (livestock, fertilizer application) and homes (failing septic systems, lawn fertilizers).

The minimum riparian buffer recommended by the US Forest Service for water quality protection *(see diagram below)* is typically a 95-foot strip along each side of a stream or water body that consists of three zones. The first zone should be a minimum 15-foot (preferably 25–35-foot) strip of undisturbed forest next to the stream or water body, which provides detritus and helps maintain lower water



USDA Forest Service, 1992

The Streamside Forest Buffer

temperatures vital to fish. If steep slopes exist near the stream, this first zone may extend to 50 feet or beyond. The second zone is a 60-foot 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 typically a 20-foot strip of grass, or grass and shrubs, reducing the effects of accelerated runoff where concentrated flows are converted to dispersed flows by water bars or spreaders, facilitating ground contact and infiltration. Vegetation management is important in all three zones to maintain a functioning buffer.

David Steckel

Uncontrolled stormwater runoff from adjacent roads and open areas can result in erosion within forested areas.

- *Excessive Stormwater Runoff*

Stream water quality is degraded by erosion, sedimentation, and serious flooding associated with ineffective management of stormwater from impervious surfaces. Uncontrolled roadside runoff (which often contains oils, metals, and salt) from ditches and culverts is a region-wide problem. Severe erosion impacts are evident along stretches of headwater streams in the region, particularly in certain agricultural settings where functioning vegetated buffers have been lacking for many years. Sediment is generated by storm runoff and associated soil erosion from streambanks, farm fields, and construction sites. Excessive sediment in streams can inhibit fish reproduction by smothering eggs, and can harm other aquatic life, particularly bottom-dwelling species that live between pebbles and cobbles, an important link in the aquatic food chain.

Unfortunately, forests are often seen as a good place to direct concentrated runoff from farm fields and roads. While forest cover and forest soils are able to capture and absorb precipitation better than any other land cover, forest vegetation is not good at protecting soils from high amounts of surface water inputs. Frequently, gullies are created within forests by stormwater runoff from adjacent agricultural or residential areas.

- *Household Impacts*

Residences in local watersheds may contribute to high fecal coliform bacteria levels and nutrient levels through failing septic systems and use of phosphate-based detergents. Phosphorus often contaminates runoff from lawns and gardens where chemical fertilizers are used and is an ingredient in household and commercial detergents, which enter creeks through wastewater systems. Phosphorus is the main nutrient responsible for eutrophication (nutrient enrichment, which causes algal blooms) in waterways. As algae decompose, dissolved oxygen is consumed, thereby diminishing the ability of the creek to support healthy populations of fish and other aquatic life. Residents can exacerbate streambank erosion and sedimentation by mowing and dumping near streams (which prevents the growth of tree and shrub

root structures that can stabilize the soil), altering channel shape, or filling wet areas that slow and absorb stormwater.

- *Livestock and Pets in Streams and Wetlands*

The presence of cattle and horses in streams and wetlands can degrade stream quality through trampling and erosion of streambanks and input of waste material. Dogs, even though they are smaller, can have a similar impact on streambanks and water quality, including inputs of nutrients, sediment, and fecal coliform bacteria.

- *Canada Goose Populations*

Unnaturally high levels of fecal coliform bacteria and nutrients are evident in some locations downstream from ponds that attract large Canada goose populations.

- *Dams*

Dams, historically built to facilitate transportation and mills, or more recently for sediment- and flood-control, negatively affect water quality and aquatic habitats. Dam pools trap sediment and allow greater sunlight exposure. The resulting turbidity, silt-covered stream bottom, and high summer water temperature are conditions that native aquatic wildlife cannot easily tolerate. Reservoirs also attract large numbers of Canada geese, adding nutrient and fecal coliform pollutants, and reducing dissolved oxygen.

When floodplains are kept naturally forested and with networks of wetlands, they serve to dissipate the velocity and disperse the volume of flood waters. This reduces downstream hazards to human health and impacts to property.

Aquatic wildlife migration patterns also suffer disruption by dams. Although fish ladders are being installed on the largest dams, thousands of dams exist on streams of all sizes across the region, preventing migration of many species, from shad to American eels to stoneflies.

- *Thermal Pollution*

Unnaturally warm water temperatures along some reaches of local streams may exacerbate the impact of non-point-source pollution on the health of aquatic life. Warm water temperatures are mainly attributable to lack of shade along streambanks, discharge of warm surface water runoff from ponds and detention basins, and runoff from heated pavement and lawn areas. Thermal pollution can trigger a vicious cycle as warm water encourages algal blooms, which absorb more sunlight, further warming water. Algae is decomposed by bacteria, which consume oxygen from the water, further depleting dissolved oxygen.

Flooding

Flooding is a natural process whereby streams overflow their banks during heavy precipitation events or snowmelts and spill into floodplains. In natural settings in this part of the continent, streams typically reach bankfull stage and above once every 1½ years, on average. When floodplains are kept naturally forested and with networks of wetlands, they serve to dissipate the velocity and disperse the volume of floodwaters. This reduces downstream hazards to human health and impacts to property.

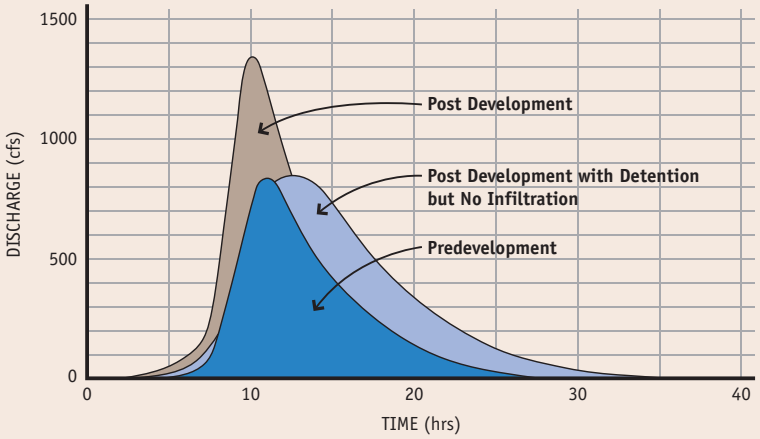
Many of the agricultural areas of the region have been cleared of natural vegetation for centuries. This allows streams to cut deeply into their channels, which reduces their ability to overflow

their banks and disperse energy into the floodplain. As a result, even more downcutting occurs, further increasing the volume of water that the stream channel holds during storm events.

By clearing vegetation, grading and compacting soils, and paving more of the land—even with stormwater management systems—we alter the natural flooding process in a way that prolongs periods of high flow in local streams. The major cause of dangerous flooding is altered runoff patterns, as we plow fields and pave over watersheds, allowing most of the stormwater runoff to head directly into streams rather than recharging into the soil as it would do naturally. The suburban land-use pattern favors seemingly benign single-family residential neighborhoods and shopping centers. However, the construction sites, roads and parking lots, lawns, and sewage systems of this deceptively tame suburban landscape are responsible for the greatest threats to water quality and quantity in the watershed.

Groundwater Depletion

Groundwater depletion is a serious condition that can lead to drying of local wells and loss of baseflow to wetlands and streams. Soils lose their natural groundwater recharge ability when natural vegetation is cleared and replaced with lawn, graded and compacted soils, and impervious surfaces such as paved areas and rooftops. Depletion of groundwater is difficult to monitor, since it requires comparison of groundwater well and stream gauge data over time.



STORMWATER RUNOFF HYDROGRAPH
Conventional stormwater management facilities that do not provide infiltration or evapotranspiration only control the peak rate of runoff, not total runoff volume. Streams may still become degraded, even with stormwater basins, because standard detention facilities unnaturally prolong periods of high flows. All stormwater management facilities should include a volume reduction component.

- *Drinking Water Supplies*

Most local wells are private. Well-drilling permits and data on private well levels and yields has only recently been required by the Montgomery and Chester County Health Departments. When wells go dry, it is difficult to pinpoint the cause—it may be a combination of factors including drought, shallow well depth, increased demand from surrounding wells, and increased impervious surface coverage.

- *Stream Baseflow*

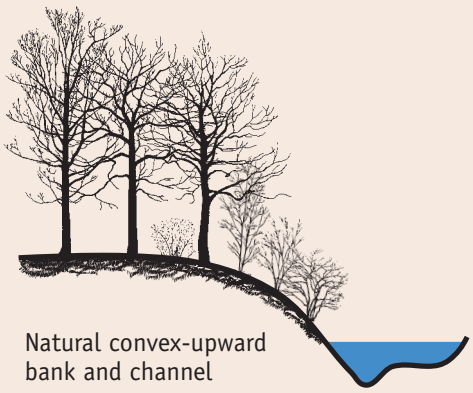
As groundwater supplies diminish, less water reaches the streams that depend on groundwater during dry months. In first and second order streams, decreased

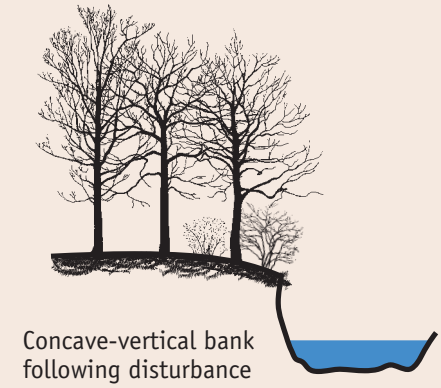
Groundwater depletion is a serious condition that can lead to drying of local wells and loss of baseflow to wetlands and streams.

baseflow magnifies the effects of pollutants. This results in increased stress on pollutant-sensitive aquatic species. Under drought conditions, some southeastern Pennsylvania streams can have so little input from groundwater that 90% of the stream flow is treated sewer discharge during dry summer months.

Streams once buffered by forests that absorb and slow surface runoff must accommodate larger quantities of runoff flowing from developed landscapes and with higher peak rates—"flashier flooding."

Streams in developed watersheds cannot manage the higher stormwater flows, resulting in undercut banks and the stream's loss of access to its floodplain.





In sum, the quality and quantity of surface and groundwater and the ecological integrity of natural areas are closely interrelated. Increased surface runoff generated by poorly planned development results in increased flooding and erosion, diminished groundwater levels, increased pollution of ground and surface water, increased concentration of pollutants, and reduced diversity of native plants and wildlife. **Stormwater Management** *(page 149)* provides general guidelines and innovative strategies for areas under suburban development that will minimize the impact to on- and off-site land and water resources.

Streambank Stabilization

Every stream and its floodplain evolves over time in the context of the specific slope, geology, vegetation, and climate of its drainage area. However, as land use changes, watershed hydrology changes, so the stream system must adapt to manage the new flows. Streams once buffered by forests that absorb and slow surface runoff must accommodate larger quantities of runoff flowing from suburban landscapes and with higher peak rates—"flashier flooding." These same streams, which were once fed by a steady flow of groundwater seeping from a natural landscape, may in turn cease flowing in drier months due to depleted groundwater baseflows.

Natural stream systems in Pennsylvania develop a dynamic equilibrium with their floodplain and channel that creates natural areas of moderate sedimentation and erosion, both in the channel and out onto the floodplain. In an undisturbed watershed, a stream meanders back and forth across its floodplain over the course of time. Streams respond to flashier flood patterns created by land clearing and suburban development by quickly

expanding their channels wider and deeper, inhibiting the meander dynamic.

Broader, more entrenched streams are unable to overflow their banks in flood, restricting all the erosive velocities to the channel. These streams undercut surrounding vegetation, further destabilizing their banks. This causes still more erosion.

Recreational Use

As the amount of natural lands decreases across the region, the value of those remaining grows for both private landowners (as quiet retreats from today's overdrive world) and public landowners (as places for their constituents to recreate). Public landowners and private landowners permitting public access to natural lands are under increasing pressure to allow and facilitate more types of use by greater numbers of people.

Natural lands can accommodate many types of recreational use if the type and level of use is tempered by the ***resiliency*** of the resources within the natural lands. Each type of use places different demands on site resources and each site has a different level of resiliency to each type of use depending on site characteristics, especially soils, slope, and hydrology. Larger expanses of natural land with well-drained soils, isolated wetlands, and no special plant or animal resources can tolerate a greater volume and more types of use than smaller land areas with extensive wetlands or habitats for species of special concern.

Each landowner must decide which uses will be allowed within the natural lands under his or her control. Sometimes this decision has already been made by a previous owner and conveyed through a restriction placed in a will, conservation easement, or deed restriction. If public

Natural lands can accommodate many types of recreational use if the type and level of use is tempered by the **resiliency** *of the resources within the natural lands.*

Why recreational uses matter

the ability of a natural area to tolerate recreational use depends on the site's resiliency

less resilient sites are degraded by use

solve by

gradually adding uses in order of least impact

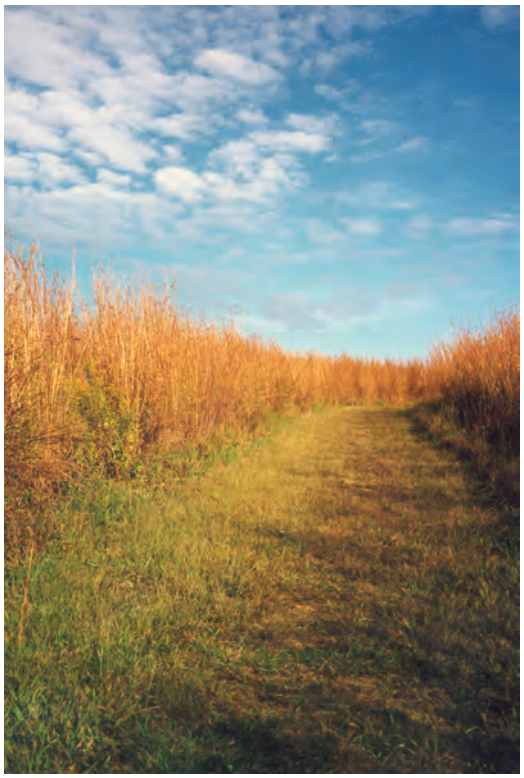
David Harper

A paved walking trail adjacent to wetlands and meadow at the West Vincent Township municipal complex provides observational access to natural areas but is not integrated into them, an appropriate choice for small, heavily used sites.

money (state, county, municipal) is used to protect a property, there is often a requirement to allow some form of public access. In general, use of protected natural lands should be restricted to passive recreation such as hiking, birdwatching, and nature study. In some cases use by equestrians and mountain bikers can be compatible with site resources. Motorized vehicles are usually only appropriate for stewardship activities.

As part of developing a stewardship plan, the landowner should understand the inherent environmental conditions and determine what types of use can be allowed and the appropriate level and place for each use. It is important to make sure that recreational uses do not degrade the environmental and ecological benefits that made the natural lands worth protecting. To that end, it is a good rule to gradually add uses only after the impacts of permitted uses have been ascertained. Start with allowing the use that has the least impact—pedestrian use—and add new uses, or expand current use areas, if the natural lands have not been noticeably degraded. It is much easier to prohibit a particular use from the start than to try to stop it after negative impacts are realized.

The following are a few issues and considerations related to public use that should be addressed in a stewardship plan for natural lands that will be used for recreational purposes.



Mark Eberle

Mowed grass trails at Natural Lands Trust's Gwynedd Wildlife Preserve enable visitors to experience grassland habitat while minimally disturbing wildlife.

Trails

Trails are a feature that can both facilitate stewardship and recreational enjoyment of a property and compromise management efforts and wildlife habitat. On the one hand, trails provide easier access through a natural area for stewardship activities and opportunities for observation, contemplation, exploration, and learning by recreational users. On the other hand, they often serve as avenues for the spread of invasive plants such as stiltgrass *(Microstegium vimineum)* and garlic-mustard *(Alliaria petiolata)*. If sufficiently wide and heavily used, they can become both a barrier to the movement of some wildlife (mice, salamanders) and a "wedge of edge," resulting in a loss of interior forest habitat.

Trails are essential for proper stewardship and recreational enjoyment of natural lands, but if poorly designed or misused they can become stormwater channels that cut into hillsides and remove soil resources. In severe cases, gully erosion can lower the water table and stress established vegetation. Users of natural lands (hikers, equestrians, mountain bikers) may create rogue trails as the "need" or whim arises. This not only results in the formation of potential

erosion channels, but also crushes vegetation, disturbs wildlife, and expands the amount of compacted soil. Compacted soil results in lower water percolation and soil gas exchange—both detriments to vegetation even beyond the area of surface disturbance.

Where recreational use of natural lands is a high priority, trails are the best way to direct that use. ***The main concerns with walking trails are (1) limiting the number of trails to minimize soil exposure, (2) properly routing trails to direct pedestrians to where they should go and away from where they should not go, and (3) minimizing soil erosion potential through proper construction and maintenance.***

If a trail system already exists within the natural lands, it should be reviewed and modified with the goals of minimizing the number of trails (to limit maintenance needs, erosion potential, and soil compaction) and addressing current erosion and safety problems. In general, this will entail closing redundant trails, rerouting trails, and installing appropriate water control structures in unavoidable problem areas. Construction of any new trails should be kept to a minimum, particularly in forested areas, to prevent fragmentation. Unwarranted creation of new trails or inappropriate use of trails in publicly accessible natural lands should be addressed through education (signage, informational brochure, meetings with user groups) and enforcement. It is also recommended that the use of vehicles on trails be minimized, as heavy equipment can disturb and compact soil and can deliver weed seeds to new areas in soil adhering to tires.

Guidelines are given in **Trail Design and Maintenance** *(page 155)*.

© iStockphoto.com/Abby Wilcox

Dogs on trails must be firmly controlled to prevent stress on wildlife and habitat, as well as on other trail users.

Dogs

People walking dogs can be a compatible use of natural lands if dog owners follow a few simple rules. First, dogs should be leashed at all times. Allowing a dog to run off-leash—except on the owner's property or for lawful hunting—is prohibited by state and (most) local community laws. Unleashed dogs threaten the safety and enjoyment of other users. Second, dog walking should be limited to an established trail system to prevent dogs from harassing or killing wildlife, disturbing understory vegetation and degrading streambanks. This damage may seem insignificant or even unnoticeable to us, but to birds nesting in a meadow or native plants just peeking through the soil, the disturbances can be severe, even deadly. Finally, owners should clean up after their pets. Besides being a public nuisance, dog waste can degrade local water resources. Waste left in a natural area can be washed into streams or ponds during storm

events and contribute disease-causing bacteria—including *E.coli* and fecal coliform bacteria—and excess nutrients to local water sources. The latter can lead to algal blooms that eventually decrease the oxygen level of the water body and adversely affect aquatic organisms.

Denise Barringer

On appropriate sites, responsible equestrian use can be compatible with stewardship goals. Riding horses in sensitive areas (steep slopes, wetlands) or at inappropriate times can severely damage trails and degrade soil and water resources.

© iStockphoto.com/Bill Grove

If used infrequently, in large areas with resilient resources, mountain bikes can be compatible with stewardship goals. Otherwise their presence in a natural area can be problematic.

Horses

Southeastern Pennsylvania has a long tradition of equestrian use of natural lands. Equestrian use can be compatible with other recreational uses and have minimal impacts on natural lands if trails are properly laid out and maintained and equestrians are responsible users. Otherwise, potential conflicts with stewardship goals and other users are likely to result. Horses can damage trails under heavy use or if used during wet conditions. Using natural lands as a horse training or exercise facility is hazardous to pedestrians; horse excrement on trails is an unwelcome obstacle for pedestrians and another potential vector for weed seeds. Unless it is an existing use of the site, equestrian use should be added cautiously and only after other uses are established. Ideally, trails can be wide enough—or separate trails created—to minimize the potential conflict between pedestrians and riders.

Mountain Bikes

Mountain bikes can be relatively benign in natural lands under certain conditions (large area, low frequency of use, resilient resources); however, they are problematic if the activity is concentrated and in mixed-use situations. Repeated use of trails (particularly in forested areas) can accelerate trail erosion by funneling stormwater into narrow, continuous channels. Off-trail exploration disturbs understory plants and wildlife. Most importantly, irresponsible use of trails can threaten the safety and enjoyment of pedestrians. Like equestrian use, mountain bikes are best permitted after primary uses are established and only if appropriate conditions exist.

Hunting

The overabundance of white-tailed deer and Canada geese can significantly affect the plant and water resources of a site. The impact of geese can often be addressed by eliminating the cover types that attract them (open water and lawn). However, reducing the impact of deer on large natural lands is best achieved—at this point—through lethal removal. Under current Pennsylvania game laws, the most practical lethal removal option is hunting during established seasons. *(See* **Wildlife Management**, *page 104, for discussion of other lethal and non-lethal options.)* Hunting can be compatible with other recreational activities if it is properly regulated and organized. Ideally, hunters should be screened and required to pass a proficiency test so that only responsible and skilled hunters are allowed on site. This will result in quick, clean kills and maximize safety for other users, including other hunters. Hunters should be informed that they are a vital part of the stewardship program for the site and not just involved in a recreational activity. See the description of Natural Lands Trust's deer management program under **Wildlife Management** *(page 116)* as a model for a regulated hunting program.

Dead Wood

Although often viewed as unsightly waste material, dead wood is the foundation of the forest food chain and also provides shelter to many animal species. In addition, fallen logs and limbs serve as a water reservoir in times of drought. They soak up water and can retain it for long periods of time, providing nursery sites for seedlings (especially during dry spells) and moisture for small animals like salamanders and tiger beetles. Logs also help control erosion by slowing surface water flow and by absorbing water in place. Mycorrhizal filaments reach up from tree roots into fallen wood to extract valuable nutrients.

Individual standing dead trees—"snags"—are also important to leave, when they do not pose a hazard to humans or structures, because they are used as dens by many animals and harbor insects and microorganisms that provide food for many birds and small mammals. These, in turn, are food for larger mammals and birds of prey.

Dead wood should be viewed as a valuable resource within natural areas. It should receive as little "processing" as possible. Hazard trees should, of course, be dropped to prevent injury to trail users, neighbors, or structures. Any tree downed by nature or chainsaw, however, should be left on the ground and cut only as needed to eliminate any trail obstruction, future hazard, or attractive nuisance, and to avoid covering areas of special value such as dense stands of spring ephemeral wildflowers.

Organic Waste Disposal

Placing organic waste (grass clippings, pulled weeds, pruned branches, leaves, etc.) from landscaped areas in natural lands may appear to be a benign, perhaps even beneficial, means of disposal, but this practice can pose real threats. *(Note: Organic waste dumps are different from brush piles created from native materials or the piles of branches resulting from timber harvests, both of which can be food and cover for wildlife and protect tree seedlings from deer browsing. Brush piles are addressed on page 137.)* Materials from landscaped areas are often foreign to the ecosystem and behave

David Steckel

Stockpiled and discarded organic waste is unsightly and also a hazard to humans, wildlife, and the health of natural areas.

very differently from naturally accumulated materials. They can bear seeds of exotic (and in some cases invasive) plants, insects, fungi, bacteria, and chemical properties, some of which can cause harm to native species. They are invariably placed in piles or thick layers and take much longer to decompose than the thin layers of organic material laid down naturally in forests. These unsightly piles severely inhibit the establishment of native plant species from seed while typically providing favorable establishment sites for many introduced invasive species.

In many cases, the dumping of organic (and non-organic) trash originates from adjacent properties. Property boundaries should be monitored on a regular basis to curtail dumping of lawn and garden waste by neighbors.

Aesthetics and Hazards

The long history of intensive human activities in this region (homesteads, agriculture, logging) has left a great variety of debris and hazards within our natural lands. Examples include open wells and foundations, barbed-wire fences, farm dumps, abandoned equipment and vehicles, and toxic materials (e.g., old pesticide and fuel cans, painted and treated lumber). Natural lands are still used as dumping sites for construction and landscape debris and as party spots. To improve the aesthetic and recreational value of a property and to protect both humans and wildlife from harm, an effort should be made to catalog and remove unsightly and potentially harmful materials and structures from natural lands.

In addition to the removal of old debris and hazards, a regular monitoring program should be established to identify and address future issues as soon as possible to minimize their potential impacts. Periodically (as often as practical for the landowner or manager) walking the property boundary and any internal public roads is a good way to identify dump sites and other unwarranted use.

Of particular interest to every landowner with forested natural lands should be the monitoring and removal of "hazard" trees. A landowner can be held responsible for injuries or damages that might result from trees with obvious defects located on their property. All landowners

have the obligation to make a reasonable effort to identify and remove hazard trees (see **Hazard Tree Monitoring Program**, *page 165*).

Trees can become a hazard if they exist near an area or structure with high human use (e.g., residence, road, bench, picnic area) and they have a high potential to fall (whole or in part) due to structural defects. The level of scrutiny for hazard trees in any particular area should be driven by the amount of human use and the presence of structures that could sustain damage. The monitoring program should focus on high use areas or areas with significant structures. Ideally, an arborist, certified by the International Society of Arboriculture, should be hired to annually monitor high hazard areas (public and internal roads, off-site and on-site structures) and remove hazard trees. If possible, any cut portion of a tree in natural lands should be left on site as dead wood. Snags (dead, standing trees) in areas that are infrequently used are best retained for their wildlife benefits.

David Steckel (all)

Typical unsightly and hazardous structures and obstacles found on natural lands: attractive nuisances such as trees fallen across trails, tree forts, and abandoned foundations and wells.

Preparing a Stewardship Plan

The ultimate purpose of any stewardship plan is to provide direction for the landowner or manager to take a parcel of land from its **current state** *to the* **desired state** *based on the landowner's* **goals** *for the parcel.*

IN THIS SECTION

How do I decide what to do with what I've got?

A stewardship plan is essential to good land stewardship. Here you will find a 9-step planning process that will help you to decide what to do with your land and how to achieve your goals.

Natural lands offer a broad menu of both stewardship challenges and opportunities for benefiting wildlife and human users. Successfully addressing the challenges and maximizing environmental, ecological, and recreational benefits requires a serious, on-going commitment to stewardship based upon a long-term perspective of protecting and enhancing the existing natural resources. Developing a stewardship plan is a good process for cataloging existing resources and issues, delineating the landowner's stewardship goals, and developing and implementing strategies for meeting the stewardship goals.

The ultimate purpose of any stewardship plan is to provide direction for the landowner or manager to take a parcel of land from its ***current state*** to the ***desired state*** based on the landowner's ***goals*** for the parcel. This might entail a significant change and detailed instructions or a simple plan that confirms or slightly modifies the stewardship activities already in place. Consider the example of an existing healthy meadow. If your strategy is to create a forest in this area to meet the goal of increasing interior forest habitat, the plan would need to address many issues involved in converting the meadow to forest, including the types and number of trees to plant, when to plant them, and how to protect them from deer and invasive plants over several decades. If your goal is to maintain the meadow for grassland bird habitat, the plan will codify the current stewardship regimen and address minor issues (e.g., spot-spraying scattered invasive plants) to better protect on-site resources.

The complexity of the plan will be directly proportional to the complexity of the parcel (the number of different cover types) and the number of goals the landowner wishes to meet. A stewardship plan also grows in complexity with the degree of degradation of existing resources and how much the area will need to be modified to help meet stewardship goals.

The process for developing a stewardship plan involves nine steps:

Step 1: Inventory existing natural resources and current stewardship issues.

Step 2: Delineate natural lands from the remainder of the property.

Step 3: Establish stewardship units, delineating areas with similar vegetation and past management.

Step 4: Establish the conservation priority for the natural lands.

Step 5: Establish the stewardship goals for the natural lands.

Step 6: Determine appropriate stewardship strategies for each unit.

Step 7: Prioritize and schedule stewardship tasks for each unit.

Step 8: Establish a monitoring program to determine if goals are being met within each stewardship unit.

Step 9: Assemble the Stewardship Plan to record information gathered and decisions made.

Remember that ***because natural systems are continually evolving, land stewardship must similarly evolve over time*** as new stewardship issues are identified, land management knowledge and technology change, and stewardship goals are modified. Therefore, stewardship plans should be revisited on a regular basis (every 3–5 years, or following a significant change, such as new ownership or modification of the conservation priority or stewardship goals) to make sure they are still appropriate in all respects. Steps 6 and 7 should be reviewed and revised as needed on an annual basis.

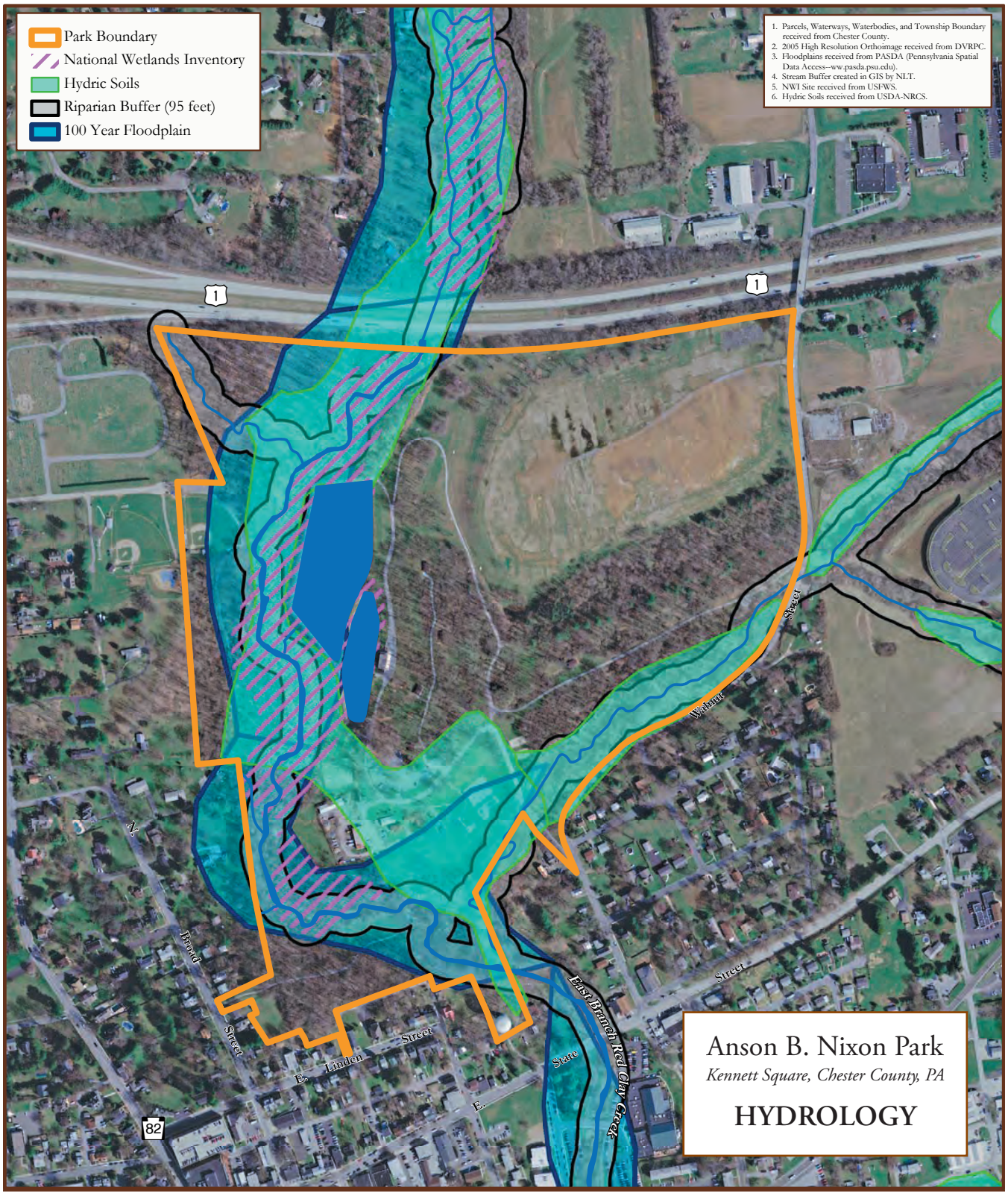
Step 1
INVENTORY EXISTING NATURAL RESOURCES

The first step in developing a stewardship plan is to survey the property to identify the existing natural resources and document any issues that might affect the stewardship or use of the property through a process called ***site analysis***. A site analysis will: (1) identify any legal restrictions on the property; (2) document the physical resources (geology, soils, hydrologic features, slopes) and vegetation (type, condition, and extent); and (3) note special features, such as rare plants, scenic locations, trails, and large trees, as well as the presence of stewardship challenges and issues, such as invasive species, erosion, or safety hazards. This process should result in a thorough understanding of the property's environmental and ecological resources, the threats to the integrity of those resources, and the property's potential—and limitations—for use.

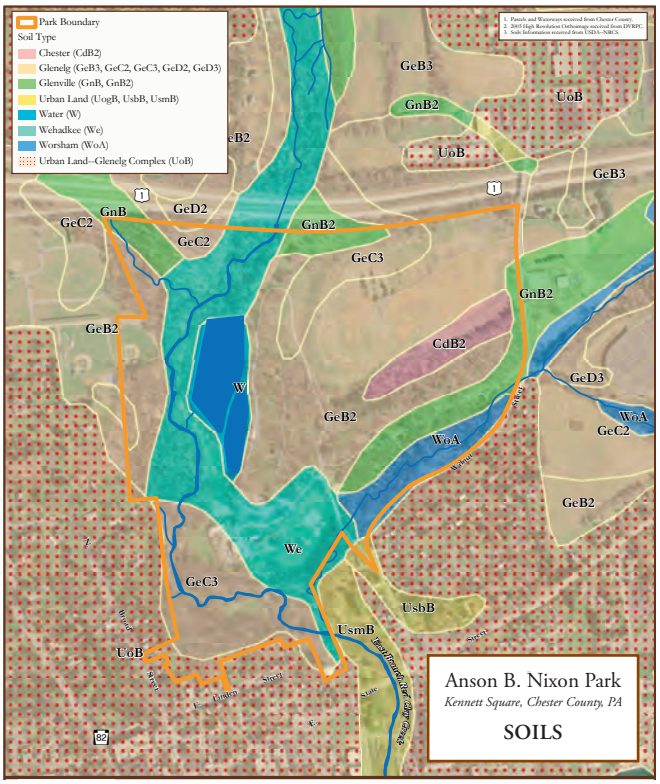
A site analysis starts with a base map showing property boundaries, easements and rights-of-way, adjoining ownership, existing roads and structures, water features, forested and open areas, and any other relevant features. Mapping of the detailed natural features (geology, soils, topography and slopes, hydrology, and vegetation cover), along with existing man-made features such as historic structures, gardens, and landscape elements, is then overlaid on the base map individually or in combination.

Geology and soils will indicate what general type of plant communities—terrestrial (upland) or palustrine (wetland)—would typically occur on various parts of the site. Unusual bedrock types can indicate the potential for uncommon plant communities (e.g., serpentine barrens, diabase meadows, calcareous fens). Hydrologic features include surface water features (ponds, streams, springs), wetlands, floodplains, and hydric soils. Moderate (15–25%) and steep slopes (>25%) can be calculated from topographic contour lines.

The vegetation information gathered for a site analysis can range from simply



Michael McGeehin



listing major cover types (deciduous forest, agricultural field, etc.), to identifying the plant communities present and noting dominant native and invasive species, to undertaking a detailed inventory of the canopy, understory, shrub, vine, and herbaceous layers. Obviously, because stewardship largely involves manipulation of plant resources, the greater the detail the better. The level of detail, however, will depend on the available resources of the landowner.

Special features important to note include large trees, plant and animal species of special concern (endangered, threatened, or rare), patches of uncommon wildflowers (especially spring ephemerals), seasonal pools, and wetlands. Stewardship issues that might be encountered include lack of native plant advance regeneration, invasive species, erosion (due to on- or off-site uses or problems), lack of adequate riparian buffer, old structures, hazard trees, and dumps.

The maps on these two pages are examples of detailed maps showing the range of site characteristics that can be cataloged for a site analysis and on the following page is an example of a simplified site analysis map that would be sufficient for many landowners.

Michael McGeehin (all)

Holly Harper

Mapping and Site Analysis Information Sources

INFORMATION SOURCE	TYPE OF INFORMATION PROVIDED	AVAILABLE FROM
Property deed	property line description, easements and rights-of-way, adjoining ownership	county recorder of deeds
Tax map	property boundaries, easements and rights-of-way, adjoining ownership, roads	county and municipal offices
Survey	property boundaries, easements and rights-of-way, adjoining ownership, roads, structures, water features, wooded areas, topography, soils, wetlands, floodplain	owner, surveyor
Aerial photographs	roads, structures, water features, wooded and open areas	Delaware Valley Regional Planning Commission (www.dvrpc.org), Pennsylvania Spatial Data Access (www.pasda.psu.edu), county
US Geological Survey (USGS) quadrangle maps	roads, structures, water features, topography	sporting goods stores, map stores/ dealers, library, Pennsylvania Spatial Data Access (www.pasda.psu.edu)
Geology maps	geology	Atlas of Geologic Quadrangle Maps of Pennsylvania, library, Pennsylvania Spatial Data Access (www.pasda.psu.edu)
County soil survey	soils, previous vegetation	Natural Resources Conservation Service (NRCS), Pennsylvania Spatial Data Access (www.pasda.psu.edu)
National Wetlands Inventory maps	wetlands	US Fish and Wildlife Service, Pennsylvania Spatial Data Access (www.pasda.psu.edu)
County Natural Areas Inventories	natural areas, species of special concern	county, Pennsylvania Natural Heritage Program (www.naturalheritage.state.pa.us)
Field surveys	natural resource assessment, stewardship issues	natural resource consultant

Step 2

DELINEATE NATURAL LANDS

The next step in developing a stewardship plan is to use the information gathered through the site analysis to determine which areas of the property will be designated as natural lands and addressed under the plan. (For the purpose of the *Stewardship Handbook*, we define natural lands as areas that are covered entirely or mostly by plants that are native—or those that have become naturalized—to the southeastern Pennsylvania region. In general, natural lands do not receive or require ongoing, intensive management—as do agricultural or landscaped areas—to perpetuate.)

For most properties in this region, the

DELINEATING NATURAL AREAS

Holly Harper

general limits of the natural lands are fairly easy to establish. They are basically the areas outside of the landscaped and agricultural (cultivated fields, pasture, orchard) areas on the property. What will require some thought is: (1) whether any part of the current natural area will be used for other purposes in the future, such as the site for a house or playing field; or (2) if any of the current area in landscape plantings (e.g., lawn) or agriculture can be converted to natural lands.

To illustrate this step we will consider two scenarios: (1) delineating natural lands on a residential property; and (2) delineating natural lands for a conservation subdivision. Using the site analysis map shown on page 48 for the first scenario, we can delineate the natural lands most easily by outlining and excluding the areas that will be maintained in formal landscaping (areas that will be maintained as lawn, gardens, or recreation sites) or managed for agricultural purposes (crops or pasture for livestock). As the property is used now, the natural lands would include the forest, hedgerows, wetlands, and old field/shrub areas.

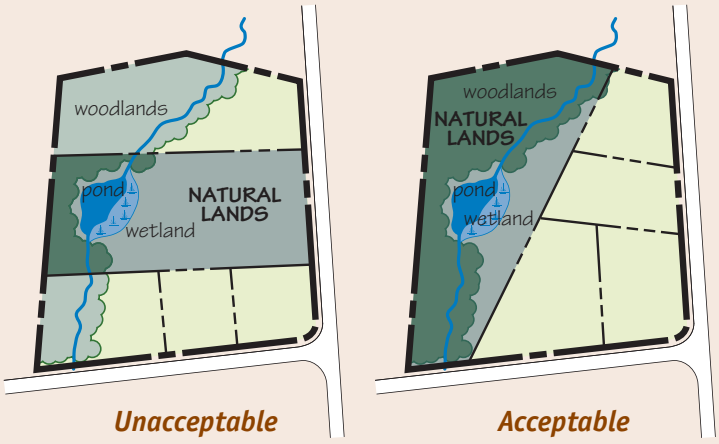
Additional parts of the property could be added to the natural areas depending on the specific conservation priorities and the financial resources of the landowner. For example, if a conservation priority for the property is to protect the stream and the landowner no longer needs the income generated from the crop fields, the crop fields could be converted to forest or native meadow to better buffer the stream *(see map at left)*. The area around the pond could also be converted to native meadow or forest to shade the water surface, discourage Canada geese, and improve habitat for less common waterfowl and other wildlife.

The second scenario, delineating natural lands for a conservation subdivision, is more complicated because you also need to delineate multiple residential lots. The examples on this and the following pages illustrate simple design guidelines for refining the boundaries of the natural lands. Following these guidelines will result in the design of better, more effective natural lands that meet the conservation goals of the municipality and landowner, maximize environmental and ecological benefits, and are easier to steward.

Natural areas design guidelines

1.0

Natural lands should include the most sensitive resource area of a property.



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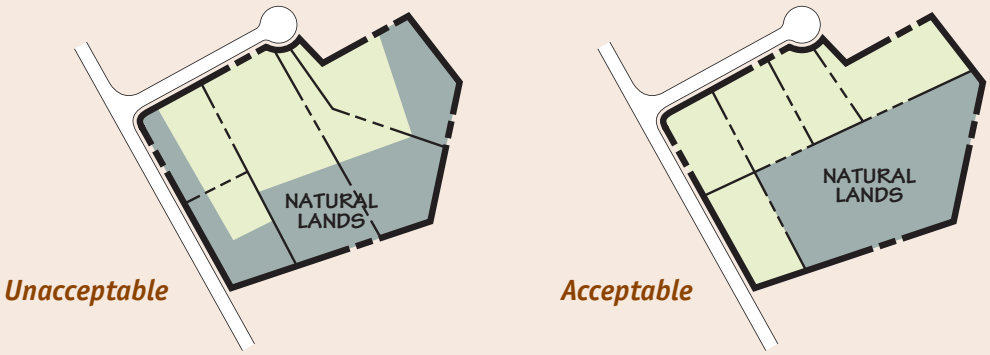
Natural areas design guidelines, *cont.*

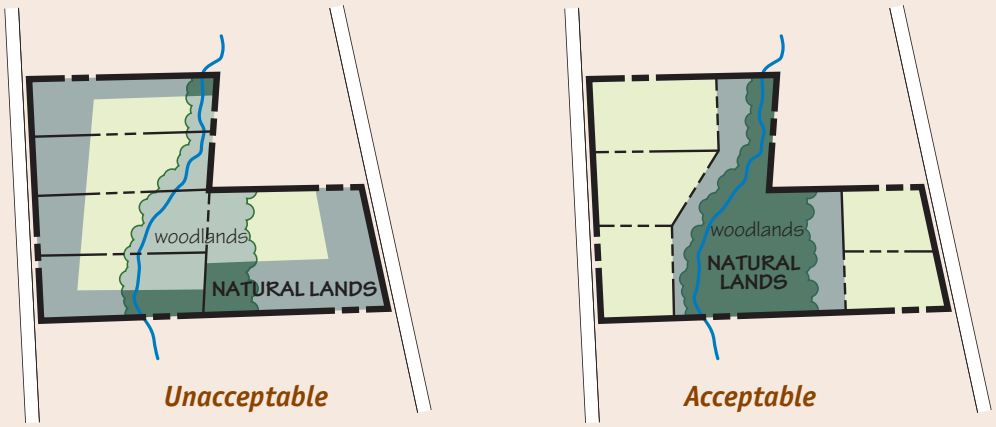
2.0

Natural lands should be designed as one, large block of land with logical, straightforward boundaries.



Unacceptable ***Acceptable***

2.1 In the case of a planned subdivision with common open space, the natural lands should encompass as few ownerships as possible (preferably just one) to limit the difficulty and complexity of future monitoring and enforcement. If more than one ownership is absolutely unavoidable, then the natural lands should be configured so that one parcel contains all of the most sensitive features of the natural area such as wetlands and riparian buffers, to avoid fragmenting the natural system and to ease the burden of monitoring and enforcement.



Unacceptable ***Acceptable***

2.2 Long, thin strips of land should be avoided as natural lands unless they are necessary to connect other significant lands or are designed to protect a linear resource that cannot otherwise be protected, e.g., a stream or trail.

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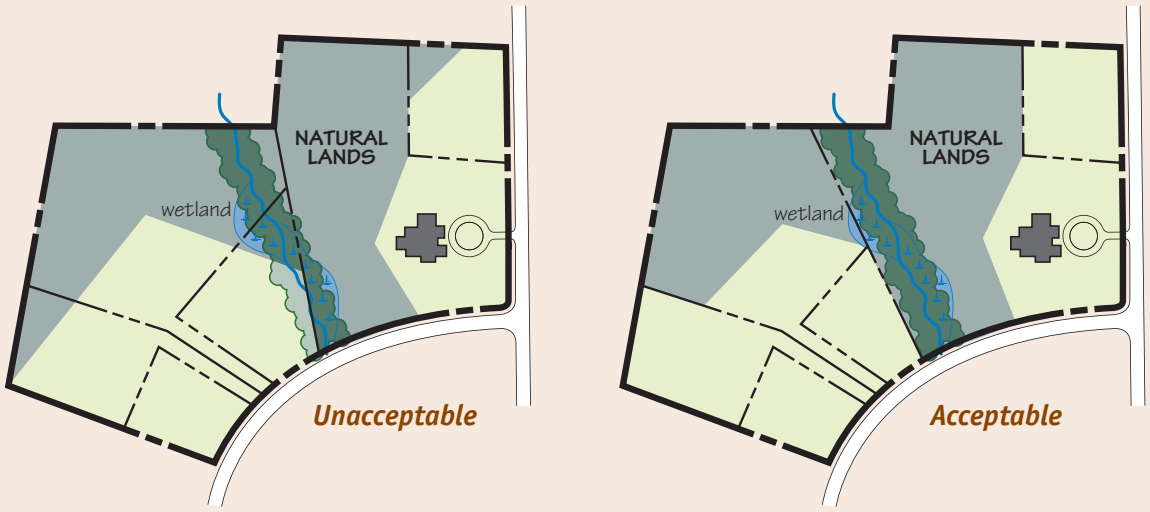
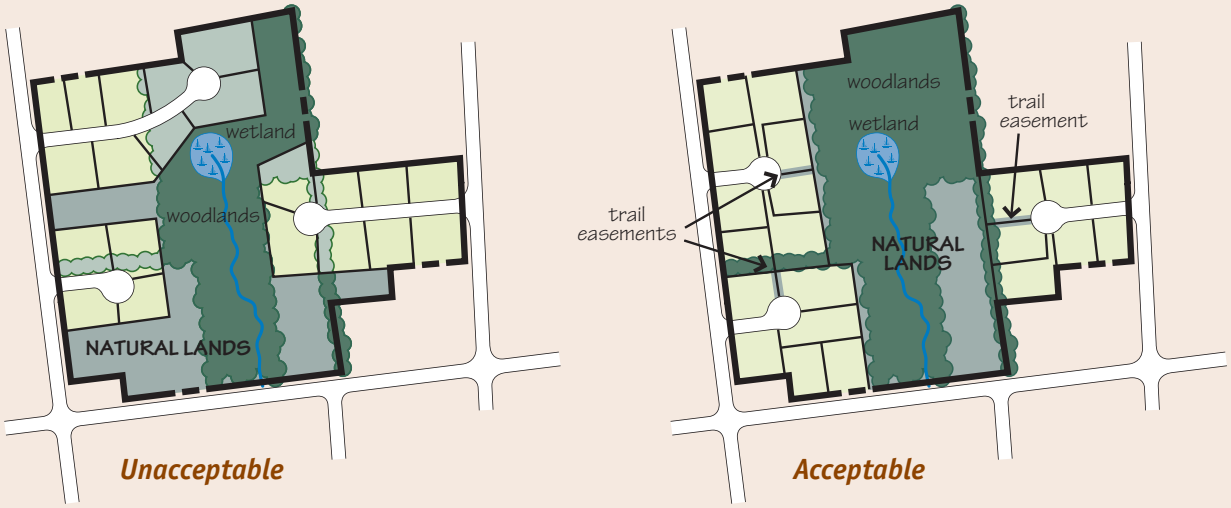
Natural areas design guidelines, *cont.*



2.3 Under no circumstances should a natural area extend into small corners of individual lots.



2.4 The boundaries of natural lands should be designed to be as simple and straight as possible, so they can easily be found in the field and enforced. Where possible, natural boundaries or existing features of the land should be used, such as a forest edge or a stream buffer.

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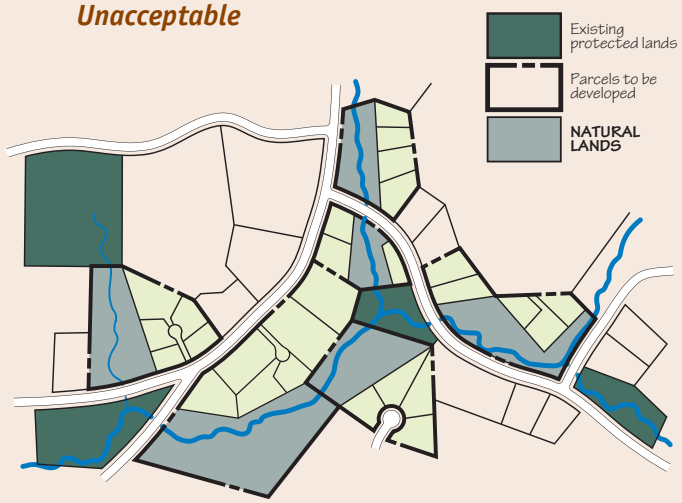
Natural areas design guidelines, *cont.*

3.0

Natural lands should be designed as part of a larger continuous and integrated open space system. Maintaining or creating connections to natural lands on adjoining properties significantly increases the value of both areas.

Unacceptable

3.1 If the natural lands are or will be legally protected, they should be designed to be contiguous to other protected areas on adjoining lands, if possible.



Acceptable

3.2 Where this is not possible, some connection to the other protected areas should be made.

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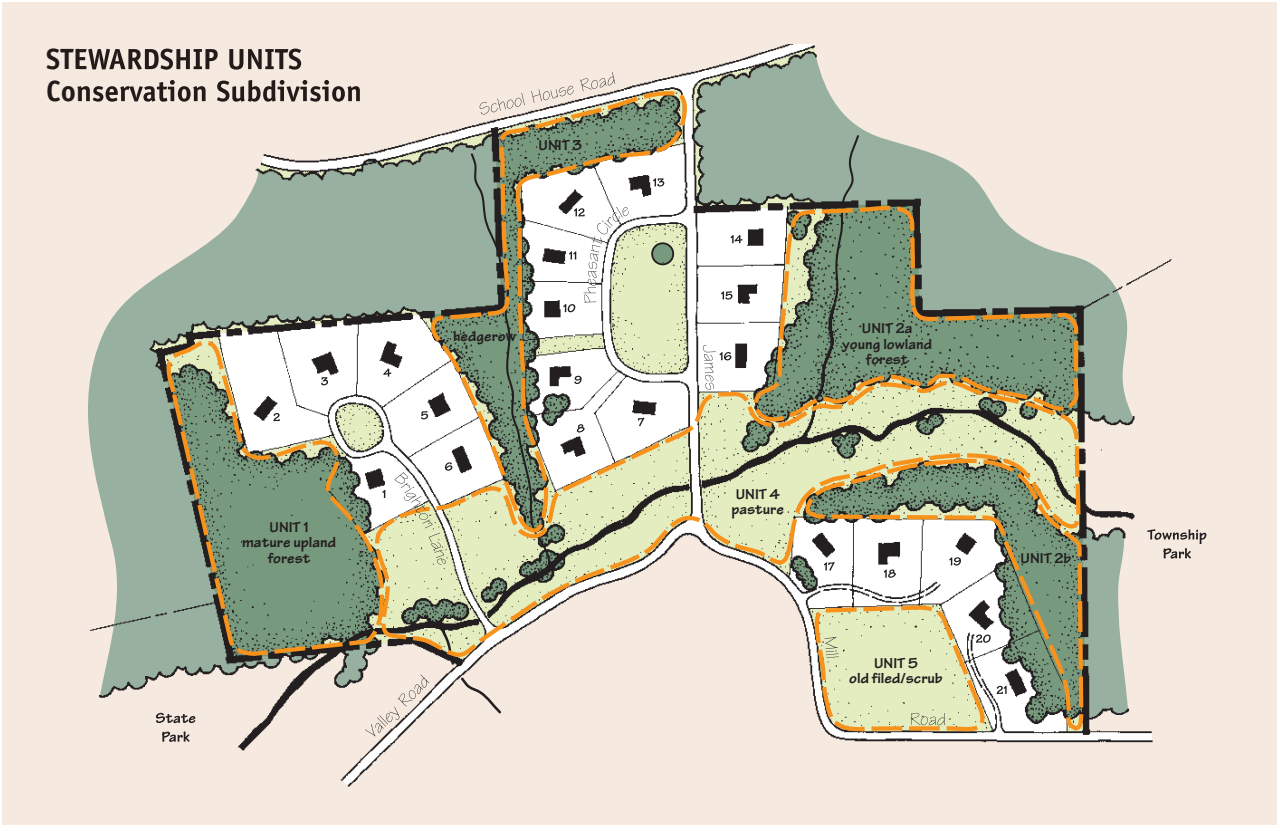
Step 3
ESTABLISH STEWARDSHIP UNITS

Unless the property is very small, its natural lands will usually consist of more than one cover type. Because stewardship goals, strategies, and tasks are often different for different cover types, it is helpful to separate areas with different cover types—or disconnected areas with the same cover type—into stewardship units. Delineating stewardship units on a map creates a common view and vocabulary for the property and allows you to discuss the current features and condition of each area of the property more clearly with stakeholders (family, residents, constituents, staff), consultants, and contractors.

The map at right shows the stewardship units for the residential property scenario



Holly Harper (both)

from Step 2. The second map on page 55 is an example of a fully designed conservation subdivision with stewardship units.

Step 4
ESTABLISH THE CONSERVATION PRIORITY

Natural lands are conserved because they have some type of ***conservation value*** to current or former decision-makers. Examples of conservation values include:

- **Environmental** – high quality water resource, special geologic feature
- **Ecological** – important wildlife habitat, rare and endangered species
- **Recreational/Scenic** – natural environment for homeowner or local community, gamelands, viewshed from public roadway
- **Historical** – cultural features and use
- **Programmatic** – environmental education
- **Income Sources** – timber production

The decision-maker is the person(s) that placed a legal restriction (such as a conservation easement or deed restriction) on the property that runs with the property title or the person or entity (corporation, municipality) who currently holds legal title to the land. If the landowner is trying to determine the conservation values of a site, the site analysis will identify the special features of the property that warrant conservation. The site analysis will, in most instances, identify more than one conservation value. Unfortunately, it is not always possible to steward natural lands in a manner that protects and enhances every conservation value of a site. The critical decision that must be made in developing a stewardship plan is which conservation value is most important, in other words, what is the ***conservation priority***. *The conservation priority will be the engine that drives all future stewardship decisions for the natural lands.* All stewardship decisions should focus on protecting and enhancing the conservation priority of the natural lands. (It is possible to have multiple conservation priorities, particularly for very large properties, but more than two or three will muddle the decision-making process.)

What or who determines the conservation priority of each site? While the relative importance of all conservation values should—and usually does—figure prominently in this decision, the conservation priority is ultimately determined by those with legal authority over the property. The following decision tree will help you determine the conservation priority for the natural lands of any site.

1. **Do any legal documents, for instance, the will of the former owner, a conservation easement, a deed restriction, municipal open space plan, or subdivision approval, specifically dictate how the natural lands should be used or managed?** Examples could include: the site must remain in a particular condition (forest, meadow, agriculture); be managed for a specific species or group of animals (bog turtle, interior forest birds); or used for environmental education.

- *If yes, the conservation priority is determined.*
- *If no, proceed to Question 2.*

2. Are there any features protected by federal regulations? Plant and animal species listed on the federal Endangered Species List (e.g., bog turtle, bald eagle) are protected from activities that threaten the viability of a local population. Landowners with a listed species on their property should consult with the US Fish and Wildlife Service before undertaking any activity—you will be given an Incidental Take Permit if the activity will not harm the species—within the property. Although you do not violate any law by not consulting with the US Fish and Wildlife Service, if you proceed with an activity that does harm the population, you can be prosecuted under the Endangered Species Act.

- *If yes, the conservation priority, at least for part of the natural lands, is determined.*
- *If no (or yes, but it only affects part of the natural lands), proceed to Question 3.*

3. Does the current landowner have a specific conservation interest? Without any specific legal restriction or federally regulated resource on the property, the current landowner has the authority to determine the stewardship of any property, within the guidelines of local ordinances. The landowner may have a specific interest for the natural lands such as environmental education or timber production.

- *If yes, the conservation priority is determined.*
- *If no, proceed to Question 4.*

4. Can the property help protect or enhance a local, regional, or statewide conservation priority? In many cases, the former or current decision-maker (landowner, township board of supervisors) did not or does not have a specific stewardship interest, but instead desires to see the property used to support a general interest such as wildlife habitat, the protection of a high quality stream, or as a place for private or public recreation. While these interests will need to be addressed in the stewardship plan, their more general nature allows the conservation priority to be shaped by other conservation considerations and to change over time as the needs and concerns of the landowner or general conservation community change.

In order to determine how best to use the property to fulfill general conservation goals, it is helpful to understand the conservation priorities of local, regional, or statewide organizations and agencies *(see* **Resources**, *page 211)* and to view the property as part of a larger landscape. Helping to address a larger conservation priority could help determine the conservation priority of the property. Using the residential scenario from Step 2, the two maps on page 58 provide a simplified illustration of how the surrounding landscape might influence your choice of conservation priority. The first map shows the property within a large forested landscape. Converting the open areas to forest

The critical decision that must be made in developing a stewardship plan is which conservation value is most important, in other words, what is the **conservation priority**.

Landscape context might help you determine your conservation priority. Depending on the cover type of surrounding properties, you may choose to manage for forest birds *(top)* **or grassland birds** *(bottom)*.

Holly Harper (both)

would significantly add to interior forest habitat to the benefit of threatened songbirds. On the other hand, if the property rested within an open landscape of farmland and meadow and the more isolated forested areas on the property are heavily degraded, it might be best to eventually convert them to native meadow to expand interior habitat for threatened grassland birds. These two examples show that the same general landowner interests (wildlife habitat) can result in very different conservation priorities depending on the landscape context.

Step 5

ESTABLISH THE STEWARDSHIP GOALS

Once you have determined the conservation priority for the natural lands, you are well on your way to establishing the stewardship goals, that is, the desired future condition and use of the natural lands. ***The first stewardship goal should always be to protect and enhance the conservation priority of the property.*** There can be many other stewardship goals, but none should conflict with this primary goal. From the examples of conservation values in Step 4 above, the stewardship goals could be as follows:

Primary goal

- Protect and enhance the forest bird species of special concern

Secondary goals

- Protect the water quality of the creek
- Provide recreational access for local residents

Step 6

DETERMINE APPROPRIATE STEWARDSHIP STRATEGIES

Once goals are set for the entire area of natural lands of a property, stewardship strategies to achieve them can be established for each stewardship unit. Simply stated, the strategies lay out what will happen over the coming years in each unit to further the stewardship goals of the entire area of natural lands. Stewardship strategies should generally increase the environmental and ecological values of a unit while meeting a stewardship goal. The following are examples of common stewardship strategies.

Vegetation Management

~ Maintain current cover type

~ Convert to new cover type (discussed in detail in **Cover Type Options**, page 66)

~ Control invasive plants (physical removal, cutting, planting, herbicides, fire)

~ Establish mowing or burning regimen

Wildlife Management

~ Control disrupted wildlife populations such as an extreme abundance of white-tailed deer or Canada geese

~ Enhance habitat by creating snags, leaving dead wood, installing nesting boxes and basking logs

Improve Aesthetics/ Eliminate Hazards

~ Remove trash

~ Discourage dumping

~ Remove or secure obsolete/ deteriorating structures

~ Remove hazard trees

Stormwater Management

~ Take action to halt active erosion

Public Use

~ Construct or realign trails

~ Create interpretive materials

~ Establish an environmental education program

Step 7

PRIORITIZE AND SCHEDULE STEWARDSHIP TASKS

The next step in creating a stewardship plan is determining what tasks need to be done and in what order to implement the stewardship strategies and achieve stewardship goals.

Stewardship tasks are generally divided into ***restoration tasks*** and ***routine tasks***. Restoration tasks typically require a concentrated effort for a relatively short period of time. The need for them is often a legacy of insufficient resources, interest, or knowledge to perform routine tasks (such as invasive species control, deer management) in the past or the result of an unexpected disturbance, for example, tree blowdowns from high winds, erosion from heavy rain, or illegal dumping. Routine tasks are ongoing (monitoring for unwarranted use or hazards, mowing trails, equipment maintenance) or cyclical (cutting vines in the winter, mowing or burning meadows in early spring, administering a controlled deer hunt).

Restoration and routine tasks are largely outgrowths of the stewardship strategies for the natural lands. Unless time or financial resources are unlimited, you will need to prioritize tasks in order to have the greatest impact with the available time and money.

The following are general guidelines for prioritizing restoration tasks.

- **Address hazards to humans and wildlife**, such as hazard trees, obsolete structures (abandoned wells, fencing, buildings), or hazardous waste.
- **Address conditions that are actively degrading the conservation priority or other conservation values**, such as ongoing soil erosion that is degrading high quality water resources.
- **Remove unsightly debris** to avoid encouraging additional dumping.
- **Address issues affecting the desired cover type**, such as invasive plants or overabundant deer.

This should not be viewed as a list to be completed sequentially, but it is the typical order of importance or urgency of restoration tasks in our region. In many cases these tasks will require the services of contractors or volunteers, which can complicate the logistics of starting the work. Also, because support is sometimes available from public agencies for restoration tasks (tree planting, erosion control) implementation can be delayed by administrative requirements (e.g., grant applications, budget approvals).

The timing of routine tasks is generally dictated by the season *(see table on following page)*. Routine monitoring of property boundaries, hazard trees, and invasive species is often best done during the winter months when access to and visibility within natural lands is best. Meadow mowing has least impact on wildlife in late winter (prior to March 15); trail mowing needs to occur throughout the growing season. Time available for deer management using recreational hunters is restricted to the seasons set by the Pennsylvania Game Commission.

General Stewardship Task Schedule

(see individual sections under **Stewardship Techniques and Procedures** *for more details)*

QUARTER	TASK
1st Quarter (January – March)	**Monitor property boundaries for unwarranted use** 1. Repost as needed 2. Address unwarranted use as needed **Monitor for hazard trees** 1. Prune or remove as needed **Control invasive plants** 1. Cut vines in canopy trees 2. Cut/herbicide shrubs 3. Spray evergreen vines on days above 45˚F **Maintain meadows** 1. Mow or burn if appropriate conditions and approvals exist **Mow/selectively cut shrublands if needed** **Perform winter maintenance on equipment and structures**
2nd Quarter (April – June)	**Prep and plant meadows prior to June 1st** **Water recently planted trees and shrubs as needed** **Maintain established meadows** 1. Burn meadows if appropriate approvals and conditions exist **Control invasive plants** **Maintain trails** 1. Mow bi-weekly through growing season 2. Regrade and seed as needed 3. Install and maintain waterbars as needed **Perform equipment maintenance as needed**
3rd Quarter (July – September)	**Maintain trails** 1. Mow bi-weekly through growing season **Water recently planted trees and shrubs as needed** **Administer wildlife management programs if needed** **Control invasive plants** 1. Spray broadleaf weeds in grasslands **Maintain meadows** 1. Mow or burn if needed **Perform equipment maintenance as needed**
4th Quarter (October – December)	**Administer wildlife management programs if needed** **Prep and plant meadows prior to November 15th** **Control invasive plants** 1. Cut vines in canopy trees 2. Cut/herbicide shrubs 3. Spray evergreen vines on days above 45˚F **Maintain meadows** 1. Mow or burn if needed **Perform equipment maintenance as needed**

Step 8
ESTABLISH A MONITORING PROGRAM

To most efficiently and effectively meet the conservation goals established in a stewardship plan, environmental and ecological changes—those resulting both from management activities and from new influences on the property—should be tracked. With periodic feedback as to which stewardship activities are or are not working, together with increased knowledge and new technologies, the stewardship of natural areas can be modified to better achieve established conservation goals. There should also be periodic (at least annual) monitoring to identify new disturbances (dumping, new invasive species, erosion) so they can be addressed as soon as possible.

Monitoring should involve regular collection and analysis of data (measurements or observations) to evaluate change or progress toward meeting stewardship goals. The recommended approach for a practical monitoring program is to use the modern decision-support concept of ***adaptive resource management*** (ARM), which is a scientifically based way of "learning by doing." ARM has been termed "managing in the face of uncertainty, with a focus on its reduction." Implicit in this definition is that management can be improved if uncertainty is reduced.

Monitoring should address measurable goals; specific monitoring techniques should be designed to be repeated at regular intervals and to produce statistically valid results.

Adaptive Resource Management (ARM) *has been termed "managing in the face of uncertainty, with a focus on its reduction."*

ARM involves five basic steps

1. **Determine (or review and update) conservation priorities for the property.**
2. **Set and quantify resource stewardship goals for each conservation priority.**
3. **Formulate a set of stewardship strategies and tasks that are designed to move the system toward the goals.**
4. **Measure progress toward the goal at regular intervals (e.g., every three years) using indicator species and other environmental indicators.**
5. **Update the set of stewardship strategies and tasks based on the effectiveness of each action to move toward the goals.**

Repeat cyclically.

Step 9
ASSEMBLE THE STEWARDSHIP PLAN

The final step in preparing a stewardship plan is organizing all of the information gathered and decisions made in a single document. The resulting stewardship plan becomes a handy reference and an annual reminder of stewardship unit strategies that will guide the development of a task list each year.

Because the stewardship plan is intended to be a living document—growing as new information is learned about the property and evolving as conservation priorities change—it is often best to keep the document in a three-ring binder that can easily accommodate these adjustments. The following is a sample outline for constructing a stewardship plan.

GENERAL AND BACKGROUND INFORMATION

- Name of property
- Plan writer/Plan date/Revision dates
- Landowner
- Date of acquisition
- Property size, location and directions
  - ~ *Location map (USGS)*
  - ~ *Site map*
- Regional context
  - ~ *Aerial or satellite photo of surroundings and description*
  - ~ *Protected lands map and description*
- Ownership/stewardship history
  - ~ *Historical aerial photos*
- Legal restrictions/Donor's wishes/Vision

NATURAL RESOURCES INVENTORY AND ANALYSIS

- Geology
- Soils
- Topography and slopes
- Hydrology

~ *Individual or combined maps for above*

- Plant resources
  - ~ *Plant communities map and summary, including condition*
  - ~ *Plant species summary*
  - ~ *Plant communities and species of special concern/county natural area inventory*
  - ~ *Representative photos*
- Animal resources
  - ~ *Animal species summary*
  - ~ *Animal species of special concern/county natural area inventory*
- Special features
  - ~ *Scenic views description and map*
  - ~ *Rock outcrops and other geological features description and map*
  - ~ *Photos*

CULTURAL AND HISTORIC RESOURCES INVENTORY AND ANALYSIS

- Existing structures and facilities
  - ~ *Buildings, bridges, boardwalks, etc. description and map*
  - ~ *Parking, trails, signs, fences, gates, etc. description and map*
  - ~ *Photos*
- Public use
  - ~ *Policy*
  - ~ *Existing uses*
  - ~ *Proposed uses and improvements*

STEWARDSHIP ISSUES

- Forest regeneration
- Overabundant wildlife species
- Edge effects
- Invasive plant species
- Lack of riparian buffers
- Erosion

continued...

...continued

- Recreational use
- Unwarranted use
- Aesthetic degradation and hazards
- Other

~ *Individual or combined maps for above where appropriate*

~ *Photodocumentation*

CONSERVATION VALUES AND PRIORITIES

- Conservation values
- Conservation priority/priorities

LAND MANAGEMENT

- Stewardship units
  ~ *Map*
- Stewardship goals
- Stewardship strategies and tasks
  ~ *Unit 1*
    - *Strategies to protect and enhance natural resources*
    - *Restoration tasks*
    - *Routine (annual) tasks*
    - *Strategies to facilitate public use*
    - *Programmatic tasks*
    - *Monitoring tasks*
    - *Photos where appropriate*

  ~ *Unit 2*
    - *(Categories as above)*

  ~ *Unit 3 (etc.)*
- 5-year prioritization and scheduling of tasks

FINANCIAL RESOURCES

- Operating budget
- Capital budget
- Funding needs

APPENDICES

- Legal description/survey
- Donation agreement/Grant restrictions
- Plant inventory
- Animal inventory
- Pennsylvania Natural Heritage Program/County Natural Area Inventory descriptions of community or species of special concern
- Techniques and procedures – wildlife management program, invasive plant management program, hazard tree monitoring program, etc.

STEWARDSHIP PLAN SUMMARY

STEP	PURPOSE	LEVEL OF FOCUS
Step 1: Inventory existing natural resources	Catalog and map existing resources	Entire property
Step 2: Delineate natural lands	Identify lands to be included in natural lands	Entire property
Step 3: Establish stewardship units	Outline areas with similar conditions for ease of planning and discussion	Natural lands
Step 4: Establish the conservation priority	Identify why the area is important to conserve and establish the most important conservation value	Natural lands
Step 5: Establish the stewardship goals	Establish the desired future condition and use of the natural lands	Natural lands
Step 6: Determine appropriate stewardship strategies	Determine what will be done to take natural lands from current condition to desired future condition	Stewardship units
Step 7: Prioritize and schedule stewardship tasks	Determine the order that tasks will be completed to implement stewardship strategies	Stewardship units
Step 8: Establish monitoring program	Create a means for determining the effectiveness of current stewardship strategies for achieving stewardship goals by setting measurable goals and monitoring periodically	Natural lands
Step 9: Assemble Stewardship Plan	Organize information gathered and decisions made into a single document	Natural lands
Periodically repeat Steps 4 through 7 and update Stewardship Plan as needed		

Cover Type Options

OVERVIEW

To protect and enhance your natural lands, the most important stewardship strategy to develop is the desired vegetation (cover type).

Usually the ***greatest effect a land manager can have on achieving stewardship goals is through vegetation (cover type) management***. This can range from as little as removing a few invasive plants from a relatively pristine forest to converting an open field to forest through tree planting or converting a pond to wetlands. Before you can make the decision to maintain the current cover type of a stewardship unit or convert a stewardship unit from one cover type to another, it is best to understand the characteristics of each cover type. This section of the *Handbook* highlights the major cover types that can be found in southeastern Pennsylvania. For each cover type there is:

- an overview of the cover type;
- the common forms or categories of this cover type in the region;
- its potential for addressing regional conservation priorities;
- the current stewardship issues generally associated with the cover type; and
- general stewardship guidelines.

This information and the site analysis *(see page 45)* is used to develop the cover type strategy for each stewardship unit, that is, the desired vegetation (forest, meadow, etc.) of each unit. Generally this is the most important stewardship strategy to develop in order to protect and enhance the conservation priority. The **Stewardship Matrix** on the following page and guidelines within each cover type section provide direction for the development of the cover type strategy.

The determination of which cover type option is best for a given stewardship unit will be influenced by numerous considerations. These include site conditions, existing resources on adjacent properties, the historical use of the site, and the amount of financial commitment that can be given to the stewardship of the natural lands. All factors must be weighed in determining which avenue to pursue. On sites that require fairly severe and expensive restoration measures, the best approach may be to plan for a slow, long-term, phased restoration that spreads the cost over many years.

IN THIS SECTION

What's here?

What should I do with it?

Here you will find guidance on developing strategies for managing different types of vegetation (cover type) to achieve your stewardship goals.

A Stewardship Matrix summarizes acceptable options for each cover type (do I preserve, restore or convert?)

Then for each cover type:

- An overview
- Its potential for addressing conservation priorities
- Stewardship issues
- Stewardship guidelines

Stewardship Matrix

EXISTING COVER TYPE	ACCEPTABLE OPTIONS					
	preserve as is/enhance (healthy)	*restore (degraded)*	*convert to forest*	*convert to shrubland*	*convert to meadow*	*convert to wetland*
healthy native forest	✓	✗	✗	✗	✗	✗
degraded forest	✗	✓	✗	✓	✓	✓
hedgerow	✓	✓	✓	✓	✓	✓
shrubland	✓	✓	✓	✗	✓	✓
meadow/grassland	✓	✓	✓	✓	✗	✓
pasture/cropland	✓	✓	✓	✓	✓	✓
wetland	✓	✓	✓	✓	✓	✗
riparian area	✓	✓	✓	✓	✓	✓
pond	✓	✓	✓	✓	✓	✓
lawn/landscaped area	✗	✗	✓	✓	✓	✓
traditional stormwater control structures	✗	✗	✓	✓	✓	✓

Areas with landscaped and agricultural cover types are not considered natural lands (although agricultural lands sometimes do provide wildlife benefits such as food and hiding places from predators) due to the frequent disturbance and use of biocides and fertilizers that are typical of most farmland management regimens. Assistance for developing stewardship plans for these cover types can be obtained from the Pennsylvania Agricultural Extension Service (see **Resources**, *page 211*, for contact information).

An overview and general stewardship guidelines for each option are provided in the following sections. The existing cover types are broadly divided into tree dominated areas and open areas. The forested areas section is further segregated into healthy and degraded forests. For the purpose of this *Stewardship Handbook* the term "healthy" refers to plant communities and wildlife habitats consisting entirely of native species (or nearly so) that show little sign of having been degraded by processes of human origin (e.g., pollution, overabundant deer, eroded streambanks; *see* **Major Stewardship Issues,** *page 20*).

TREE DOMINATED AREAS

Overview

There are several types of tree dominated areas. A ***forest*** is an area dominated by trees that are greater than 15 feet tall and have a canopy cover of at least 60%. Areas dominated by trees with 25–60% canopy coverage are termed ***woodlands***. In this region woodlands historically occurred where frequent fire or river floodplain ice-scour thinned the tree canopy. Forested areas can exist as unbroken blocks, hundreds or even thousands of acres in size,

FOREST AGE – Because most forests in southeastern Pennsylvania started growing after the site was last clearcut for timber or cultivated for crops, trees are typically within 10–20 years of each other in age. Even-aged forests progress through four broad age categories: young, maturing, mature, and old growth. Forests in the region most commonly fall into the "maturing" and "mature" categories. As healthy forests age, they increase in structural diversity (three-dimensional layering of plants) and wildlife species diversity.

David Steckel (all except right)

Ann Fowler Rhoads

or as narrow woodlots surrounded by fields or lawns. Because most existing forests started in areas subject to clearcutting within the past 150 years or on abandoned agricultural fields, they are mostly even-aged forests, with most canopy trees of the same age. Due to variation in both the growth rates of different species and the growing conditions around each tree, tree size does not necessarily correlate with age. Uneven-aged stands will become more common—assuming no major wind event or the widespread use of clearcutting within the region again—as old canopy trees die and new generations of canopy trees mix with the old.

In addition to being classified by community type *(see* **Plant Communities**, *page 14)*, forests are often described by their relative age. Even-aged forests have four broad age categories through which they progress. The wildlife and recreational benefits and stewardship challenges of the forest vary with each stage.

A ***young forest*** (also called sapling and pole stands) is dominated by trees less than a foot in diameter. They are typically dense stands with few shrub or herbs. Although they contain dense vegetation, they do not provide low browse—characteristic of the old field and shrub stages that precede them—and cover. In most cases the trees are also too young to produce nuts or seeds. For these reasons, even-aged young forests are, in general, the poorest wildlife habitat of all forest stages.

Within a ***maturing forest***, the number of canopy trees decreases and numerous small snags (dead standing trees) are created by the overtopping (suppression) of slower growing trees by more vigorous trees in the race to capture additional sunlight in the canopy. As the number of trees decreases through suppression mortality and the remaining trees grow taller, more light reaches the forest floor, encouraging the establishment and growth of shrubs and forest wildflowers. As structural complexity and species diversity increases, the wildlife value of the forest increases dramatically with the proliferation of nesting sites (snags, shrubs, understory trees) and food resources (nuts and seeds from older trees, new shrubs, and herbs). Unfortunately, in southeastern Pennsylvania, this is often the stage when the forest is colonized by invasive shrubs and vines, which, if left uncontrolled, will rapidly degrade the forest and prevent it from reaching maturity.

A healthy ***mature forest*** is commonly described as one that, as a whole, has age and structural diversity (well-defined canopy, understory, shrub, and herbaceous layers) and a variety of native plant species in all layers. Because of these characteristics, a healthy, mature forest is often dramatically more aesthetically pleasing than younger age classes. The high diversity and complexity create many habitats that are beneficial to a wide variety of wildlife species, which use different areas within this three-dimensional mosaic to meet their food and cover needs. During this stage, the common nut-producing species—oaks, hickories, beech—are most productive and the size of snags and associated cavities increases. As snags gradually fall to the ground, the amount of down and dead wood increases. As it is gradually decomposed by fungi and insects, it provides additional habitat (food, water, living space) for amphibians and small mammals, which in turn are food for larger animals (snakes, hawks, owls, skunks, foxes, bears). In general, maturing and mature forests are the most common forest age classes in the region.

Forests that survive environmental stresses and disturbances (ice storms, diseases and pests, high wind events,

logging) for an extended period of time eventually become ***old-growth forest***. Although age is one factor that determines whether a forest is "old growth"—some define old growth as early as 150 years old—its definition also requires the stand to have high structural complexity and species diversity, a heavy accumulation of down woody debris, and a large number of snags. Because nearly every acre of forest in southeastern Pennsylvania has been subject to repeated disturbance from agriculture and logging, only a few small, isolated patches can be considered as true old growth in the region today.

In addition to wildlife habitat, forests provide many benefits for landowners, local residents, and travelers passing through the area. Forest vegetation improves air quality by filtering dust and other air pollutants, absorbing carbon dioxide, and releasing oxygen. Healthy forests with high structural diversity are extremely effective in capturing precipitation and their soils are able to absorb high volumes of water, which helps to minimize stormwater inputs to small streams while recharging groundwater supplies. Forests also provide recreational opportunities such as hiking, birdwatching, and hunting, and offer a welcome visual relief from sprawl development for motorists. Finally, they can be a periodic source of income from timber harvesting and the sale of specialty crops such as mushrooms, ginseng, and goldenseal if managed properly.

Overall, the forest cover type provides the greatest number of environmental, ecological, and recreational benefits. Unless a forested stewardship unit is highly degraded and the conservation priority would benefit from additional open cover, every effort—within the practical limits of the landowner's resources—should be made to maintain the unit as forest. Cover type options for forests in different forest conditions (healthy, degraded) are addressed below. Hedgerows—swaths of trees that are too narrow to be considered as forests—are addressed separately (see page 77).

Overall, the forest cover type provides the greatest number of environmental, ecological, and recreational benefits. Unless the stewardship unit is highly degraded and the conservation priority would benefit from additional open cover, every effort—within the practical limits of the landowner's resources—should be made to maintain the unit as forest.

Benefits to regional conservation priorities

- ***Interior forests***—those areas over 100 meters (305 feet) from an edge—are increasingly rare in the region due to fragmentation from past agricultural use and more recent increases in suburban development. They support many migratory songbird species that are declining with the loss of this habitat.
- ***Riparian forests*** provide the greatest benefits to adjacent water bodies, particularly small streams. They help to maintain water temperatures through shading, absorb pollutants and accumulate sediments from agricultural and residential runoff, stabilize streambanks, and add leaves and woody debris to the stream, which furnishes food and shelter for aquatic organisms.

- Healthy forests absorb large amounts of carbon dioxide and sequester (store) carbon in various forms—leaves, soil organic matter, woody stems—for various lengths of time until these materials decay or are burned. Increasing the region's forested area and maintaining forest health can help to ***sequester more carbon and reduce greenhouse gases*** that contribute to global warming.

Current stewardship issues

- ***White-tailed deer overabundance*** is a major problem affecting forests throughout the region and state. The current overabundance of deer makes both the perpetuation of existing forests and the establishment of new forested areas difficult to achieve. Maintaining forest as a cover type (which should be the strategy for all but the most degraded sites) requires that measures are taken to reduce deer access to forest resources, particularly seeds and seedlings.
- ***Invasive plants*** degrade forests in a number of ways. Invasive vines (oriental bittersweet, Japanese honeysuckle, grape, porcelainberry, five-leafed akebia, mile-a-minute) can shade the leaves of large canopy trees and add significant weight to a tree that can lead to windthrow during high winds or ice storms. They can also smother shrubs and small trees in the understory. Invasive trees (Norway maple, ailanthus) and shrubs (multiflora rose, exotic shrub honeysuckles, privets, Japanese barberry, autumn-olive) create a forest that is much less diverse in native species and key food sources for wildlife, especially plant-eating insects, than a native forest. The result is a decline in native wildlife populations, particularly migratory songbirds.
- ***Fragmentation and edge effects*** exacerbate the impacts of deer and invasive plants by providing the habitat that is most attractive to them. Fragmentation also lowers the habitat value of forest cover by reducing the amount of interior forest.
- ***Two exotic insects***—the emerald ash borer and Asian long-horned beetle—are poised to join the chestnut blight and gypsy moth as major pests that can alter the species composition of Pennsylvania forests. Ashes (white, green, black) and maples (red, silver, sugar, box-elder)—the preferred targets of these pests—are major components of the region's forests, both as canopy trees and seedlings.

Landowner Input

Of all cover types, forest can require some of the least intensive management or some of the most intensive, depending on the current condition of the forest and the specific stewardship goals of the landowner. If the forest is already in a healthy condition, landowners or their hired managers will need only to monitor the property to identify future stewardship issues (overbrowsing by deer, invasive plants) that can threaten forest health. On the other hand, if the forest is highly degraded or one of the stewardship goals is timber production favoring oak species *(see* **Timber Harvesting**, *page 122)*, a larger commitment will be required to steward the forest. The table on the following page shows the basic tools and considerations that will be required of landowners under different stewardship scenarios, along with the assistance available from public agencies and private organizations and consultants *(see* **Resources**, *page 211, for contact information)*.

Resources and Considerations for Forest Stewardship

CONDITION	STEWARDSHIP GOAL	
Healthy Forest	*General Wildlife / Recreation / Scenic / Biodiversity*	*Timber Production*
Assistance	• Pennsylvania Audubon • Pennsylvania Bureau of Forestry, Pennsylvania Game Commission • Penn State Extension • Private consultants (foresters, forest ecologists, wildlife biologists, botanists)	• Pennsylvania Bureau of Forestry • Private consulting foresters
Tools/Materials	• Monitoring: plant identification books, deer impact guidelines *(see page 112)* • Invasives control: pruners, pruning saw, chainsaw, "Weed Wrench," herbicide	• Monitoring: plant identification books, deer impact guidelines *(see page 112)* • Invasives control: pruners, pruning saw, chainsaw, herbicide
Considerations	• Monitor for invasive species at least annually and control as quickly as possible • Monitor deer impact on vegetation and reduce population to meet Impact Level 2 *(see page 112)* • Determine types of use; develop facilities (trails, bridges, benches, signage), as needed, to accommodate	• Monitor for invasive species at least semi-annually and control as quickly as possible • Monitor deer impact on vegetation and reduce population to meet Impact Level 2 *(see page 112)*
Degraded Forest	*General Wildlife / Recreation / Scenic / Biodiversity*	*Timber Production*
Assistance	• Stewardship information: available from Pennsylvania Audubon, Pennsylvania Game Commission, Penn State Extension • Contractor/volunteers to reduce invasive species cover and plant native replacements • Wildlife management consultant to develop deer management program	• Timber management: engage a private consulting forester to produce a timber stand improvement (TSI) plan • Contractor/volunteers to reduce invasive species cover • Wildlife management consultant to develop deer management program
Tools/Materials	• Monitoring: plant identification books • Invasive species control: pruners, pruning saw, chainsaw, "Weed Wrench," herbicide, heavy equipment • Tree and shrub planting: adding seedlings to forest gaps and areas of invasive species removal	• Monitoring: plant identification books • Invasive species control: pruners, pruning saw, chainsaw, "Weed Wrench," herbicide, heavy equipment • Tree planting: adding seedlings to forest gaps
Considerations	• Prioritize invasive species control tasks • Determine appropriate method to decrease deer impacts • Determine types of use; develop facilities (trails, bridges, benches, signage) to accommodate	• Prioritize invasive species control tasks • Determine appropriate deer control method • Determine types of use; develop facilities (trails, bridges, benches, signage) to accommodate

Cover Type 1
Healthy Native Forest

Overview

There are few forested areas in southeastern Pennsylvania that remain in an ecologically healthy condition. To qualify as such would require a site to be well stocked with native trees relative to its age and site conditions, free of invasive plants, and not overbrowsed by deer. These criteria could encompass a variety of forest types, site histories, terrains, and "looks," from dense to relatively open, all young trees to varied age classes, reclaimed old field to never-logged steep hillside, or dry, sandy soils to muck that is saturated year-round. Any healthy native forest is rare in our region and provides important environmental (air and water purification, soil formation, erosion control, groundwater recharge, nutrient cycling, climate moderation), ecological (habitat for native wildlife, biodiversity conservation), and recreational benefits.

Cover type option and guidelines

1a. Preserve As Is

The preferred stewardship option for healthy native forests is to preserve it in its current condition. In order to achieve this goal every effort should be made to minimize disturbance either directly or indirectly from human sources. Interior trails are compatible although their extent should be minimized since they often act as avenues for other disturbance factors such as invasive plants and dumping. Most importantly, the site should be monitored on a regular basis for the presence of invasive vegetation, reduced levels of advance regeneration due to overbrowsing by white-tailed deer, or changes in environmental conditions (air or water pollution) that may adversely affect existing vegetation. If any of these conditions arise, the landowner/manager should consult **Cover Type 2: Degraded Forest** *(this page)* or contact a qualified resource manager for an appropriate solution. The Pennsylvania Bureau of Forestry can provide general information on forest stewardship and financial assistance programs, and a list of consulting foresters that may be contacted for further assistance.

David Steckel

Healthy native forests, with abundant tree regeneration and no invasive plants, are, sadly, uncommon in southeastern Pennsylvania.

Cover Type 2
Degraded Forest

Overview

The majority of forests in our region exist in a more or less degraded condition. This usually results from the presence of invasive vegetation or a lack of advance tree and shrub regeneration due to over-browsing by deer. Forests also are degraded often by dumping and soil erosion.

The majority of forests in our region exist in a more or less degraded condition.

The amount of degradation by invasive vegetation on any given property will vary relative to the age of the forest, the degree of fragmentation, the availability of seed, and the aspect of the site. In general, the vitality and impact of invasive plants increases directly with available light (an exception to this rule is Norway maple, a tree that is well adapted to growing in dense shade). Consequently, forests usually are degraded most severely along their edges (particularly those with southern or eastern exposure) and within interior gaps.

Cover type options and guidelines

There are two preferred cover type options for degraded forest. Which option or options are chosen will depend on the degree of degradation, site conditions, available stewardship budget, and the environmental, ecological, and recreational benefits of the resource. In general, options 2b and 2c should be considered only for sites that have been severely degraded.

2a. Restore to Healthy State

Because of the many environmental, ecological, and recreational benefits of forests, the preferred option is to restore the degraded resource to its original state.

(1) Address the source of degradation as soon as possible to minimize restoration costs.

(2) Use an established deer impact index *(see* **Wildlife Management**, *page 104)* to determine whether degradation is due to an overabundance of white-tailed deer. If so, develop a strategy for reducing deer access to forest vegetation either by physical barriers or a reduction in the deer population.

(3) It will often require many years of treatment to successfully control invasive plants due to budgetary constraints and the vitality and persistence of the invasive plants. See **Invasive Vegetation Management** *(page 125)* for recommendations on how to prioritize invasive species management tasks.

David Steckel (both)

Compared with healthy forests *(see page 73)***, a degraded forest has less ecological value because of its lack of structural diversity (no shrubs or tree seedlings), which typically results from deer overbrowsing** *(left)* **and prevalence of invasive plants in the understory** *(right)***, or both. Unfortunately this is the most common condition of forest in the region.**

(4) To promote native tree and shrub regeneration within forest gaps protect existing seedlings with fencing, tree shelters, or flexible tree guards. If there is insufficient natural advance regeneration, plant native trees appropriate to light and moisture conditions *(see* **Native Plant Materials***, page 172–200)*. Trees should be planted on a 10-foot x 10-foot spacing and protected from deer damage with measures such as fencing, tree shelters, or flexible tree guards. This should continue on an as-needed basis to assure that sufficient advance regeneration is available to replace canopy trees as they die.

(5) Heavy equipment should be used only in extreme situations. If used, protect existing trees by staying as far away as possible (at least outside of the drip line) to prevent soil compaction and trunk scarring.

(6) Remove any trash and dispose of it according to current municipal and Pennsylvania Department of Environmental Protection regulations.

(7) Correct soil erosion by rerouting trails along the contour and controlling the water source. Fill gullies and plant with a fast-growing, native, perennial grass such as Canada wild-rye, riverbank wild-rye, or Virginia wild-rye (or exotic annual rye or oats, which produce fast cover but do not persist) and native trees and shrubs. Do not use standard conservation seed mixes—they will introduce persistent exotic species into the forest.

(8) Inspect the forest annually and address degradation as needed.

2b. Convert to Native Shrubland

Native shrubland is the preferred option if the conservation priority is to protect threatened shrubland birds and the landowner has the resources to complete necessary stewardship tasks. The landowner can either follow the guidelines under 2a to establish tree seedlings (using short-statured species) and shrubs across the area, or, if adequate native tree and shrub regeneration is present, maintain through periodic mowing or selective cutting to prevent canopy tree species from dominating the site. The easiest and most cost-effective shrublands to maintain are those that have occurred naturally in the region for thousands of years and tend to maintain themselves, to a degree. On upland sites, the most persistent types are heathlands, which are dominated by members of the Ericaceae or heath family (blueberries, black huckleberry, mountain-laurel, sheep-laurel, native azaleas, and others) and scrub oak thickets, dominated by scrub or bear oak, a native oak species that grows as a tall shrub. Note that evergreen shrubs (two species in our region—rosebay rhododendron and mountain-laurel) will not tolerate a management regime of mowing or burning, but many native deciduous shrubs resprout prolifically from their roots after cutting or fire.

(1) Determine the limits of available mowing machinery (how large of a tree or shrub can be cut) to set mowing frequency. In southeastern Pennsylvania, the mowing frequency will usually need to be between three and ten years to maintain a shrubland cover type. In most cases, it is advisable to engage a contractor with specialized equipment to perform this work.

(2) An alternative method to maintain native shrubland is to selectively remove, through cutting or herbicide application (see discussion of appropriate use of herbicides, *page 133*), invasive woody plants and seedlings and saplings of tree species that typically grow above 25 feet in height, while leaving tree species that typically do not exceed this height (*see* **Native Plant Materials**, *pages 172–200, for a list of appropriate trees and shrubs that are locally available)*.

(3) Inspect annually for invasive species and control as needed.

2c. Convert to Native Meadow

A forest or hedgerow sometimes becomes so degraded by invasive plants that it is better to remove part or all of it with heavy equipment. This is most obvious when the majority (>75%) of the canopy trees have been killed or drastically deformed by vines, or when an invasive species (e.g., Norway maple, ailanthus) is dominant. Creating a native grass and wildflower meadow is one option other than reforestation that will provide many of the environmental benefits of forest and help to diversify the ecological communities within the region. This option is most appropriate if the forest is relatively small and adjacent to existing meadow. Use the following guidelines *(and information in* **Meadow Management**, *page 138)* for converting degraded forest or hedgerow to native grass and wildflower meadow. For information more specific to your site contact the USDA Natural Resources Conservation Service or Conservation District representative in your area.

Drew Gilchrist

In some cases, a forest can become so degraded that it is best to clear the site before starting restoration. If adjacent to existing open lands (meadow, agricultural fields), it might be appropriate to convert a forest in this condition to meadow.

(1) Prepare the area for seeding by eliminating all existing vegetation. Remove trees and shrubs manually or mechanically; use a non-selective (kills all vegetation) herbicide as needed (it may take multiple applications at two-week intervals) to eliminate undesirable (invasive) plant species, such as non-native vines (oriental bittersweet, Japanese honeysuckle), shrubs (multiflora rose, autumn-olive), or herbs (Japanese stiltgrass, Canada thistle) that might compete with native meadow plants (see discussion of appropriate use of herbicides, *page 133*).

(2) Use only native grass and wildflower species appropriate to site conditions (*see* **Native Plant Materials**, *pages 172–200, for a list of species adapted to wet and dry sites)*. Plant at a rate of 10–15 pounds (pure live seed) per acre. If tall grasses such as Indian-grass, big bluestem, and switchgrass are used, they should be planted in patches rather than mixed in with shorter grasses and forbs because they are highly competitive in most situations, tending to overwhelm other species and form monocultures. Add a fast-growing, native, perennial, cool-season grass such as Canada

wild-rye, riverbank wild-rye, or Virginia wild-rye (or exotic annual rye or oats, which do not persist) to seed mixes at one half pound per acre to provide a quick cover for erosion control, except when using a herbicide with pre-emergent effects, such as Plateau, which would prevent the seeds from sprouting. Plant in spring (preferred) prior to June 1st or fall (mid- to late November). Liming and fertilization should be strictly avoided. Fertilization gives invasive species a competitive advantage over many native species, which are fully adapted to the indigenous soils in our region. Where invasive plants are abundant and fertilizers have been applied in the past, it may be best to establish only grass species initially and add wildflowers to the meadow after a few years. This allows time to monitor the meadow and to use broadleaf herbicides (which would also kill native wildflowers) to treat any residual weeds (see discussion of appropriate use of herbicides, *page 133*). However, adding wildflowers where warm-season grasses have become dominant often requires that the grasses be removed (mechanically or with herbicide) in patches where wildflowers are to be planted.

(3) Mow meadows no more than twice a year (except for trails) between mid-August and early March at a height of 8–12 inches to prevent intrusion by tall shrubs and trees. One mowing annually is preferable on sites with high or moderately high soil fertility; one mowing every 2–3 years may be enough on low-fertility sites. Meadows should not be mowed between April 1st and July 15th, to prevent disturbance of nesting and feeding wildlife (insects, small mammals, birds) or, on larger contiguous blocks of meadow (more than 50 acres), until August 15th, when threatened interior grassland and meadow birds may still be nesting. See **Meadow Management** *(page 138)* for more information on preferred mowing times. Mow trails as needed at a 6–8-foot width.

(4) Inspect meadows annually for intrusion by invasive plants. Spot-spray as needed to prevent reestablishment of invasive species. For recommendations see **Invasive Vegetation Management** *(page 125)*.

(5) If desired or needed to boost species diversity in species-poor meadows, augment existing meadow species with additional native species appropriate to site conditions by clearing scattered patches and seeding or planting plugs.

Cover Type 3 Hedgerow

Overview

Hedgerows are narrow swaths of trees between agricultural fields. They typically arose along fences (perching birds would deposit tree and shrub seeds) or as planted "living fences" of Osage-orange or multiflora rose. Over time they became repositories of rocks, trash, and old farm equipment. Unless they are periodically cut back, hedgerows tend to widen over time as shrubs and tree seedlings creep into the open field. Due to the relatively high availability of sunlight, they are dominated typically by shade-intolerant or intermediate-tolerance tree species common in the region. They are a ubiquitous remnant of the agricultural legacy of the region, inhabiting remaining farmland, parks, nature preserves, and subdivisions.

Benefits to regional conservation priorities

- Traditionally, hedgerows were seen as important ***corridors*** for wildlife movement, providing cover for small mammals and birds. With recent interest in protecting grassland birds this traditional value can be outweighed by hedgerows' propensity to facilitate predation on these threatened species (see below).
- Native species in hedgerows can be valuable as ***seed sources*** for afforestation projects on adjacent agricultural fields that are under conversion to forest. However, this benefit is often outweighed by the detrimental contribution by most southeastern Pennsylvania hedgerows of vast quantities of non-native, invasive shrub and vine seeds.
- Hedgerows are often used to ***buffer*** new residential development and are cultural features that may be desirable to maintain in a new subdivision, reducing its impacts on more ecologically significant areas.

Hedgerows, narrow swaths of trees between agricultural fields, typically arose along fences or as planted "living fences."

Dan Barringer

Hedgerows, remnants of windbreaks between agricultural fields, can be corridors for the spread of invasive plants *(above)* **and predators of grassland birds. Hedgerows can be valuable if used as a seed source in the conversion of adjacent farm fields to forest.**

Current stewardship issues

- ***Invasive plants*** are often prolific within hedgerows due to the high availability of sunlight. Hedgerows can act as bountiful reservoirs of invasive species' seeds that can be transported into nearby forests by wind and birds.
- Ground ***predators of threatened meadow bird species*** (fox, raccoon, coyote, feral cat, large snakes) use hedgerows as cover and as travel corridors. Avian predators (e.g., Cooper's hawk) use the canopy trees as perch sites from which to hunt these same birds. Hedgerows fragment meadows just as open areas fragment forests; they eliminate viable nesting habitat within 150 feet of the hedgerow edge. This impact can be reduced by using shrub species and avoiding tree species, to limit the potential height of the hedgerow and the availability of perch sites for predators, and by cutting lower branches so that the hedgerow is open beneath. This is a particularly good method for protecting (shading) small streams that flow through meadows without significantly compromising the surrounding meadow habitat.
- ***Hazard trees*** can be a potential problem if the hedgerow is part of a trail system with benches or observation

points. Hedgerow trees are more exposed to environmental stresses than forest trees. High use areas near hedgerows should receive regular monitoring for hazard trees.

Cover type options and guidelines

Hedgerows are an historical remnant cover type whose value is diminishing as new conservation priorities are identified in the region. Whether or not to maintain a stewardship unit in this cover type will depend upon the conservation priority of the natural lands.

3a. Preserve As Is

If the hedgerow will eventually be part of a larger forest to enhance the conservation priority or if it acts as a visual buffer or cultural feature, then it should be stewarded along with the other forest resources within the natural lands following guidelines under 1a above.

3b. Convert to Native Shrub-dominated Hedgerow

This is the preferred option if the conservation priority is to protect threatened shrubland birds and the landowner has the resources to complete necessary stewardship tasks. This will require the eventual removal of tall trees (>25 feet) either through attrition or by cutting. As tall trees are removed from the hedgerow, the landowner can either follow the guidelines under 2a to establish tree seedlings (using "short" species) across the area, or, if adequate tree and shrub regeneration is present, maintain through periodic mowing or selective cutting to prevent tall-growing tree species from dominating the site.

(1) Determine the limits of available mowing machinery (how large of a tree or shrub can be cut) to set mowing frequency. In southeastern Pennsylvania, the mowing frequency will usually need to be between three and ten years to maintain a shrubland cover type. In most cases, it is advisable to engage a contractor with specialized equipment to perform this work.

(2) An alternative method to maintain a native shrub-dominated hedgerow is to selectively remove, through cutting or herbicide application (see discussion of appropriate use of herbicides, *page 133*), invasive woody plants and seedlings and saplings of tall-growing tree species, while leaving tree species that typically do not exceed 25 feet in height *(see* **Native Plant Materials**, *pages 172–200, for a list of appropriate trees and shrubs that are locally available)*.

(3) Inspect annually for invasive species and control as needed.

3c. Convert to Native Meadow

If the conservation priority calls for maximizing open meadow habitat, the removal of the hedgerow could be warranted if it significantly reduces the fragmentation of meadow habitat. This is likely to be a challenging task, requiring heavy equipment to remove tree stumps and rock piles. It could be undertaken all at one time, if resources permit, or staged as resources allow and need dictates (the hedgerow could be a targeted source for firewood cutting). After clearing part or all of the hedgerow, follow guidelines under 2c to establish native meadow.

OPEN AREAS

Overview

Open areas in natural lands are portions of the landscape not dominated by trees. Scattered trees can be present but they shade less than 25% of the total area. Categories of open native vegetation include meadows and grasslands (more than 50% herbaceous cover, often with some shrub cover), shrublands (more than 50% shrub cover, often with some herbaceous cover), savannas (dominated by herbaceous plants or shrubs with scattered trees shading 10–25% of the area), "barrens" (any of the preceding, where the lack of tree dominance persists for many years or centuries), and open wetlands (marshes and shrub swamps). The natural tendency for most sites within our region is to exist as forest. Maintaining areas in artificial cover types (agricultural fields, pastures, gardens, lawns) or in open native vegetation (grasslands, shrublands, savannas, marshes) continually sets back the process of ecological succession that moves a site from domination by herbaceous plants (grasses and forbs), to an intermediate stage dominated by shrubs and small trees, and then finally to forest. When the (more or less) frequent disturbance required to perpetuate these cover types stops, succession proceeds. Succession towards forest cover is slowest on soils that are low in nutrients, droughty, or often saturated. Any of these conditions makes it easier to maintain open areas. It is fastest on soils with intermediate nutrient and moisture levels. On soils where nutrient levels are artificially high due to past use of fertilizer, forest succession may be hindered by the dense growth of invasive species.

Maintaining areas as agricultural fields, meadows, pasture, or lawn essentially freezes the process of ecological succession.

Trees—and therefore forests—gain dominance of the landscape by developing the largest and sturdiest stems and branches of any members of the plant kingdom, enabling them to place their photosynthetic or food-producing surfaces (leaves) above the leaves of other types of plants. This elevated position, however, exposes trees to numerous environmental stresses, including high winds, ice, and drought. These stresses, along with tree pests and pathogens, result in recurring disruption of the forest canopy by killing or toppling individual trees or large patches of forest. This has allowed open cover types to persist at the scale of a landscape or region, although in most cases their sizes and specific locations shift over long time spans in response to random environmental disturbances.

Human activities have added to these ambient disturbances in our region for more than 10,000 years. The extensive use of fire, mainly by Native Americans, and agricultural practices (forest clearing, cultivation, and subsequent abandonment of fields as fertility or markets decline), mainly after European settlement, helped to maintain enough land in these cover types to support wildlife species adapted to their conditions. Actively cultivated land has little value for wildlife except for just a handful of species such as white-tailed deer, Canada goose, and raccoon. However, before the 20th century, practices such as cropland rotation with long fallow periods, devoting a large acreage to hayfields, and delaying hay harvest until late summer sustained a large total area of habitat that

had much in common with the all-native meadows that had existed in the region for thousands of years. Twentieth-century changes in farming began to erode the extent and habitat value of open areas; they included mowing earlier in the summer before the end of many birds' nesting season, switching to more intensive rotation with little or no fallow, pesticide use, and widespread abandonment of cultivation. As the region's human population grows and additional land is more or less permanently disturbed (converted to houses, roads, shopping malls, etc.), the amount of land in open cover types continues rapidly declining to the further detriment of specialist species dependent on these habitats. Maintaining natural lands in nonforest cover types can help support declining wildlife populations and perpetuate an historical component of the regional landscape.

Landowner input

Like forests, the amount of landowner input for open areas will depend upon the current condition of the area and the landowner's interests. Open areas share many of the stewardship issues affecting forested areas. However, because open lands have a natural tendency to succeed to forest, the actual stewardship of these cover types can be more challenging, requiring larger, more expensive equipment. On page 84 is a table that shows the basic tools and considerations that will be required of the landowner who chooses to steward the two major open cover types (shrubland and meadow), along with the available assistance from public agencies and private organizations and consultants (*see* **Resources**, *page 211 for contact information*).

Cover Type 4 Shrubland

Overview

Shrublands are nonforested areas that have moved to the intermediate shrub/small tree stage of succession or are dominated by shrub species that greatly slow forest succession by inhibiting tree seedling establishment. The intermediate successional stage shrublands, often called thickets, usually grow into the forest stage in just a few years unless exposed to frequent tree-killing disturbance. The more persistent shrublands are those in which the dominant species change the environment to the detriment of tree regeneration or the soils are extremely wet, dry, or infertile. They may last many years without disturbance, but eventually they too are invaded and shaded out by trees of the species that are most tolerant of the dominant shrubs' influence or of the soil conditions, unless subjected to occasional disturbance.

David Steckel

Maintaining shrubland as a cover type requires periodic disturbance—typically mowing every three to ten years—to keep both tall trees and invasive plants from taking over.

The difficulty of maintaining healthy native shrublands and their potential to be reservoirs for invasive plants if not properly maintained make them a challenging cover type for the typical landowner. However, it is a very valuable cover type for wildlife.

Due to thousands of years of Native American burning and agricultural practices over much of the past three centuries, shrubland was relatively abundant. Until recently clearcutting and farmland abandonment across the region continually produced new shrubland to replace acreage steadily lost to forest succession. Shrubland abundance has rapidly declined as forests have matured and houses have consumed more recently abandoned farmland. The result has been the decline of birds and other wildlife that depend on this cover type.

Benefits to regional conservation priorities

- Native shrublands provide many of the same environmental benefits as forests and some unique ecological benefits, including habitat for threatened wildlife. Because they are used by species of birds uncommon or declining in our region (e.g., chestnut-sided warbler, blue-winged warbler, prairie warbler, yellow-breasted chat, white-eyed vireo, willow flycatcher, blue grosbeak, indigo bunting, whip-poor-will, American woodcock, grouse, northern bobwhite), they provide unique recreational (birdwatching and hunting) opportunities.

Current stewardship issues

- Their relatively open character makes native shrublands vulnerable to ***invasive plants*** becoming established, adding to the stewardship time commitment. In fact, existing shrublands in our region are dominated by exotic invasive shrub and vine species; restoring and maintaining such sites as native shrublands may be more difficult and time-consuming than converting them to native meadows or forests.
- The perpetuation of native shrublands requires the ***use of heavy mowing equipment*** or the intensive "weeding" of tall-growing tree species.

Cover type options and guidelines

There are four options for shrublands: preserve as is, restore to healthy state, convert to forest, or convert to native meadow. Which option or options are chosen will depend on the stage of succession, the degree of degradation by invasive plant species, site conditions, available management budget, and the relative environmental, ecological, and recreational benefits of the resource. The difficulty of maintaining healthy native shrublands and their potential to be reservoirs for invasive plants if not properly maintained make them a challenging cover type for the typical landowner. However, if the conservation priority is threatened bird species, the site lends itself to persistent dominance by shrubs (has very wet, dry, or infertile soils), and the landowner has the resources to undertake the required stewardship tasks, it is a very valuable cover type for wildlife.

There are few shrublands in southeastern Pennsylvania that are in an ecologically healthy condition. To qualify as such would require a site to be dominated by native shrub species and free of invasive plants. Because shipping ports, croplands, and gardens in southeastern Pennsylvania have been points of entry for exotic species for centuries, invasive plants are particularly well established here. This means that abandoned farm fields and pastures—the usual precursors of shrublands in the region—typically receive a plentiful supply of invasive species' seeds. The most likely sites for healthy existing shrublands are those with extremely wet, dry, or infertile soils, conditions native shrub species tend to be better equipped to deal with than invasive species. Healthy shrub swamps and upland native shrublands are rare in our region and provide important environmental (air and water purification, soil formation, erosion control, groundwater recharge, nutrient cycling, climate moderation) and ecological (habitat for native wildlife, biodiversity conservation) benefits.

4a. Preserve As Is

Native shrublands are maintained in a healthy state through periodic mowing or selective cutting to prevent tall-growing canopy tree species from dominating the site. The easiest and most cost-effective shrublands to maintain are those that have occurred naturally in the region for thousands of years and tend to maintain themselves, to a degree. On upland sites, the most persistent types are heathlands, which are dominated by members of the Ericaceae or heath family (blueberries, black huckleberry, mountain-laurel, sheep-laurel, native azaleas, and others) and scrub oak thickets, dominated by scrub or bear oak, a native oak species that grows as a tall shrub. Note that evergreen shrubs (two species in our region—rosebay rhododendron and mountain-laurel) will not tolerate a management regime of mowing or burning, but many native deciduous shrubs resprout prolifically from their roots after cutting or fire.

(1) Determine the limits of available mowing machinery (how large of a tree or shrub can be cut) to set mowing frequency. In southeastern Pennsylvania, the mowing frequency will usually need to be between three and ten years to maintain a shrubland cover type. In most cases, it is advisable to engage a contractor with specialized equipment to perform this work.

(2) An alternative method to maintain native shrubland is to selectively remove, through cutting or herbicide application (see discussion of appropriate use of herbicides, *page 133*), invasive woody plants and seedlings and saplings of tall-growing tree species, while leaving tree species that typically do not exceed 25 feet in height *(see* **Native Plant Materials**, *pages 172–200, for a list of appropriate trees and shrubs that are locally available)*.

(3) Inspect annually for invasive species and control as needed.

4b. Restore to Healthy State

This is the preferred option for a mildly degraded site.

(1) Assess invasive plants and address by using recommendations in **Invasive Vegetation Management** *(page 125)*.

(2) Use guidelines under 2a, using appropriate shrubland species *(see* **Native Plant Materials**, *pages 172–200)*, to fill in any shrubland gaps.

4c. Convert to Forest

This option can be either the easiest or hardest road to take depending on the status of succession (i.e., the number of native trees established) and the level of degradation by invasive plants. It will be the least costly if native trees are about to dominate the site and the amount of invasive plant material is small. It will be the most difficult option if native trees are sparse and invasive plants are prominent.

(1) Identify native trees and release them from competition with invasive plants by cutting or wick application of herbicide (see discussion of appropriate use of herbicides, *page 133*). *(Note: native trees can usually outcompete invasive shrubs, but not invasive vines and trees.)*

(2) If necessary, augment natural tree regeneration by planting native tree seedlings. This will require a spacing of between 10 feet x 10 feet and 20 feet x 20 feet.

(3) Use protective measures such as fencing, tree shelters, and flexible tree guards to minimize deer damage to natural or planted seedlings.

(4) Reduce plant competition through selective herbicide application to kill vegetation (see discussion of appropriate use of herbicides, *page 133*), particularly sod-forming grasses, around the base of each tree (once or twice annually) or mowing (at least four times) during the growing season until the canopy exceeds 60% cover.

Resources and Considerations for Shrubland and Meadow Stewardship

	SHRUBLAND	MEADOW
Assistance	• Pennsylvania Audubon • Pennsylvania Game Commission • Penn State Extension	• Pennsylvania Audubon • Pennsylvania Game Commission • Penn State Extension • USDA Natural Resource Conservation Service
Tools/Materials	• Monitoring: plant identification books • Vegetation control: pruners, pruning saw, chainsaw, herbicide, "Weed Wrench," heavy-duty field mower/brush cutter	• Monitoring: plant identification books • Vegetation control: field mower, herbicide
Considerations	• Monitor for invasive species at least annually and control as quickly as possible • Monitor deer population and maintain at appropriate level to sustain a healthy community *(see discussion on estimating deer impact, page 112)* • Determine type and frequency of cutting	• Monitor for invasive species at least annually and control as quickly as possible • Monitor deer population and maintain at appropriate level to sustain a healthy community *(see discussion on estimating deer impact, page 112)* • Determine types of use; develop facilities (trails, bridges, benches, signage) to accommodate uses • Determine appropriate mix of native grasses and forbs

After the canopy has reached 60% closure monitor for invasive plants and control as needed.

(5) Inspect annually for invasive species and treat as necessary.

4d. Convert to Native Meadow

This option is best if the site is dominated by invasive plants and adjacent to established meadow. After clearing shrubs and trees, use the guidelines under 2c *(and information in* **Meadow Management**, *page 138)* to convert the area to grass and wildflower meadows.

Cover Type 5 Meadow/Grassland

Overview

Meadows and grasslands are open areas dominated by herbaceous plants. Areas predominantly covered by grass species are called grasslands; those having a strong forb (wildflower) component are known as meadows. They provide many environmental (erosion control, stream buffer), ecological (wildlife habitat), and recreational (walking and equestrian trails) benefits, and can be an attractive part of the landscape.

Historically, meadows and grasslands occurred as breaks in the eastern deciduous forest resulting from disturbances such as fire, periodic flooding, insect infestation, and human clearing or because of site conditions (saturated soil or unusual geology). Most meadows existed as temporary ecosystems; without repeated disturbance, succession would eventually return the area to forest. As the Native American and then European populations increased, disturbance by fire, logging, and agriculture maintained a shifting mosaic of meadow communities.

There are few meadows or grasslands in southeastern Pennsylvania that are in an ecologically healthy condition, that is, dominated by native grass and forb species and free of invasive plants.

Most meadows and grasslands exist as temporary ecosystems; without repeated disturbance, succession will eventually return the area to forest.

Drew Gilchrist (both)

Grasslands *(left)* **are open areas dominated by grasses. Meadows** *(right)* **are open areas dominated by grasses and wildflowers. Meadows and grasslands need annual disturbance by mowing or burning to prevent woody vegetation from becoming established.**

Because shipping ports, croplands, and gardens in southeastern Pennsylvania have been points of entry for exotic species for centuries, invasive plants are particularly well established here. This means that former agricultural fields—the foundation of most meadows and grasslands in the region—typically receive a plentiful supply of invasive species' seeds. The most likely sites for healthy existing meadows are those with extremely wet, dry, or infertile soils, which provide growing conditions far more favorable to native grass and forb species than to invasive species. Healthy marshes, wet meadows, and upland native meadows and grasslands are rare in our region and provide important environmental (air and water purification, soil formation, erosion control, groundwater recharge, nutrient cycling, climate moderation) and ecological (habitat for native wildlife, biodiversity conservation) benefits.

Benefits to regional conservation priorities

- Preserving habitat for ***grassland interior species***, which require large blocks of meadow unbroken by hedgerows or highways, including several increasingly rare species of grassland birds (grasshopper sparrow, savannah sparrow, vesper sparrow, eastern meadowlark, bobolink, horned lark, northern bobwhite) whose populations have become imperiled due to the decline in this cover type. Maintaining meadows and grasslands in large blocks (at least 25 acres but preferably greater than 50 acres) or as part of a larger open landscape is necessary to provide habitat for these species.
- Preserving habitat for meadow and grassland species that do not require large, unbroken blocks, including many species of ***declining and imperiled butterflies*** (e.g., two-spotted skipper, black dash, cobweb skipper, mulberry wing, long dash, frosted elfin, silvery blue, bronze copper, silver-bordered fritillary, eyed brown, Atlantis fritillary, giant swallowtail, falcate orangetip, northern metalmark). Native meadows and grasslands of just a few acres can provide habitat for these and other imperiled species. See **Resources** *(page 211)* for resources to help determine whether a meadow has potential to support threatened species.
- ***Increasing biological diversity*** at a local (neighborhood) scale. Many wildlife species whose populations are still secure in the region but are seen less and less often with increasing suburban sprawl thrive in large or small meadows, including many butterflies (e.g., eastern tiger swallowtail, pipevine swallowtail, zebra swallowtail, northern metalmark, great spangled fritillary, Aphrodite fritillary, mourning cloak, painted lady, red admiral, viceroy, monarch) and birds (e.g., American kestrel, red-tailed hawk, yellow-shafted flicker, barn swallow, tree swallow, northern rough-winged swallow, eastern bluebird, eastern kingbird, purple martin, house wren, cedar waxwing, red-winged blackbird, indigo bunting, American goldfinch, song sparrow, chipping sparrow, field sparrow).

Current issues

- Meadows and grasslands in our region are often degraded by ***invasive plants***, particularly woody vines (oriental bittersweet, Japanese honeysuckle), shrubs (multiflora rose, autumn-olive, exotic shrub honeysuckles), herbaceous perennials (Canada thistle, common

mugwort), and herbaceous annuals and biennials (spotted knapweed, mile-a-minute, Japanese stiltgrass). They also can suffer from human disturbances such as soil erosion and dumping.

Cover type options and guidelines

There are four appropriate cover type options for meadows: preserve as is, restore to a healthy condition, convert to forest, and convert to wetlands. Which option or options are chosen will depend on the conservation priority, the degree of degradation, site conditions, available stewardship budget, and the relative environmental, ecological, and recreational benefits of the resource.

5a. Preserve As Is

Because they are uncommon in our region, the preferred cover type option for healthy meadows and grasslands (those that have not been degraded by natural or human factors) is to undertake appropriate stewardship tasks to maintain them in a healthy condition. Meadows are kept in a healthy condition by following or mimicking the stewardship practices that have kept them healthy. In most cases this means they are periodically mowed, burned, grazed, or a combination of the three to prevent colonization by woody and invasive plant species.

(1) Mow meadows no more than twice a year (except for trails) between mid-August and early March at a height of 8–12 inches to prevent intrusion by tall shrubs and trees. One mowing annually is preferable on sites with high or moderately high soil fertility; one mowing every 2–3 years may be enough on low-fertility sites. Meadows should not be mowed between April 1st and July 15th, to prevent disturbance of nesting and feeding wildlife (insects, small mammals, birds) or, on larger contiguous blocks of meadow (more than 50 acres), until August 15th, when threatened interior grassland and meadow birds may still be nesting. See **Meadow Management** *(page 138)* for more information on preferred mowing times. Mow trails as needed at a 6–8-foot width.

(2) The alternative to mowing is to use prescribed fire to burn meadows and grasslands, rotating among sections (10–20% of meadows < 50 acres or one-third to one-half of larger meadows) to maintain a refugium from which insects can re-colonize the treated area. Obviously, this should only be undertaken by persons trained in the use of prescribed fire and after notification of neighbors and public officials, particularly the local fire company *(see* **Prescribed Fire**, *page 145)*. The preferred vegetation and weather conditions for using prescribed fire in southeastern Pennsylvania are typically encountered in mid-March to mid-April. A second window of opportunity is sometimes available in early to mid-November.

(3) Inspect meadows annually for intrusion by invasive plants. Consult **Invasive Vegetation Management** *(page 125)* for recommendations on addressing any problems.

(4) If desired or needed to boost species diversity in species-poor meadows, augment existing meadow species with additional native species appropriate to site conditions by clearing scattered patches and seeding or planting plugs *(see* **Native Plant Materials**, *pages 172–200)*.

5b. Restore to Healthy State
This is the preferred option for a mildly degraded site and is one of the least costly of the five options to carry out and maintain.

(1) Regrade and seed any eroded areas following guidelines under 2c.

(2) Remove and dispose of any trash according to current municipal and Pennsylvania Department of Environmental Protection regulations.

(3) Eliminate invasive plants by spot-spraying or wick application of appropriate herbicide (see discussion of appropriate use of herbicides, *page 133*) or manual or mechanical removal. Use only herbicides approved for aquatic use for spray applications within 100 feet of water resources. Areas that are disturbed by manual or mechanical removal of invasive plants should be seeded with native wildflowers and grasses mixed with a fast-growing, native, perennial grass such as Canada wild-rye, riverbank wild-rye, or Virginia wild-rye (or exotic annual rye or oats, which produce fast cover but do not persist) to hinder reestablishment of invasive species.

(4) Mow meadows no more than twice a year (except for trails) between mid-August and early March at a height of 8–12 inches to prevent intrusion by tall shrubs and trees. One mowing annually is preferable on sites with high or moderately high soil fertility; one mowing every 2–3 years may be enough on low-fertility sites. Meadows should not be mowed between April 1st and July 15th, to prevent disturbance of nesting and feeding wildlife (insects, small mammals, birds) or, on larger contiguous blocks of meadow (more than 50 acres), until August 15th, when threatened interior grassland and meadow birds may still be nesting. See **Meadow Management** *(page 138)* for more information on preferred mowing times. Mow trails as needed at a 6–8-foot width.

(5) The alternative to mowing is to use prescribed fire to burn meadows and grasslands, rotating among sections (10–20% of meadows < 50 acres or one-third to one-half of larger meadows) to maintain a refugium from which insects can re-colonize the treated area. Obviously, this should only be undertaken by persons trained in the use of prescribed fire and after notification of neighbors and public officials, particularly the local fire company (*see* **Prescribed Fire**, *page 145)*. The preferred vegetation and weather conditions for using prescribed fire in southeastern Pennsylvania are typically encountered in mid-March to mid-April. A second window of opportunity is sometimes available in early to mid-November.

(6) Inspect meadows annually for intrusion by invasive plants. Consult **Invasive Vegetation Management** *(page 125)* for recommendations on addressing invasive species.

(7) If desired or needed to boost species diversity in species-poor meadows, augment existing meadow species with additional native species appropriate to site conditions by clearing scattered patches and seeding or planting plugs (*see* **Native Plant Materials**, *pages 172–200)*.

5c. Convert to Forest

This option is most appropriate if the area is relatively small (< 10 acres) and conversion would augment an adjacent forested area and result in reduced edge or increased interior forest habitat, connect two existing forested areas, or provide a natural screen to improve the aesthetics of the site. Although there are many environmental and ecological benefits to be realized from this strategy, it is also a strategy that requires significant time and resources to accomplish due to the overabundance of white-tailed deer and invasive plants in the region. Implementing this strategy will likely take many years of intensive stewardship because of these factors.

These guidelines assume that conditions common in the region, specifically overabundant deer and invasive species, exist on the site. If native tree seedlings are already established in the meadow or the land manager believes that an adequate number of trees will become established naturally, start the process at step (3). In the rare instance of adequate native advance regeneration and low deer and invasive species pressure, begin at step (5).

(1) Select native species that are appropriate for site conditions (*see* **Native Plant Materials**, *pages 172–200)*.

(2) Plantings should be spaced to allow for control of competing vegetation with available mowing equipment, but close enough for the canopy to close quickly. For forest and wide hedgerows this will require a spacing between 10 feet x 10 feet and 20 feet x 20 feet. Narrow hedgerows that principally serve as screens should have at least a 20-foot spacing in staggered rows to allow for good development of each tree.

(3) Use protective measures such as fencing, tree shelters, and flexible tree guards to minimize deer damage.

(4) Reduce plant competition through selective herbicide application to kill vegetation (see discussion of appropriate use of herbicides, *page 133*), particularly sod-forming grasses, around the base of each tree (once or twice annually) or mowing (at least four times) during the growing season until the canopy reaches 60% cover.

(5) After canopy closure, inspect for invasive plants annually and control as needed.

5d. Convert to Native Shrubland

This is the preferred option if the conservation priority is threatened shrubland birds and the landowner has the resources to complete necessary stewardship tasks. Use guidelines under 3b to convert meadow to native shrubland.

5e. Convert to Wetland

This is the preferred option for a meadow that is relatively small, is adjacent to existing wetlands, and has topography that would lend itself to conversion to wetlands with minimal site work (e.g., light grading, construction of a low berm to capture surface water flow). On former agricultural fields this can sometimes be accomplished by breaking the drainage tiles that were installed to make the site suitable for agriculture. This option and the specific tasks required to implement this strategy, along with potential funding opportunities, should be explored with representatives of the County Conservation District, USDA Natural Resources Conservation Service, Pennsylvania Department of Environmental Protection, or US Fish and Wildlife Service.

Cover Type 6 Pasture/Cropland

Overview

Pastures are open areas of short grasses and forbs that are used for livestock grazing. Cropland is used to grow annual plants (e.g., grains, beans) and hay for consumption by humans and domesticated animals. A well-managed pasture or cropland has minimal impacts on adjacent natural lands and can be part of a landscape that supports threatened grassland-interior birds such as bobolinks and eastern meadowlarks *(see* **Meadow/ Grassland**, *page 85)*. Poor stewardship (the area is overgrazed or full of weeds, or rows run up and down the slope) can cause soil erosion through increased surface runoff on adjacent natural lands, degrade nearby water resources through inputs of sediment and manure, or act as a reservoir for invasive plant species. If the area is to remain in agriculture, the landowner should contact the USDA Natural Resource Conservation Service about developing a conservation plan to minimize the impact on nearby natural resources. If the area is no longer needed for agricultural purposes, it can be added to the natural lands of the property. This is particularly beneficial if the pasture or cropland is currently located in an area that is often wet.

Cover type options and guidelines

There are four cover type options for converting an existing pasture or cropland to natural lands: convert to forest, convert to shrubland, convert to meadow, or convert to wetland. Which option or options are chosen will depend on the conservation priority, site conditions, and the available stewardship budget.

6a. Convert to Forest

This option is appropriate if the planted area would augment an adjacent forested area (and result in reduced edge or increased interior forest habitat), connect two existing forested areas, or provide a natural screen to improve the aesthetics of the site. Although there are many environmental and ecological benefits to be realized from this strategy, it is also a strategy that requires significant time and resources to accomplish due to the overabundance of white-tailed deer and invasive plants in the region. Implementing this strategy will likely take many years of intensive stewardship because of these factors.

The following guidelines assume that conditions common in the region, specifically overabundant deer and invasive species, exist on the site. If native tree seedlings are already established in a pasture or the land manager believes that an adequate number of trees will become established naturally, the process can start at step (3). In the rare instance of adequate native advance regeneration and low deer and invasive species pressure, it can start at step (5).

(1) Select native species that are appropriate for site conditions *(see* **Native Plant Materials**, *pages 172–200)*.

(2) Planting design should allow enough space between trees to allow for control of competing vegetation with available mowing equipment, but close

enough for the canopy to close quickly. For forest this will require a spacing of between 10 feet x 10 feet and 20 feet x 20 feet. Narrow hedgerows that principally serve as screens should have at least a 20-foot spacing in staggered rows to allow for good development of each tree.

(3) Use protective measures such as fencing, tree shelters, and flexible tree guards to minimize deer damage.

(4) Reduce plant competition through selective herbicide application to kill vegetation (see discussion of appropriate use of herbicides, *page 133*), particularly sod-forming grasses, around the base of each tree (once or twice annually) or mowing (at least four times during the growing season) until the canopy reaches 60% cover.

(5) After canopy closure, inspect for invasive plants annually and control as needed.

6b. Convert to Native Shrubland

This is the preferred option if the conservation priority is threatened shrubland birds and the landowner has the resources to complete necessary stewardship tasks. Use guidelines under 3b to convert pasture or cropland to native shrubland.

6c. Convert to Native Meadow

Meadows provide more environmental and ecological benefits than pasture and cropland and are less costly to maintain. This is a preferred option if the area is no longer needed for animal grazing and it would augment an adjacent meadow. Use the guidelines under 5b to convert pasture or cropland to native meadow.

6d. Convert to Wetland

This is the preferred option for a pasture or cropland that was formerly wetlands (previously drained for agriculture) or a pasture or cropland that is relatively small, is adjacent to existing wetlands, and has topography that would lend itself to conversion to wetlands with minimal site work (light grading, construction of a low berm to capture surface water flow). On former agricultural fields this can sometimes be accomplished by breaking the drainage tiles that were installed to make the site suitable for agriculture. This option and the specific tasks required to implement this strategy, along with potential funding opportunities, should be explored with representatives of the USDA Natural Resources Conservation Service, Conservation District, Pennsylvania Department of Environmental Protection, or US Fish and Wildlife Service.

Converting pasture or cropland to a more natural cover type would be particularly beneficial if it is currently located in an area that is often wet.

TREE DOMINATED OR OPEN AREAS

Overview

There are two cover types—wetlands and riparian areas—that can exist as either tree dominated or open areas depending on past disturbance and hydrology. Wetlands are saturated for an extended period during the growing season. Those that are dominated by woody vegetation (trees and shrubs) are commonly called swamps. Many trees and shrubs native to our region are able to survive for several months in saturated soils (e.g., red maple, pin oak, swamp white oak, blackgum, buttonbush, smooth alder, silky dogwood, winterberry), particularly if inundation occurs during the dormant or non-growing season. Wetlands dominated by herbaceous plants are commonly called marshes.

Riparian areas are lands adjacent to natural and man-made water bodies (stream, river, pond, reservoir). They can also exist as tree dominated or open lands and can be terrestrial (upland) or palustrine (wetland). In agricultural areas the riparian area is typically dominated by herbaceous plants that are harvested as food crops or serve as pasture for livestock. Riparian areas in this region that are not subject to repeated disturbance from agriculture or mowing are generally dominated by trees. Open wetlands—shrub swamp or marsh—are the exception to that rule.

Wetlands and riparian areas deserve special attention in developing and implementing a stewardship plan. Indeed, the mismanagement of these areas can have serious impacts to the quality and quantity of local water resources. In addition to reducing stormwater flow and filtering chemicals and sediment from adjacent agricultural or developed lands, they provide valuable habitat for wildlife, including food, water, and protected travel routes for aquatic animals and species that prey on aquatic animals, including a vast diversity of insects, fish, amphibians, birds, and mammals. To protect water and soil resources, wetlands and riparian areas should be left as undisturbed as possible. This means keeping livestock out and avoiding mowing or other vegetation management, with the exception of planting native species and spot-controlling invasive species. Wetlands and waterways are heavily regulated resources; the landowner should seek input from the County Conservation District, Pennsylvania Department of Environmental Protection, or USDA Natural Resource Conservation Service before undertaking stewardship around wetlands and streams in order to comply with federal, state, and local laws.

Cover Type 7 Wetlands

Overview

Wetlands may be defined as areas that satisfy at least two of the following three parameters: (1) they support hydrophytic (water-loving) plants, (2) they contain hydric soils, or (3) their hydrology is such that there is permanent or periodic inundation, or soil saturation for seven days or more during the growing season. Although historically maligned as wasteland, wetlands (particularly forested wetlands) are finally receiving proper recognition for the many important ecological and environmental benefits they provide. Because the stewardship of wetlands is covered by federal and state regulations that are periodically

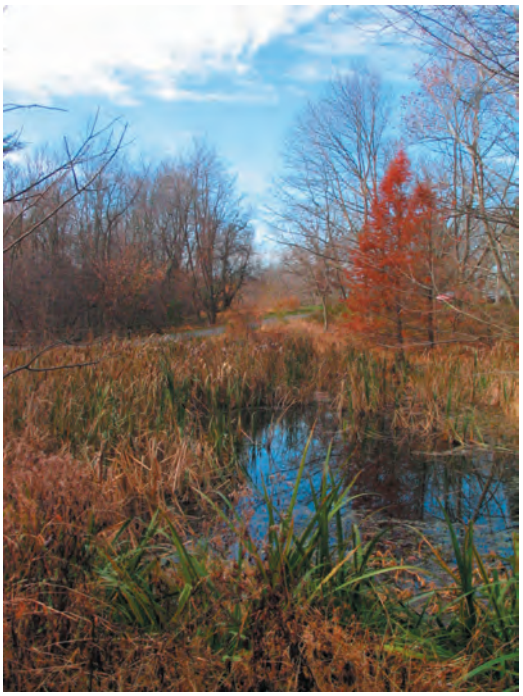
modified, it is prudent to contact the USDA Natural Resources Conservation Service, Pennsylvania Department of Environmental Protection, or the Conservation District before conducting any stewardship activity in or near a wetland area.

Benefits to regional conservation priorities

- ***Wildlife habitat***. Amphibians, aquatic insects, and many animals that depend on them as a major food source use wetlands as breeding and feeding sites.
- ***Water quality protection***. Wetlands buffer streams by absorbing sediments and chemical pollutants.
- ***Stream flow moderation***. By absorbing large amounts of precipitation, wetlands reduce the volume of water entering streams during storm events. By slowly replenishing groundwater and streams they help maintain stream flows during dry periods.

Current issues

- There are three species of ***invasive plants*** that can be especially destructive to wetland values in the region: purple loosestrife, reed canary grass, and phragmites can monopolize wetlands and reduce their ecological value. Common cat-tail—although it is a native species and capable of effectively filtering pollutants from water—can also monopolize wetlands and reduce biodiversity where runoff or groundwater is polluted with nutrients from fertilizer use or septic drain field leakage in the watershed. Other invasive plants that are typically found in uplands can also be highly invasive in wetlands, notably multiflora rose and Japanese stiltgrass.



Molly Smyrl

Historically maligned, filled, dredged, and drained, wetlands are now considered essential for maintaining water quality. Good stewardship includes compliance with several levels of regulation designed to protect this valuable, yet vulnerable, habitat.

Although historically maligned as wasteland, wetlands are finally receiving proper recognition for the many important ecological and environmental benefits they provide.

Cover type options and guidelines

There are five options for wetland areas: preserve as is, restore to healthy state, convert to forest, convert to shrubland, or convert to meadow. Which option or options are chosen will depend on the conservation priority, site conditions, and the available stewardship budget. Any permitted stewardship work within wetlands is best undertaken when the ground is frozen or dry (to minimize the impact to the resource) and after consultation with a representative of the Conservation District, Pennsylvania

Department of Environmental Protection, or USDA Natural Resources Conservation Service.

7a. Preserve As Is
This is a preferred option if the existing cover type is swamp (wet forest or shrubland) or marsh (wet meadow) in a healthy condition. Consult Cover Types 1, 4a, and 5a for stewardship guidelines for maintaining healthy forest, shrubland, and meadow, respectively.

7b. Restore to Healthy State
This is a preferred option if the existing cover type is wet forest, shrubland, or meadow in a degraded condition. See 2a, 4b, and 5b for management guidelines for

Resources and Considerations for Wetland and Riparian Stewardship

	WETLAND	RIPARIAN
Assistance	• Pennsylvania Audubon • County Conservation District • Pennsylvania Department of Environmental Protection, Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Game Commission • Penn State Extension • USDA Natural Resource Conservation Service	• Pennsylvania Audubon • County Conservation District • Pennsylvania Department of Environmental Protection, Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Game Commission • Penn State Extension • USDA Natural Resource Conservation Service
Tools/Materials	• Monitoring: plant, bird, amphibian, insect identification books • Vegetation control: pruners, pruning saw, chainsaw, "Weed Wrench," herbicides approved for aquatic use	• Monitoring: plant, bird, amphibian, insect identification books • Vegetation control: pruners, pruning saw, chainsaw, "Weed Wrench," herbicides approved for aquatic use, heavy-duty field mower/brush cutter
Considerations	• Contact Conservation District or Pennsylvania DEP about technical assistance and required permits before beginning work • Monitor for invasive species at least annually and control as quickly as possible • Monitor deer population and maintain at appropriate level to sustain a healthy community *(see discussion on estimating deer impact, page 112)* • Create/extend adjacent forest or meadow buffer • Use proper timing (when soils are very dry or frozen) for any necessary activity • Consider potential changes to hydrology from upstream land use change	• Contact Conservation District or Pennsylvania DEP about technical assistance and required permits before beginning work • Monitor for invasive species at least annually and control as quickly as possible • Monitor deer population and maintain at appropriate level to sustain a healthy community *(see discussion on estimating deer impact, page 112)* • Create/extend adjacent forest buffer • Use proper timing (when soils are very dry or frozen) for any necessary activity • Consider potential changes to hydrology from upstream land use change

restoring degraded forest, shrubland, and meadow, respectively.

7c. Convert to Forest
This is a preferred option if the existing cover type is shrubland, meadow, pasture, or lawn and the hydrology permits trees to survive. See 4c, 5c, 6a, or 10a, respectively, for guidelines to convert shrubland, meadow, pasture, or lawn to forest.

7d. Convert to Native Shrubland
This is the preferred option if the conservation priority is threatened shrub swamp birds, the landowner has the resources to complete necessary stewardship tasks, and the existing cover type is degraded forest, meadow, pasture, or lawn. Follow guidelines under 2b, 3b, 6b, or 10b, respectively, to convert degraded forest, meadow, pasture, or lawn to native shrubland.

7e. Convert to Native Meadow
This is the preferred option if the existing resource is pasture or lawn/landscaped area. This would not be a preferred option if the existing resource is forest or shrubland. Follow guidelines under 6c and 10c, respectively, to convert pasture or lawn/landscaped area to native meadow.

Cover Type 8 Riparian Area

Overview

Riparian areas are lands immediately adjacent to streams or ponds and typically include floodplains, alluvial soils, and stream-related wetlands ("oxbow" swamps, marshes, and ponds). Given their critical position adjacent to water resources it is preferred that all riparian areas be maintained as forest or native shrubland to maximize their buffering role. An outside strip of meadow may be preferred in situations where high inputs of surface stormwater are directed into the riparian area from adjacent agricultural fields or developed areas. Riparian forests can provide many benefits including environmental (as silt and chemical buffers for associated streams and areas of high carbon sequestration), ecological (wildlife habitat), and recreational (fishing) benefits and can be an attractive part of a property. The width of the buffer needed to protect the stream resources and provide environmental and ecological benefits will vary depending on soils and slope. In general the buffer should be no

Given their critical position adjacent to water resources it is preferred that all riparian areas be maintained as forest or shrubland to maximize their buffering role.

Claudia Steckel

Vegetation on forested riparian corridors adjacent to streams or ponds is extremely important for filtering pollution from runoff and slowing down stormwater. Stewardship should focus on maintaining the forest cover.

less than 25 feet (ideally 95 feet or more) on either side of the stream and may need to be more to include sensitive areas such as wetlands. The extent of the protected stream corridor should be determined on a case-by-case basis.

Benefits to regional conservation priorities

- Protect water resources through ***shading and uptake of agricultural and urban runoff***, and provide ***food for aquatic macroinvertebrates***.

Current issues

- The stewardship of riparian buffers adjacent to or within residential developments can be compromised due to the ***proximity of residences*** and their owners who complicate or eliminate deer management, use the area as dump sites, or prune understory vegetation to improve the view of the water body.
- ***Excessive overland flow*** from agricultural fields, lawns, or impervious surfaces can lead to gully erosion.

Cover type options and guidelines

As stated above, riparian areas should consist of forest, shrubland, or meadow to buffer the adjacent water resource. Therefore, regardless of the existing resource, the goal should be to maintain the corridor as healthy forest, shrubland, or meadow, or to move the existing resource to healthy forest, shrubland, or meadow. Use the **Stewardship Matrix** *(page 67)* to reference the appropriate section for guidelines to achieve this goal.

HUMAN-ENGINEERED AREAS

Overview

The final cover types that can be encountered in natural lands or potential natural lands have the common characteristic of being more or less "engineered," that is, they have resulted from modifications such as regrading, paving, and construction of buildings and other structures. They also are or have been the focus of more intense human activity. In general, they require significant maintenance and, if not properly maintained, can present a hazard to the landowner, visitors, and neighbors, and compromise other natural resources.

The degree to which each cover type can be incorporated into a property's natural lands depends on how much it can be modified and continue to perform its intended function. A pond can become part of a natural area if the area around it is converted to forest, shrubland, or meadow; it can also be converted to a fully vegetated wetland—generally increasing its wildlife value, but losing its recreational (fishing, boating) function. Stormwater basins can be somewhat naturalized through less frequent mowing and the planting of native trees, shrubs, and herbs. Lawn, however, can only become natural land by converting it to another cover type. The landowner needs to weigh the benefits of naturalizing these areas with the loss of original function when determining their long-term stewardship.

Cover Type 9
Pond

Overview

Ponds are open bodies of water formed by damming a stream or through the excavation of an area with a high water table or water source (springs or seeps). Because southeastern Pennsylvania was never glaciated, ponds are not a natural component of the landscape except for a few oxbow ponds along large streams, but they are common in the region due to their former use for irrigation, fire control, water supply, or flood control, and for their aesthetic appeal. Ponds can provide some benefit, including environmental (silt traps for associated streams), ecological (habitat for aquatic plants and animals), and recreational (fishing, boating) benefits, and they can be an attractive part of the landscape. However, the maintenance costs and liability concerns associated with ponds and their impacts on water quality often outweigh these benefits. Unless shaded or very small, they can elevate water temperatures of associated streams (particularly if outflow is from the surface), block the migration of aquatic organisms, and, if surrounded by lawn, attract large numbers of Canada geese, which further degrade the water through their droppings. From a basic stewardship perspective they also can require costly, specialized maintenance, including periodic dredging and dam repairs, and they can be an attractive nuisance. In this *Stewardship Handbook*, we will address only ponds that are relatively small and part of larger existing or potential natural lands.

Benefits to regional conservation priorities

- ***Habitat for wildlife***, particularly amphibians, waterfowl, and wading birds.

Current issues

- ***Thermal pollution*** of associated streams.
- When combined with low vegetation they are an ***attractive cover type for Canada geese***. Aggregation of geese in large numbers leads to degradation of ponds and associated streams.
- Older ponds are likely to need ***costly maintenance***, including dredging and repairs to berms and spillways.
- The dams of in-stream ponds usually ***obstruct the movement of aquatic organisms***, including fish, which restricts their access to upstream feeding and breeding sites.

Holly Harper

Large unshaded bodies of water contribute to thermal pollution of streams and attract large numbers of Canada geese. If a pond is retained, stewards should aim to reduce its negative effects on water quality with vegetated riparian buffers that help shade the water surface and attract a greater diversity of wildlife and fewer geese.

Cover type options and guidelines

There are six cover type options for ponds: preserve as is, restore to healthy state, convert to forest, convert to shrubland, convert to meadow, or convert to wetlands. Which option or options are chosen will depend on the conservation priority, site conditions, and the available stewardship budget. The appropriate option will also depend on whether the pond is in-stream or not. The conversion of in-stream ponds to restore the original stream channel is highly desirable because of the direct impacts on water quality; off-stream ponds have a lesser impact on water quality if they do not empty into a stream, so their conversion to a different cover type is driven more by maintenance costs and liability concerns. Conversion of in-stream ponds is a much more complicated process that involves removal of the dam and legacy sediments (the silt that builds up behind the dam) and the regrading and stabilization of the streambank. Ideally, a restoration specialist can locate the historical stream channel and regrade and plant the area to encourage its reestablishment.

9a. Preserve As Is/Restore to Healthy State

This is the preferred option if there are sufficient funds to maintain or restore the resource and water-based recreation or education is the conservation priority. It is recommended that the pond be buffered by forest, shrubland, or meadow, or a combination. Consult the **Stewardship Matrix** *(page 67)* to reference the appropriate section for converting lawn, invasive vegetation, or other cover to forest, shrubland, or meadow. The buffer should have a width of at least 95 feet to be effective. Contact the USDA Natural Resources Conservation Service, Pennsylvania Department of Environmental Protection, or Conservation District to make sure all current regulations are followed when undertaking pond restoration and maintenance.

Ponds are seen currently as having largely negative effects on the water quality of any associated stream.

9b. Convert to Forest

This is a preferred option if there is no desire to preserve the pond and approval can be obtained from the Pennsylvania Department of Environmental Protection for filling in the pond or breaching the dam. These guidelines start with the assumption that conditions common in the region, specifically overabundant deer and invasive species, exist on the site. If the land manager believes that an adequate number of native trees will become established naturally, skip steps (3) and (4). In the rare instance of adequate native advance regeneration and low deer and invasive species pressure, begin at step (7).

(1) Follow Pennsylvania Department of Environmental Protection or USDA Natural Resources Conservation Service recommendations for draining, removing structures, and filling. Regrade as needed to restore the natural topography of the site.

(2) Seed exposed ground with a fast-growing, native, perennial grass such as Canada wild-rye, riverbank wild-rye, or Virginia wild-rye (or exotic annual rye or oats, which produce fast cover but do not persist) to stabilize the exposed soil.

(3) Planting design should allow enough space between trees to allow for control of competing vegetation with

available mowing equipment, but close enough for the canopy to close quickly. This will typically require a spacing of between 10 feet x 10 feet and 20 feet x 20 feet. The spacing can be more random if persistently wet soils or other conditions prohibit the use of heavy mowing equipment, necessitating manual control of competing vegetation.

(4) Select native species that are appropriate for the site (*see* **Native Plant Materials**, *pages 172–200*). For best survival trees should be 1–2 inches in caliper for hardwoods and 6–8 feet in height for conifers.

(5) If seedlings are planted, use protective measures such as fencing, tree shelters, and flexible tree guards to minimize deer damage.

(6) Reduce plant competition through selective herbicide application (see discussion of appropriate use of herbicides, *page 133*) to kill vegetation around the base of each tree (once or twice annually) or mowing (at least four times) during the growing season until the canopy reaches 60% cover. After closure monitor for invasive plants and control as needed.

(7) Inspect annually for invasive species and treat as necessary.

9c. Convert to Native Shrubland

This is the preferred option if the conservation priority is threatened shrubland birds, the landowner has the resources to complete necessary stewardship tasks, and approval can be obtained from the Pennsylvania Department of Environmental Protection for filling the pond or breaching the dam. After filling and restoring the area to its natural topography according to Department of Environmental Protection recommendations, follow the guidelines under 3b to convert a pond to native shrubland.

9d. Convert to Native Meadow

This is a preferred option if there is no desire to preserve the pond and approval can be obtained from the Pennsylvania Department of Environmental Protection for filling the pond or breaching the dam. After filling and restoring the area to its natural topography according to Department of Environmental Protection recommendations, follow the guidelines under 2c to convert a pond to native meadow.

9e. Convert to Wetland

This is a preferred option if there is no desire to preserve the pond and approval can be obtained from the Pennsylvania Department of Environmental Protection for filling the pond or breaching the dam. This option and the specific tasks required to implement this strategy, along with potential funding opportunities, should be explored with representatives of the USDA Natural Resources Conservation Service, Conservation District, Pennsylvania Department of Environmental Protection, or US Fish and Wildlife Service.

Cover Type 10 Lawn/Landscaped Area

Overview

Lawn and landscaped areas are open areas that are formally landscaped and maintained principally for recreational and aesthetic benefits. Because they afford the least environmental and ecological benefits (indeed they can create environmental problems if not managed properly) and usually are the most costly in the long term in personnel time, fuel and equipment costs, and carbon "footprint," their extent

Because they afford the least environmental and ecological benefits and usually are the most costly in the long term in personnel time, fuel and equipment costs, and carbon "footprint," the extent of lawn and landscaped areas should be minimized.

should be minimized. Adding part of this area to natural lands is a good way to increase environmental and ecological benefits and reduce overall stewardship costs for a property. Using native species for landscape plantings (*see* **Native Plant Materials**, *pages 191–200*) will lessen the ecological impact of landscaping by providing food for key components of the food web, especially native insects (most cannot eat exotic species) and birds, and not promoting the introduction of invasive species into nearby natural areas.

Benefits to regional conservation priorities

- None

Current issues

- The increase in suburban development has led to the ***proliferation of this cover type***. The use of chemical biocides to maintain this cover type can add insult to injury by polluting the remaining natural resources nearby. Using natural lawn care and native plant material, and developing a tolerance for "weeds" can help to minimize the ongoing impact of this environmentally and ecologically worthless cover type.

Cover type options and guidelines

There are four options for lawn and landscaped areas: convert to forest, convert to shrubland, convert to meadow, and convert to wetlands. Which option or options are chosen will depend on the conservation priority, site conditions, and the available stewardship budget.

10a. Convert to Forest

This option is appropriate if the planted area would augment an adjacent forested area (and result in reduced edge or increased interior forest habitat), connect two existing forested areas, or provide a natural screen to improve aesthetics of the site. Although there are many environmental and ecological benefits to be realized from this strategy, it is also a strategy that requires significant time and resources to accomplish due to the overabundance of white-tailed deer and invasive plants in the region. Implementing this strategy will likely take many years of intensive stewardship because of these factors. Use the guidelines under 6a to convert lawn or landscaped area to forest.

10b. Convert to Native Shrubland

This is the preferred option if the conservation priority is threatened shrubland birds and the landowner has the resources to complete necessary stewardship tasks. Use guidelines under 3b to convert lawn or landscaped area to native shrubland.

10c. Convert to Native Meadow

Converting lawn or landscaped areas to native meadow would increase the environmental and ecological benefits of the site, especially if it augmented an existing meadow, buffered a stream corridor, or was located on a wet or steep

(>15%) site. Non-native meadow can be created from lawn areas simply by reducing the mowing frequency to once or twice annually. Converting to native meadow requires clearing the existing vegetation and planting native meadow species. The latter option is preferable in that it allows the landowner to introduce desired native species and to eliminate exotic grasses (e.g., tall and red fescues, perennial rye, Kentucky bluegrass, creeping bentgrass) and other invasive plants that compete with native species. The former option, however, may be more appropriate on wet or steep areas where native meadow establishment procedures would be more difficult and could create environmental problems. Any plan that calls for the eradication of existing vegetation to establish meadow on wet or steep (>15%) areas should follow USDA Natural Resources Conservation Service recommendations to minimize environmental impacts. Use the guidelines under 5b to convert lawn and landscaped areas to native meadow.

10d. Convert to Wetland

This is the preferred option for lawn/landscaped area that was formerly wetlands (typically once drained for agriculture), is relatively small, is adjacent to existing wetlands, and has topography that would lend itself to conversion to wetlands with minimal site work (light grading, construction of a low berm to capture surface water flow). This option and the specific tasks required to implement it, along with potential funding opportunities, should be explored with representatives of the USDA Natural Resources Conservation Service, Conservation District, Pennsylvania Department of Environmental Protection, or US Fish and Wildlife Service.

Cover Type 11
Stormwater Control Structures

Overview

Natural lands are rarely the source of stormwater problems, but they often suffer from the effects of poor stormwater management on properties upslope or upstream. Managing stormwater runoff from impervious surfaces is an essential part of land and water stewardship. If designed with careful attention to the ecology and hydrology of each site and each watershed, and with the use of innovative best management practices (BMPs), projects can match or improve upon the predevelopment condition. New residential subdivisions provide excellent opportunities to work "on-contour" with broader systems of berms, swales, and vegetated filter strips and better utilization of natural soils and vegetation than typically were used in past building practices.

Unfortunately, many existing stormwater basins are maintained as lawn, which provides no wildlife benefits except for Canada geese. There are several options for converting to an alternative cover type to improve this condition and make stormwater structures a beneficial part of the property's natural lands.

Benefits to regional conservation priorities

- Stormwater basins maintained as lawn have no benefits as natural lands.

While natural lands are rarely the source of stormwater problems, they often suffer from poor stormwater management on properties upslope or upstream.

Current issues

- Conventional stormwater systems provide virtually ***no means of filtration for contaminants*** found in stormwater runoff, other than by allowing suspended solids to settle out in detention or retention basins.
- Stormwater basins maintained as lawn ***attract large numbers of Canada geese***.

Cover type options and guidelines

The number of options for stormwater control basins varies depending on which professional you speak with. Engineers are usually opposed to planting woody vegetation within stormwater basins—particularly on the berms—because of concerns that the tree or shrub roots will undermine berms and any liners or recharge beds at the bottom of the basin and that woody detritus can clog outflow structures. Ecological designers believe that woody vegetation will anchor soils on berms (as it does on streambanks) and promote recharge in basin beds (any clogging of outfall structures simply requires seasonal maintenance as an alternative to weekly mowing). As a relatively easy alternative to traditional lawn, stormwater basins can be converted to native meadow to increase ecological benefits and eliminate the basin as an attraction to flocks of Canada geese.

11a. Convert to Forest
Follow guidelines under 10a.

11b. Convert to Native Shrubland
Follow guidelines under 10b.

11c. Convert to Native Meadow
Follow guidelines under 10c.

HISTORIC RESOURCES

Overview

Southeastern Pennsylvania is brimming with historic resources, many of which contribute to community character. They can be categorized as follows: (1) built resources such as residences, barns, commercial buildings, houses of worship, civic structures, etc., (2) archaeological resources—the artifacts and relics of past human cultures, and (3) cultural resources including combinations of built and natural resources, such as trees, streams, bridges, walls, spring houses, corn cribs, railroad tracks, and cemetery markers.

Many township historical commissions and review boards have inventoried local historic resources. Because historic resources provide area residents and visitors with a critical link to the past, it is recommended that you contact your local historical commission directly for advice if your natural lands contain built, archaeological, or cultural resources.

Cover type options and guidelines

There are two preferred management options for historic resources: preserve as is and restore to a healthy state. The option selected will depend upon the condition and integrity of the resource, the available management budget, and the interpretive value of the resource. A local

historical review board will likely consider a resource to have a high degree of integrity if it possesses one of the following: (1) an authentic, remnant historic or architectural identity evident through surviving or physical characteristics such as location, setting, design, materials, or workmanship; (2) the documented potential of possessing retrievable or surviving characteristics; or (3) documented association with an historical event or person, accompanied by surviving relevance to the setting of the event or person. It is recommended that you contact your local historical commission or a consultant trained in historic resource conservation for assistance in determining the integrity and interpretive value of your historic resource(s). If required, the commission will also help identify potential sources of preservation funding.

12a. Preserve As Is

If a resource has a high degree of integrity and interpretive value, measures should be taken, at the very least, to sustain the existing form, integrity, and material of the resource. Preservation may include either initial stabilization or ongoing maintenance. Because of the varied nature of historic resources, it is recommended that an expert in the type of resource present be retained to advise on the most appropriate methods for preservation, that is, an architect specializing in historic architecture, an archeologist, or landscape historian.

12b. Restore to a Healthy State

If a resource that has a high degree of integrity and interpretive value exists in a state of disrepair, every effort should be made (funds permitting) to restore the resource to its form and condition at an appropriate point in history. If restoration is not feasible for financial or other reasons, the goal should be to stabilize the resource in order to prevent further damage. Consultation with your local historical commission will help determine the appropriate point in history and provide guidance on how to preserve a resource's authenticity in the restoration process.

Southeastern Pennsylvania is brimming with historic resources, many of which contribute to community character.

Stewardship Techniques and Procedures

IN THIS SECTION

This section provides an overview of the stewardship techniques and procedures that can help land managers in southeastern Pennsylvania address the problems highlighted in the **Major Stewardship Issues** section *(page 20)*. New information and methods pertaining to stewardship are emerging all the time. The land manager should keep current on natural lands management issues to become aware of new options as soon as possible. The land manager should also keep track of what techniques and procedures work best on his or her property and share this information with colleagues in the region (through Natural Lands Trust and other stewardship information networks) to improve prevailing best management practices.

WILDLIFE MANAGEMENT

The problems posed by an overabundant deer population are highlighted under **Major Stewardship Issues**. Deer overabundance causes the most significant adverse impacts affecting native Pennsylvania forests. The following is a discussion of the methods currently available and their applicability to reducing the impact of overabundant deer populations in southeastern Pennsylvania. It is followed by a much briefer discussion—an indication of their much lower impact—of Canada geese.

Deer Management Options

Wherever deer are present on natural lands in southeastern Pennsylvania, there is a strong likelihood that the population is higher than the ecosystem can sustain without substantial losses of native plant and animal species, forest structural diversity, and advance tree regeneration and the proliferation of exotic (non-native) invasive plant species, black-legged ticks, and the bacterium that causes Lyme disease. That is because deer populations are no longer regulated as they were for millions of years, first by native predators and more recently by Native Americans hunting to supply their families with food. Year-round, geographically pervasive predation is the only force that has been demonstrated to be capable of limiting deer population numbers in most of our region, but all of their major predators are gone and will not be returning. Foods preferred by deer are so abundant across southeastern Pennsylvania that competition for food does not limit deer numbers, at least not until they are so plentiful that browsing has caused catastrophic changes to native ecosystems. Recreational hunting as it

has been practiced since game laws were first instituted over a century ago is very different from predation or subsistence hunting. It does not regulate deer numbers at levels that allow native species diversity, forest structure, and advance tree regeneration to be sustained. However, the Pennsylvania Game Commission has been making changes to hunting regulations recently in recognition of the problems created by overabundant deer, expanding the hunters' "tool kit," extending hunting seasons, and allowing non-recreational culls in some circumstances. This has broadened landowners' options if they wish to reduce deer impacts on their natural lands. This section is designed to help a land manager determine which option or options are most appropriate for his or her property.

No management

No deer management is an option if natural factors (predators, disease, famine) and human activities (hunting, car accidents) within the area are maintaining the deer population at a level that does not adversely affect important natural or cultural resources. Another basis for no management that applies even where deer are overabundant and there is clear evidence of adverse ecosystem impacts is a landowner's belief that wild animals should not be harmed, perhaps coupled with the hope that nature or human ingenuity will eventually remedy the impacts without the need for lethal methods. In most situations in southeastern Pennsylvania, landowners with conservation priorities that include wildlife habitat, natural plant communities, or income from timber harvesting are likely to see those priorities compromised by the consequences of the no-management option.

Failure to manage the deer population will make healthy natural forest communities unsustainable in southeastern Pennsylvania.

David Steckel

Choosing not to manage deer can result in a park-like forest with only canopy trees and an herbaceous layer dominated by exotic invasive species.

An instructive example of the effects of the no-management approach is a 3,400-acre preserve north of Carlisle, Pennsylvania, managed by Natural Lands Trust. This property has suffered from extreme deer overabundance (densities over 100 per square mile) since the late 1960s when hunting was prohibited by the donor's will. The deer population has remained high—despite the total lack of understory vegetation—through the consumption of the annual mast crop (acorns, beech nuts, hickory nuts, etc. from the existing canopy trees), the few tree seedlings that are able to germinate, and agricultural crops on adjacent farm fields. As a result, the forest resembles a park with canopy trees and a carpet of

Japanese stiltgrass spread and sustained by deer disturbance of the soil. Studies of forest gaps—the usual site of dense regeneration—by biologists at Dickinson College show a complete absence of tree seedlings. Computer models confirm the obvious: in the best case scenario, one without a major wind event or forest pathogen, the forest will gradually degrade into an impoverished savanna community with extremely low native species diversity as the current canopy trees decline and die.

Based on the current understanding of deer ecology and results on properties with high-density deer populations, failure to manage the deer population will make healthy natural forest communities unsustainable in southeastern Pennsylvania. The loss of native species diversity and structural variation in the understory will reduce habitat for local and migratory wildlife. A forest without a diverse understory lacks cover for ground-nesting birds such as ovenbird, worm-eating warbler, and Louisiana waterthrush and protected feeding and nesting areas for other forest-interior birds, including barred owl, Acadian flycatcher, wood thrush, cerulean warbler, northern parula, American redstart, Kentucky warbler, and hooded warbler. A forest devoid of an understory also lacks shelter and moist conditions preferred by reptiles and amphibians, including salamanders, frogs, and turtles. The likely shift in plant dominance to exotic invasive species from natives, which are preferred browse for deer, will decrease food resources for insects (a key link in the food web sustaining larger animals), birds (the growth and survival of young birds, and often adults as well, depend on insects to supply fat and protein), and aquatic invertebrates in associated forest streams (they are largely unable to digest leaves of exotic plant species).

Without deer management, perpetuation of some semblance of natural forest communities would require the use of artificial regeneration (planted trees and tall shrubs) to regenerate the forest until the deer population collapses through disease or starvation. Trees and shrubs will need to be tall enough (>5 feet) when planted to escape browsing of terminal buds and be planted in numbers sufficient to maintain at least a 60% closed canopy under pressure from environmental stresses and pests and pathogens. The land manager will also need to accept the likely loss or severe degradation of the native herb layer.

Active management

Active methods to control deer overbrowsing can be grouped into two categories: those that restrict or deter deer access to desired vegetation and those that reduce the deer population within a tract of land. The current tools used to modify white-tailed deer behavior include barriers, repellents, and lethal removal. Two other approaches that are often talked about but are infeasible at present or are prohibited in the state are contraceptives and trap and transfer.

Barriers

Barriers physically restrict deer from interacting with vegetation in the treated area. Options under this method include tree shelters, netting, and deer exclosure fencing. Tree shelters and netting protect individual trees or shrubs; fencing excludes deer from all the vegetation in a specific area. Physical barriers have proven to be effective in protecting trees and shrubs in formal landscapes and forest vegetation although they can be expensive if used over a large area.

Tree shelters are useful to protect seedlings in open areas (estate areas, forest

gaps, and edges) until they reach 6 feet in height and are above the maximum browsing height of deer. However, their cost and maintenance requirements might limit their use by some landowners (financial assistance for planting and tree shelters may be available from the Pennsylvania Bureau of Forestry or the USDA Natural Resource Conservation Service). A 5-foot tree shelter with support stake costs $5 to $6 depending on the quantity purchased. A per-acre cost at a 12-foot x 12-foot spacing will therefore run $1,500 – $1,800, plus tree seedlings and installation. Tree shelters also require periodic monitoring and maintenance as they are attractive to deer as rubs and are sometimes targets of vandals.

Fencing holds more promise as a deer management tool, but it involves significant up-front expense and frequent monitoring to ensure the integrity of the fence. Deer fencing around significant areas of land are 8–12 feet high and constructed of box wire, plastic mesh, or electrified wire (shorter fencing can be effective if the enclosed area is very small or narrow, such as a vegetable garden). The Pennsylvania Bureau of Forestry uses two 4-foot sections (8-foot total height) of box wire fencing kept tight to the ground to protect tree regeneration following timber harvests. Bowman's Hill Wildflower Preserve in Bucks County fenced 80 of its 100 acres with electrified wire in the early 1990s, effectively protecting its wildflower collection. Tyler Arboretum, near Media, Delaware County, in 2000 installed a 12-foot-tall, 2-mile-long deer fence around 105 acres of its collection at a cost of $350,000 (including more than $50,000 to provide vehicular access and a portion placed in the endowment for continuing maintenance). In addition to its high initial cost, fencing requires constant monitoring to quickly repair any breaks caused by falling limbs or vandals and restricts not only deer movement, but also the movement of several other animal species. Cost estimates for large-scale fencing projects are currently on the low end about $8–$10 per running foot of fence and, depending on site characteristics and materials used, can range up to $30 or more per running foot, including installation.

Gary Gimbert

Tree shelters are useful to protect seedlings in open areas (forest gaps and edges) from deer damage until they reach six feet in height and are above normal browsing height.

Costs and monitoring are complicated by internal roads, paths, or streams, requiring gates and stream crossing devices. One option that reduces the cost is to use temporary fencing, enclosing large (a quarter to half of the forested area) sections on a rotating basis to protect vital forest regeneration from deer browsing while maintaining accessibility to the rest of the forest for management and recreation. However, once advance tree regeneration is established and the fence is moved, the previously fenced areas are open to understory degradation again by deer browsing.

Fencing can also be used as an instructional and monitoring tool. Small (10 meter square) deer exclosures can be built at a relatively low cost (approximately $300 per exclosure) to be monitored and compared to the existing forest. These study and demonstration areas provide a picture of the forest's potential when browsing impacts from deer are removed. They also provide a feasible, more understandable, and far more useful barometer of deer overabundance than estimating deer density. The state of the forest within the exclosure can guide deer management outside.

Repellents

Repellents create unpleasant sensory experiences that discourage deer from physically interacting with vegetation in the treated area. Repellents include periodic loud sounds, bright lights, or foul-tasting foliar sprays, often with a base of capsaicin, the fiery alkaloid in chili peppers. Repellents can be effective in small areas where the goal is to reduce browsing damage to tolerable limits.

The main drawbacks to repellents are cost (approximately $150 per acre, plus application) and their short-term effectiveness. Deer, particularly those in dense populations, quickly adapt to these tactics. The manager must be committed to continually monitoring application needs and experimenting with new products as deer adapt. Although foliar sprays may be useful for landscape and other special plantings, repellents are usually impractical for natural lands.

The use of contraceptives to manage the deer population on natural lands in southeastern Pennsylvania is not only prohibited by law, except as part of an established research program, but it is also infeasible at this time due to the high cost.

Contraceptives

Contraceptives to prevent pregnancy in deer have been tested and are a subject of ongoing research. The two major types of contraceptives are immunocontraceptives and hormonal contraceptives.

Immunocontraceptives "vaccinate" an animal against egg proteins. When an ovary releases an egg, the deer's immune system views the egg as a foreign body and rejects it before it can implant itself within the uterus. Although very expensive and labor-intensive, immunocontraceptives have proven effective in arresting deer population growth under certain circumstances, such as on islands or within fenced parks or zoos where deer are confined to a relatively small area.

At present, the cheapest and most common method for administering immunocontraceptives is through the use of dart guns—close-range arms that are accurate to about 40 yards. Most population biologists feel that in order to stop herd growth in deer, they have to prevent pregnancy in 90% of the female population. Immunocontraceptives developed so far have to be readministered periodically to sustain sterility in each individual doe.

Hormonal contraceptives work primarily by preventing ovulation in does. The most effective method for administering this type of contraceptive is through subcutaneous implants. Although one treatment can be effective for multiple years there are logistical and health concerns associated with the use of hormonal contraceptives in natural areas on free-ranging deer (entering

and leaving properties at will). The first is the need to immobilize each deer to apply the treatment, which is logistically difficult, very expensive, and stressful to the animal, often leading to self-injury or death. Potentially more problematic is the unknown consequences of introducing these hormones into the food supply.

Currently, there are no contraceptives for free-ranging deer that are approved by the FDA or any other governing body. Also, the effects of deer contraceptives on other animals (including humans) have not been studied. Because deer in southeastern Pennsylvania are free ranging, there is a high probability of human consumption of treated animals. It is even more likely that hormonal contraceptives will enter the food chain when treated deer die and are consumed by other animals, for instance, raccoons, opossums, foxes, coyotes, turkey vultures, crows, or turtles. Introducing hormonal contraceptives into the environment and food chain could have unknown and far-reaching effects.

The use of contraceptives to manage the deer population on natural lands in southeastern Pennsylvania is not only prohibited by law, except as part of an established research program, but it is also infeasible at this time due to the high cost (over $1,000 per doe annually for immunocontraceptives), the potential health risks of hormonal contraceptives, and the high mobility of the local deer herd. The fact that deer are free ranging throughout the region makes treating enough of the right animals almost impossible.

Trap and Transfer

Trapping or darting deer (requiring a permit from the Pennsylvania Game Commission) and moving them to another location is the most expensive, difficult, and ineffective deer control method. It is an option fraught with problems, the greatest of which is finding a location willing to accept more deer. This problem has become more difficult with the recent spread of chronic wasting disease (CWD) to nearby states (West Virginia and New York). Attracting well-fed deer into baited traps is the next challenge. Finally, survival rates of transported deer have been low. At present, the Pennsylvania Game Commission has a policy of issuing no permits for trapping and transferring deer.

Trapping or darting deer and moving them to another location is the most expensive, difficult, and ineffective deer control method.

Lethal Removal

Hunting is the most frequently used deer population reduction and maintenance method commonly available to landowners and land managers. Other lethal removal options, including deprivation permits for farmers and culls by sharpshooters are available, but tightly controlled by the Pennsylvania Game Commission. All lethal means of deer management focus on reducing the number of does by mainly targeting antlerless deer. Removing bucks has almost no effect on the year-to-year rate of population increase, decrease, or maintenance.

A controlled, recreational hunting program in most cases is the most practical deer management tool available in southeastern Pennsylvania at this time.

Hunting is the most frequently used deer population reduction and maintenance method commonly available to landowners and land managers.

A controlled hunting program is probably the most effective deer management tool available to landowners in southeastern Pennsylvania at this time.

Drew Gilchrist

However, scientific evidence is still lacking that it is fully effective over a broad range of situations for reducing impacts of deer to levels adequate for the restoration and maintenance of ecosystem health. The likelihood of success rests to a large degree on the level of experience, skill, and dedication of the particular set of hunters who are the mainstay of the program.

There are several concerns surrounding the effective use of a deer-hunting program that should be considered by any land manager prior to implementation. The foremost issue is the safe use of firearms or archery in a region with a growing population and increasing use of natural lands. This is a particular concern in communities where natural lands are part of the common open space that is used by the local community. Any hunting program should be closely monitored by the land manager and controlled by restrictions that minimize the potential conflict between hunters and other users of the natural areas. These should include limitations on hunting areas and times, notification of appropriate persons when hunting is in progress, and an easy way to identify permitted hunters by other users. Most importantly, all hunters should be carefully screened for firearm proficiency and a history of ethical hunting practices. Any hunter who violates any program rule should be immediately removed from the program.

Ideally, hunting can lower the deer population to a level where only a few deer need to be removed each year to maintain the population at a level that allows healthy regeneration of the forest. Achieving this maintenance level is often complicated by ongoing suburban development in the surrounding landscape, which temporarily concentrates more deer on the remaining natural lands. If this is the case, it will probably require an extended period of more intense hunting, targeting mainly does, until the conversion of unprotected natural areas in the landscape to residential or other uses is complete. Perpetuating a maintenance level is also complicated by the fact that with a lower population, it may take hunters as much time to search out and remove a few deer as it now takes to remove a few dozen deer. The land manager will need to engage proficient, dedicated hunters to maintain the population at acceptable levels. Until additional options become available, recreational hunting will be the most widely used long-term method of keeping the population in check and allowing for limited forest regeneration until a point where populations stabilize in the surrounding area, which could be decades.

There are several potential alternatives and modifications within the lethal removal option that can be employed to reduce deer populations. The first is the use of archery, particularly on small

properties or properties with numerous residential structures on its borders. This would expand the hunting area (the safety zone for archery is 50 yards; firearms require a 150 yard safety zone) and extend the hunting time during the year by several weeks. An added benefit of allowing expanded access by hunters is that permitted hunters will monitor for unwarranted hunting while they are in the field.

In some situations, it is more efficient to engage a local hunting club to implement a deer population control program. They can handle all program administration, including proficiency tests, the scheduling of hunting times, and data collection on the separate harvest rates of does and bucks. The group should provide proof of insurance and be in close contact with the property landowner or manager to avoid conflicts with other activities in hunting areas.

Another alternative for expanding the number of deer harvested each year is enrollment in the Pennsylvania Game Commission's Deer Management Assistance Program (DMAP). This program provides additional permit applications (coupons) to landowners that they can then give to hunters. One coupon is granted for every 5 acres of farmland and every 50 acres of other land cover (forest, meadow, successional). Additional permits above the standard formula are available if the landowner submits a management plan with their request. Unlike in past years, the landowner is no longer required to open their land to the general public.

A final option does not involve recreational hunting at all. It is the use of sharpshooters to remove deer. Under this option qualified professional sharpshooters are hired to euthanize a high quantity of deer within a property. This requires a special permit from the Pennsylvania Game Commission. The process is very rigorous and requires the landowner to make a convincing case that hunting within current game laws is not a viable option for managing the deer population at desired levels. However, this is probably the safest (removal is usually done at night using infrared sighting scopes, over isolated baiting stations located where shots are directed into the ground) and quietest (sharpshooters use rifle silencers) removal method and is the most effective

Summary of Active Deer Management Options

METHOD	COMMENTS	MOST APPROPRIATE APPLICATIONS
Tree Shelters	High cost and maintenance requirements	Converting small open areas to forest. Protecting landscape plantings.
Deer Fencing	Significant up-front cost, frequent monitoring	Establishing tree regeneration in overbrowsed forest areas. Creating demonstration areas. Protecting collections (arboretums).
Repellents	Impractical in natural areas	Protecting landscape plantings in small areas.
Contraceptives	High cost, permit/license	Maintaining populations in areas enclosed by fencing or isolated by significant natural boundaries (e.g., water, mountains).
Trap and Transfer	Expensive, difficult, transfer location, permit/license	Removing deer that are in an area that puts humans or themselves in immediate danger.
Lethal Removal	Currently most effective, safety concerns	Reducing and maintaining populations in areas large enough to provide appropriate safety zones.

option for reducing the deer population in the shortest time. The cash outlay is relatively high but the time demands on the land manager can be considerably lower than that required to run a controlled hunting program. The venison is dressed and donated to charitable food banks or government-run institutions. Removal of other signs of the cull such as bloodied leaves may also be a part of the sharpshooters' services. Culls must be performed annually, at least until ecosystem restoration is achieved. Once the deer population is reduced and overbrowsing impacts are alleviated, a controlled hunting program—if it is permissible or feasible—may be adequate to maintain the desired deer population density.

Estimating Deer Impact

Monitoring vegetation indicators is a practical way to assess the effect of deer on forested areas. Vegetation can be assessed by two methods: (1) comparing the overall influence of deer browsing on existing vegetation to an established index or (2) quantitative sampling. The US Forest Service and Penn State University have developed a five-level deer impact index to visually assess the level of deer influence on forest health:

Deer Impact Index 1
Very low: No deer browsing. Occurs only within a well-maintained deer exclosure.

Monitoring vegetation indicators is a practical way to assess the effect of deer on forested areas.

Deer Impact Index 2
Low: Species composition and height of regeneration is determined mainly by available light, nutrients, and seed source. There is a well-developed shrub layer and native wildflowers are abundant and grow to their full size.

Deer Impact Index 3
Moderate: Evidence of browsing is common with a greater reduction in height and abundance of the most-preferred species than of the least-preferred species.

Deer Impact Index 4
High: Preferred species are sparse or absent and all plants are nearly the same height as a result of browsing. Vegetation in the shrub layer is sparse except for the least-preferred species (e.g., spicebush, American beech, exotic invasive shrubs).

Deer Impact Index 5
Very high: A pronounced browse line is evident with virtually no vegetation below the browse line except for two rhizomatous fern species, hay-scented fern and New York fern or exotic invasive herbaceous species such as Japanese stiltgrass and garlic mustard.

The deer impact index is a qualitative measure; its utility for detecting change over intervals as short as one or two years is weak and its usefulness depends heavily on the level of experience and knowledge of the evaluator on food-plant preferences of deer, expected maximum sizes of various plant species under a variety of habitat conditions, and how to distinguish signs of deer browsing from plant damage by other animals and causes other than herbivory. Please note that these impact levels apply to later successional stages, particularly maturing, mature, and old-growth forests. Young forests (up to approximately 30 years old) typically have a dense canopy that prevents sunlight from reaching the

forest floor. In this stage—called the pole or stem exclusion stage—the understory is largely free of shrubs and herbs due to heavy shade. As the forest matures and the canopy thins from the death of weaker trees, there is sufficient light to support a shrub layer on which deer can browse.

Quantitative sampling is more time-consuming but its interpretation involves less judgment and specialized expertise. A quantitative approach could include periodic surveys along a transect or cataloging vegetation change within fixed plots. The latter could be used in conjunction with the construction of deer exclosures. Methods need to be scientifically rigorous if the results are to be sufficiently credible to serve as the basis for labor-intensive and potentially costly deer management procedures. For example, the protocol should include:

- random selection of areas to be sampled;
- sampled areas large enough and sufficiently dispersed to include the variety of plant resources found within the property;
- sufficient replication and interspersion of treatments across the entire sampling area, for example, deer fencing, repellents, hunting; and
- sufficient number of samples to increase the likelihood of early detection of relatively subtle differences and to minimize the chances of confusing the effects of deer browsing with the effects of other factors that influence plant species composition.

The data gathered within sampling plots or along transects may include:

- percent cover of each plant species below 6 feet above the ground surface (maximum height of deer browsing),
- number of seedlings and saplings of each tree species, and
- special measures of indicator species (forest-floor species known to be vulnerable to deer but somewhat tolerant of moderate levels of browsing, for instance, Canada mayflower, Indian cucumber-root, and several trillium species); measures may include height of tallest plant or length of longest leaf in the plot, and number of flowering/fruiting individuals versus number of non-flowering/fruiting individuals of each indicator species in the plot.

The US Forest Service has developed assessment procedures for determining the current level of deer impact on forest regeneration as well as the level of competition from invasive species and other plants (e.g., ferns, mountain-laurel) that might interfere with the growth of established seedlings after a timber harvest. A copy of this assessment procedure is outlined in the Forest Service General Technical Report NRS-11 available from the US Forest Service, Northern Research Station, 359 Main Road, Delaware, OH 43015 or http://nrs.fs.fed.us/pubs/2471.

Estimating Deer Abundance

It is often said that a density of 15–20 deer per forested square mile is a maximum level allowing minimal advance tree and shrub regeneration, and a density of 5–10 per square mile is needed to sustain a high diversity of native species, including native herbaceous plants. These numbers come from a small set of studies in large forest tracts of a single forest type in northwestern Pennsylvania, in which deer density was known because the research areas were fenced, emptied of deer, and then restocked with exactly the numbers of

deer needed to achieve specific densities. This was excellent research, but we also know that deer density interacts with a host of other factors in determining the level of browsing impact on various forest ecosystem functions. Those other variables include forest type, understory species composition, landscape context, soil type, soil moisture regime, forest-floor light level, length of growing season, alternative food sources, historical land use, patterns of seasonal movement by deer, and legacy effects of prolonged high deer numbers (e.g., depleted seed bank, scarcity of live seed sources within dispersal distance, and disproportionate abundance of non-preferred understory plant species). These interactions are complex, unpredictable, and severely constrain the potential usefulness of deer density alone as a predictor of ecosystem impacts.

Where resources are limited, which is certainly the case for most managers of natural lands in southeastern Pennsylvania, it may be cost-ineffective to divert time and money from vital tasks, including deer management, to estimating deer density. Keeping careful track of the number of does killed each year by hunters or sharpshooters, in combination with rigorous monitoring of ecosystem indicators (see previous section) is sufficient in most cases for tracking progress in achieving and maintaining a deer density that allows forest ecosystems to be sustainable.

However, if the resources are available, it is desirable to monitor deer abundance to make certain that management actions intended to reduce or maintain deer populations actually do so. Making a full count of any animal species in the wild is nearly impossible, but several methods have been developed to estimate the abundance of white-tailed deer.

Survey methods can be classified into two general types: indirect methods based on monitoring deer signs (e.g., tracks, fecal pellets) and direct methods that require capturing or observing deer. Direct methods may deliver more accurate and precise population estimates but they tend to be prohibitively expensive.

Direct methods include aerial surveys, which have the advantage of covering large areas quickly and easily, although hiring pilots and renting aircraft are expensive. The main problem with using aerial surveys for white-tailed deer in this region is visual obstruction by vegetation. Although the region contains a predominantly deciduous forest and aerial surveys are performed only in winter, a large percentage of deer can be obscured by evergreen trees and shrubs, topographic features, and even the trunks and branches of deciduous trees and shrubs. Researchers have shown that thermal imagery—flying at night using infrared-sensitive instruments—is far more effective than daytime aerial survey methods. It is ideally done on very cold winter nights, when the thermal contrast is greatest. Sources of error include counting two or more deer lying or standing together as one and missing deer that are partially obscured by evergreen foliage, tree trunks, or topography. A recent review evaluating the application of thermal imagery technology in a variety of deciduous forest environments reported inconsistent results, with 11 to 69% of the deer missed in the audited surveys and an average detection rate of 56% of the total deer present in the study areas.

Another direct approach is the mark-recapture method, which involves marking individual deer and comparing the proportion of marked deer recaptured or killed in a subsequent roundup or hunt. This method is highly labor-intensive and extremely expensive because a large number of deer need to be marked—at

least 45% of the deer if the population is small (less than 200). In addition, the method is based on the assumptions that marks are never lost and deer do not emigrate from the study area. The mark-recapture method has been shown to overestimate deer populations because of unknown mortality of marked deer and emigration from study areas. Accurate monitoring of mortality and emigration requires the use of radio-collars in place of marks. Another problem with this method is that every deer is assumed to have the same probability of being recaptured or taken by hunters, which is likely to be violated owing to differences between older and younger deer in wariness, ability to evade pursuers, and hunter preference. The only place the mark-recapture method has been used is in a small minority of scientific research projects that are well funded; it is beyond the budgets of most land managers and researchers.

Most indirect methods do not provide estimates of absolute abundance, but are intended to provide an index of relative abundance that can be used to detect changes over time within a particular area. For example, counts of the abundance of deer trails, tracks, deer sightings per kilometer walked on foot, intensity of browsing, abundance of fecal pellet groups, and number of deer killed on roads have all been used as indices of abundance. All of the index methods assume that potential sources of variability in the index (e.g., deer defecation rates, hunter effort, movement by deer across the landscape) are constant in a specific area over time so that the changes in the index over time reflect changes in population size alone.

Counting fecal pellet groups is the most widely applied means of indirectly estimating deer density. A typical method is to visit a large sample of uniform-sized plots across the study area and eradicate all existing pellet groups on each plot, then return to those plots several weeks or months later and count the newly deposited pellet groups. Deer density can be estimated by assuming a daily defecation rate per individual deer. The assumptions of this method are that a random sample of plots has been selected, deer movement across the study area is the same from year to year, the defecation rate is known and remains constant among deer and surveys, and pellet groups are counted accurately on the plots. In practice, the pellet group technique has often been applied somewhat differently. Surveys are usually performed in winter and the number of days is taken to be the time since leaf drop. This removes the labor requirement of first eliminating all existing pellet groups on plots, but results are distorted by the precarious assumptions that all pellet groups deposited prior to leaf fall have been covered by leaves and that leaf drop occurred on a specific day.

If the resources are available, it is desirable to monitor deer abundance to make certain that management actions intended to reduce or maintain deer populations actually do so.

Although widely used, pellet group counts are subject to many sources of error, which may be minimized by careful design and execution of the specific protocol. They include observer skill and fatigue in detecting pellet groups, choice of plot shape, habitat (vegetation) influences on detection of pellet groups, and decay rate of pellets. The most sophisticated surveys apply the technique of "distance sampling" to account for differential detection among habitats, factor in the decay rates of pellet groups, and use a statistically based sampling design. However, even

NATURAL LANDS TRUST REGULATED HUNTING PROGRAM
Rules and Regulations

Natural Lands Trust conducts controlled deer hunts on 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 or her hunting permit revoked immediately. Listed below are the requirements that must be met to receive a permit, examples of what the Trust considers unacceptable behavior, and the regulations that must be followed while hunting on any Trust preserve.

Permit Requirements

1. All hunters must attend a preseason orientation course to be conducted by the preserve manager.
2. All hunters must present proof that they have completed the Pennsylvania Game Commission hunter-trapper education course. Bowhunters must present proof that they have completed a bowhunter education course.
3. Hunters must have an antlerless deer license for the deer management unit of the preserve.
4. All hunters must pass a proficiency test using the sporting arm they plan to hunt with. For **firearms**, a hunter must place 4 out of 5 slugs in a 9-inch paper plate at 45 yards. No buckshot allowed. 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.

Unacceptable Behavior *(includes, but is not limited to, the following)*

1. Shooting in marginal situations such as at running deer, when vital organs are obstructed, and at excessive distances.
2. Disrespect of Trust employees, adjacent landowners, and other preserve users.
3. Consumption of alcoholic beverages or use of controlled substances.
4. Failing to appropriately follow up every shot.
5. Displaying game animals unnecessarily.

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the most careful surveys are based on a number of questionable assumptions, including a constant defecation rate and no variation in decay rates among habitat types. Research on defecation rates indicates that they vary among seasons (presumably because of dietary changes) and among age and sex classes and that pellet decomposition rates differ according to habitat type. Despite their limitations, however, pellet group counts may be the most practical means of monitoring changes over time in deer densities in natural areas.

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 based on 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 advance tree regeneration and survival of native herbaceous species. While we employ small exclosures to protect certain plants and for demonstration purposes, over most of our lands we implement controlled hunts to reduce the numbers 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 sidebars)*. A mandatory proficiency test ensures that hunters are familiar and competent with their sporting arm and a flagged map locates hunter positions for the preserve manager and other hunters. Participants wear bright NLT armbands that allow preserve managers as well as others to tell from a distance if a hunter has permission to hunt. The rules place due emphasis on removing does from the population, because it is almost exclusively the doe removal rate that influences population size. Preferentially harvesting does is capable

NATURAL LANDS TRUST REGULATED HUNTING PROGRAM
Rules and Regulations

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Hunting Regulations

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. 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. Archers must take an antlerless deer before being eligible to harvest a buck.
4. Hunters must hunt at least 20 hours.
5. Only two shells can be loaded at any one time (one shell in the chamber, one in the magazine).
6. 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 January 26th, or they will be forfeited.
7. Crossbows and .410 shotguns are not allowed.
8. Hunters must follow the hunting procedure listed below.

Hunting Procedure

A metal box will be placed in a convenient spot, accessible to all hunters. The box will contain armbands, a map of the preserve, and the hunting log. **Prior to each hunting stand the hunter must**: (1) remove one of the armbands from the box and put it on the exterior of his or her hunting coat (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); (2) mark the map to indicate where they plan to hunt; (3) sign in on the hunting log; and (4) display a parking permit on the dashboard of their vehicle. **While hunting, the hunter must**: (1) wear the armband; and (2) carry the permit. **At the end of each stand, the hunter must**: (1) return the armband to the metal box; (2) remove the mark from the map; and (3) fill in the hunting log completely.

Termination Procedure

If the preserve manager witnesses a case of unacceptable behavior or a violation of one of the hunting regulations by a permitted hunter, or is informed of such an incident by a reliable source, he will abide by the following procedure to address each incident:

1. The preserve manager will verbally inform the hunter of the infraction.
2. The hunter will be provided the opportunity to respond to the accusation.
3. If, in the opinion of the preserve manager, the hunter has clearly exhibited an unacceptable behavior or has violated one of the hunting regulations, he will verbally inform the hunter that his hunting permit is revoked immediately.
4. If there are legitimate extenuating circumstances surrounding a violation of hunting regulation 6 or 8, the hunter will be given a warning. A second violation of these regulations will result in immediate loss of hunting privileges. Violations of any other hunting regulation or unacceptable behavior rule will not receive a warning and will result in immediate termination of hunting privileges.
5. The hunter will be notified in writing of a warning or the loss of hunting privileges.

Jack Steffenud

Dan Barringer

As part of its deer management program, Natural Lands Trust regulates the hunters it permits on its preserves. Requiring a certain level of proficiency and mapping hunter locations help protect the safety of all preserve users.

of bringing populations to tolerable levels far more quickly than would a random removal strategy; preferentially harvesting bucks has almost no effect on birth rates and therefore will not control the population size.

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, enabling managers to attend to other responsibilities.

Goose Management Options

The Canada goose did not breed anywhere in Pennsylvania before the 1930s, when the Pennsylvania Game Commission began releasing captive pairs, with their flight feathers clipped, into the wild. Since then, the species has gone from an awe-inspiring native of the high Arctic that heralded spring and fall each year with the breathtaking spectacle of its migrating flocks to a semi-domestic species regarded in many areas as an unwanted pest. Canada geese are attracted to open water—particularly open water bordered by lawn or other short, herbaceous vegetation that provides them a clear view of potential predators. Where vegetation is less disturbed or altered by humans, they usually live and feed in areas adjacent to larger streams. Goose populations in our region have exploded in recent decades with the proliferation of their ideal habitat in the form of golf course water hazards, stormwater basins, and old farm ponds that are now included in residential and other landscaped areas. The following management recommendations apply to the year-round resident population of Canada geese; the much smaller migratory population seldom if ever causes any problems.

On properties with attractive goose habitat, landowners will need to consider active management to prevent degradation of on-site and off-site water quality by coliform bacteria and nutrient input from

droppings. In cases where goose density is very high, they can also strip vegetation from stream or pond banks and facilitate bank erosion and sedimentation of the water body. Excessive goose droppings and occasional belligerent behavior during the nesting season can also discourage recreational use of these areas.

Active Management

Habitat Management

The most effective way to decrease goose impacts is to change the area into habitat that is less attractive to them, preferably to one that would qualify as natural lands. Establishing a strip of natural cover (trees, shrubs, meadow) at least 20 feet wide around the water will deter geese from wandering into the mowed areas beyond. In some cases, it may even keep geese off of the pond or lake itself. This method reinforces the general recommendation to establish and maintain riparian buffers along any water body.

Habitat management is the best long-term method for reducing goose impacts on natural lands, but it may be necessary to implement other active management techniques to further discourage geese, particularly while the new, more natural habitat is getting established. Other techniques include the following.

Fencing

A single strand of wire placed about 6–10 inches above the ground will help deter geese from walking from the pond into the adjacent planted areas. Mark the wire with flagging that flutters in a breeze. The flagging will protect humans from tripping over the wire and the fluttering will make geese nervous. Even though they can easily fly over the wire, in most cases it will keep them confined to the water. It does not need to be electrified, but if geese are pushing through the wire, electrifying it temporarily may be necessary.

Repellents

Repellents, such as methyl anthranilate and anthraquinones, are available to spray on vegetation to make it unpalatable to geese. They are expensive, but in theory should need to be used for only a short period.

Harassment

Several options are used to harass geese and discourage them from using a property, including dogs, scarecrows, or loud noises. Dogs are very effective in harassing geese. The landowner could use his own dog

The most effective way to decrease goose impacts is to change the area into habitat that is less attractive to them.

Holly Harper (bottom and top right)

Canada geese and their droppings, one of the major causes of decreased water quality of ponds and streams due to fecal contamination and nutrient overload.

or use a professional goose management service, which uses specially trained dogs for this purpose. These services, which use small herding dogs or sometimes hunting breeds, are contracted to periodically visit a site to chase the geese.

Loud noises can also be used to harass geese. This method uses firecrackers or shells that explode after being fired from a shotgun. There are also propane-fueled cannons that make loud booms. These methods can be labor intensive, but they have been successful in driving off geese in many places. Contact the Pennsylvania Game Commission for current regulations on implementing these methods.

Scarecrows are a more passive form of harassment that uses balloons, alligator models, or owl decoys to deter geese. These are very short-term solutions, at best. In most cases, geese quickly learn that they aren't a threat and ignore them.

Lethal Removal

Lethal removal is often an effective way to dissuade flocks of geese from using a property. It usually requires the removal of only a few geese to induce the remaining geese to leave the area. Landowners can kill geese during the legal hunting season (September to mid-March) or by obtaining a depredation permit through the Pennsylvania Game Commission (this requires substantial paperwork) for off-season hunting. Although hunting seasons may not coincide with the time of year when a landowner wants to discourage geese from his or her property, over time and combined with other deterrents, lethal remove could help to provide enough time for a natural riparian buffer to become established.

Egg tampering can prevent nesting Canada geese from successfully fledging offspring, but it requires registration with the US Fish and Wildlife Service and requires the greatest caution to avoid being injured by geese defending their nest.

Egg Tampering

Geese can be discouraged from using a property by killing their eggs without breaking them or removing them from the nest. Geese will produce new eggs if a clutch is lost, but they will continue caring for intact eggs, even if they are dead. A goose pair will often abandon an area after attempting unsuccessfully to nest there. Egg tampering, which consists of either oiling or addling, requires registering with the US Fish and Wildlife Service and reporting your activities by October 31 each year. Addling eggs is shaking them violently to kill the embryo. In oiling, one uses a cloth saturated with cooking oil to completely wipe the eggshell to keep air from passing through the shell wall and smother the embryo. The key is not to cause any visible changes to the eggs or nest to avoid triggering the geese to build another nest and lay additional eggs. These techniques, allowed between March 1 and June 30, should be done shortly after geese have finished laying eggs and are beginning to sit on the nest. A goose nest should be approached with the greatest caution and only when the goose pair is out of sight; geese defending their nests and offspring have been known to cause physical trauma to humans, including broken arm bones and head injuries.

Habitat Improvements

Wildlife management is more than just addressing species whose populations have reached pest proportions. In addition to improving the health of natural plant communities to the benefit of many species, land managers can encourage a particular species or group of species to use the property by supplying some components of their habitat requirements. Below are examples of improvements that can be effective in southeastern Pennsylvania. The Pennsylvania Game Commission can provide additional recommendations for game and non-game species.

Nesting Boxes

Many birds use natural cavities in trees as nest sites. Nesting boxes provide a suitable alternative that can attract particular species to a property. The box should be constructed to fit the size of the bird and be located in the appropriate plant community and at the proper height and orientation to the sun and prevailing winds. Species that commonly use nesting boxes in the region include eastern bluebird, wood duck, purple martin, Carolina wren, house wren, northern flicker, red-bellied woodpecker, screech owl, barn owl, American kestrel, tree swallow, and barn swallow. The Pennsylvania Audubon Society, Pennsylvania Game Commission, and Pennsylvania DCNR Bureau of Forestry can provide plans for constructing and locating nesting boxes for each species.

Seasonal Pools

Seasonal pools or vernal ponds—areas that hold water for just a part of each year—provide valuable habitat for amphibians, aquatic insects, and migratory waterfowl. They are uncommon in the region due to past draining for agriculture and development. Often they can be recreated through relatively minor earth moving (by hand or machine) or the destruction of existing drainage tiles in agricultural fields. The USDA Natural Resource Conservation Service and the Pennsylvania Game Commission can provide information on creating and enhancing seasonal pools.

Brush Piles

Brush piles are piles of woody debris, most commonly the branches of trees and large shrubs, that are assembled to provide resting and escape cover, nesting sites, and den sites for wildlife *(see page 137)*. Typically, the largest materials are placed at the bottom, with increasingly smaller material added in layers that alternate direction. Brush piles provide the greatest benefit if they are located in places, such as forest openings or edge, where cover at ground level is lacking. Species that benefit from brush piles include cottontail rabbit, gray squirrel, chipmunk, skunk, raccoon, fox, and many bird species, along with some amphibians and reptiles.

Nesting boxes provide a suitable alternative to natural cavities and can be used to attract at least a dozen different bird species.

FOREST MANAGEMENT

Reducing Forest Fragmentation and "Edge Effect"

Decreasing the edge-to-area ratio and increasing the area of functional forest interior can be accomplished by afforesting selected "peninsulas" and "islands" of nonforested land that presently intrude into the main body of a contiguous forest.

Edge effects are conditions in and near the forest–nonforest transition zone that foster the growth of invasive plants, provide access for nest predators (e.g., raccoon) and parasites (e.g., brown-headed cowbird), and repel forest-interior animal species. In southeastern Pennsylvania, edges with a southern, southeastern, or southwestern exposure are usually most degraded by invasive plants taking advantage of the greater amount of sunlight to creep into the forest. Dense, healthy mid-canopy and shrub layers at the forest edge can help prevent edge effects from moving into the forest interior by intercepting seeds and blocking sunlight and drying winds. A forest edge that has existed for many decades often has a well-developed wall of leaves and branches extending from near the ground to the upper leaf canopy. Remediation is often required at more recent edges, particularly on a southerly exposure where trees have been cut down within 20 years, and at edges where landscape maintenance practices restrict new growth. Such edges are said to have high permeability. Native trees and shrubs of species appropriate to specific site conditions should be planted along forest edges with high permeability (*see* **Native Plant Materials**, *pages 172–200*). Mixtures of evergreen and deciduous species should be used where the natural community would include evergreens, in order to enhance impermeability in all seasons. Construction and maintenance practices should be avoided that would damage understory and mid-canopy vegetation at the forest edge and increase its permeability to sunlight, air movement, and the influx of seeds.

The ecological and environmental conditions of forested areas within natural lands are protected and enhanced by contiguous forest on neighboring properties. Together they minimize edge effects and create a larger unfragmented forest. For this reason, it is best to engage adjoining landowners to discuss the benefits of coordinated management.

Timber Harvesting

Timber harvesting is the cutting and removal of trees for sale as veneer, sawlogs, pulp, or fuel. In southeastern Pennsylvania trees are primarily harvested for veneer or sawlogs to produce fine furniture, cabinetry, or pallet material. Timber harvesting can have, for better or worse, substantial long-term effects on the environmental, ecological, and economic benefits of the forest. Done properly, a timber harvest provides periodic income for the landowner and increases

Decreasing the edge-to-area ratio and increasing the area of functional forest interior can be accomplished by afforesting selected "peninsulas" and "islands" of nonforested land that presently intrude into the main body of a contiguous forest.

the diversity of wildlife habitat while minimizing the degradation of soil and water resources. Done poorly, long-term income opportunities are lost, habitat values are reduced, and the haul roads and skid trails associated with harvesting result in soil erosion and stream siltation. Poor harvesting practices leave the forest devoid of economic value, create a haven for invasive plants, and leave hazards for recreational users.

Timber harvesting can be viewed as an extension of the natural disturbances under which forests have evolved for millennia. Cutting canopy and understory trees significantly modifies the distribution of light within the forest vegetation layers, which mimics some of the effects of high wind, ice, fire, and pathogens. The main difference is that most natural disturbances do not result in the removal of large quantities of nutrients (contained within tree trunks and branches) from the site. Forest scientists currently are investigating whether repeated timber harvests will eventually compromise the productivity of forest soils and limit the growth of future trees. Ironically, other scientists and political leaders cite the positive consequences of removing some elements from the natural cycles, specifically carbon. By converting trees to construction material, carbon is sequestered (locked up) as long as the buildings last. If the wood died and rotted in the forest, the carbon would return to the atmosphere as carbon dioxide, adding to the accumulation of greenhouse gases.

The art of any good timber harvest—like gardening, farming, or meadow management—is to provide more growing space to desired species and less to undesired species. Harvests differ in the number of merchantable trees removed from a given area and in associated activities intended to have a positive effect on the future composition and growth of the forest. Ideally, all types of canopy harvest reduce the density of undesired species and encourage the establishment and growth of seedlings of desired tree species.

Timber harvesting can have, for better or worse, substantial long-term effects on the environmental, ecological, and economic benefits of the forest.

The following is a general overview of the three major types of timber harvest undertaken in this region. Additional information on harvesting timber, including state regulations that affect harvesting operations, can be found in *Timber Harvesting in Pennsylvania: Information for Citizens and Local Government Officials*, which is available from the Penn State Cooperative Extension or the Pennsylvania Bureau of Forestry.

Clearcutting

Clearcutting, sometimes called canopy removal, entails the cutting of all trees within an area. This is the method that was used between 1850 and 1920 to clear most of Pennsylvania to feed the great demand for chemical wood, lumber, firewood, and charcoal from the growing eastern cities. Unfortunately, this method was used without regard to slope or hydrology and resulted in extensive loss of topsoil, the siltation of streams, and many years of wildfires as the slash (residual branches) dried out in the exposed conditions. The misuse of this method here and in other parts of the country has given clearcutting a bad name. Even though clearcutting has been poorly applied in many cases, it can

be an effective method for establishing stands of economically valuable species, particularly oaks and black cherry, which have low to intermediate tolerance of shade (i.e., they require open conditions to successfully reach the canopy). Used properly, in a limited area, with consideration given to slope and avoidance of wetlands and riparian areas, clearcutting can be an effective means of perpetuating our diminishing hardwood forests.

Clearcutting diversifies wildlife habitat by creating forest openings that harbor a suite of herbs and shrubs not found under a dense forest canopy. As the cut area proceeds through various stages of growth, it offers food (berries, low buds and shoots of shrubs and trees, insects) and structural variety preferred by many game species (deer, turkey, rabbit, grouse) and migratory songbirds (yellow-breasted chat, blue grosbeak, indigo bunting, chestnut-sided warbler). It should be noted, however, that creating forest openings in southeastern Pennsylvania can be problematic because of invasive plant species that flourish in this edge habitat. If the clearcutting method is employed, the landowner should closely monitor the harvested area and quickly address any attempt by these bad actors to become established *(see* **Invasive Vegetation Management**, *page 125)*.

A variation of clearcutting is called ***shelterwood cutting***. In this method, 30–70% of the trees within an area are harvested. The remaining trees shelter the existing seedlings, provide seed for more regeneration, and hold back the competing vegetation. Once enough seedlings are established to ensure a future forest, the remaining canopy trees are harvested. Both clearcutting and shelterwood cutting result in even-aged forests.

When considering a timber sale, it is wise to confer with the local service forester from the Pennsylvania Bureau of Forestry.

Selection Cutting

Selection cutting helps to perpetuate uneven-aged forests. In this method larger canopy trees are harvested individually or in small groups. At the same time understory trees—usually with no economic value—are thinned. Thinning allows seedlings of shade intolerant species such as oaks, ashes, and tuliptree to acquire more growing space and get a jump-start towards the canopy. The smaller openings produced by selection cutting have less aesthetic impact than clearcuts, while still perpetuating tree species with greater economic and wildlife values. It also may leave some forest stands less susceptible to invasive plants.

Highgrading

Highgrading (confusingly, sometimes called selective cutting) can result in the highest short-term economic return for the landowner and the greatest profit margin for the logger. However, it reduces the potential for future timber harvests and typically reduces wildlife values. In highgrading, individual canopy trees—usually the largest and most commercially valuable—are selected for harvest. This leaves the forest stocked with less valuable and (usually) genetically inferior trees and, because the harvest creates limited change in the distribution of light, the

regeneration of shade intolerant species such as oak, ash and tuliptree is not encouraged. As a result, the forest becomes dominated by shade tolerant species, in our area mainly American beech, red maple, and sugar maple. The most extreme version of highgrading is called ***diameter-limit cutting*** in which every tree over a given diameter is harvested. This removes all the best trees (in an even-aged forest, the largest trees are those with the best genes) from the forest. This leaves the forest dominated by poor quality trees with limited potential for future economic return. Landowners are strongly discouraged from using highgrading—particularly diameter-limit cutting—to harvest timber.

When considering a timber sale, it is wise to confer with the local service forester from the Pennsylvania Bureau of Forestry. At no charge, the service forester will analyze your forest and tell you when and where it is appropriate to harvest trees. He or she can also inform you of any financial assistance that may be available for improving your forest, for example, creating a stewardship plan, tree planting, or control of invasive plants. When a harvest is appropriate, it is always best to engage the services of a private consulting forester to guide you through the process and ensure that you are getting the best price for your trees. The consulting forester will mark the trees to be cut according to your stewardship goals and make sure that the harvest operation is executed in a manner that protects soil and water resources and leaves your forest with increased potential for future harvests. The state service forester can provide a list of private consulting foresters.

INVASIVE VEGETATION MANAGEMENT

Management Strategy

In natural lands management, the most efficient and effective strategy usually results from basing stewardship goals and strategies on a thorough understanding of the environmental forces in the area and adopting only those goals and strategies that work with, and not against, these forces. This is especially 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 that support plant growth in that area: light, water, inorganic nutrients, temperature, humidity, soil structure, and other factors collectively known as the "growing space." Given that growing space in any area is finite, successful management will result from those practices that make more growing space available to desirable species (native members of natural communities) and less to undesirable species (introduced invasive plants).

Often the most difficult step in controlling invasive species is deciding what to do first. Creating a "plan of

Two rules of invasive plant management

1. **In general, the future rate of forest degradation is inversely proportional to the current level of degradation.**
2. **Management efforts should be focused on restoring that part of the plant community that controls the most growing space.**

Holly Harper

In natural lands management, the most efficient and effective strategy usually results from basing stewardship goals and strategies on a thorough understanding of the environmental forces in the area and adopting only those goals and strategies that work with, and not against, these forces.

attack" is critical in order to make the most efficient and effective use of limited stewardship resources. Although it may seem logical to address the most severely degraded areas first, this is not always the best use of resources. The following two rules can help focus management efforts.

The first rule is that, in general, the future rate of forest degradation is inversely proportional to the current level of degradation. When a tree within a healthy forest is toppled by invasive vines or a gap is colonized by an invasive tree, the resulting loss of growing space can have a major impact on the entire forest stand, by providing a seed source for the rapid spread of invasive species from that point. On the other hand, the loss of a single tree in a heavily degraded, open-canopy area creates relatively little change in the total amount of growing space in the stand that is controlled by invasive species.

The second rule is that management efforts should be focused on restoring that part of the plant community that controls the most growing space. In a forest community the canopy trees take up the majority of the growing space. Once the canopy is free of invasive species, the manager can proceed to the next layer until the ground level is reached.

Based on these rules, the focus of initial restoration efforts should be to halt the degradation of the canopy layer in the healthiest areas, moving then to the moderately invaded areas, and so on to the most degraded areas. Those areas that are severely invaded 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 affected sites are stabilized. This approach is also healthier, psychologically, for the people involved in restoration. Spending the initial phase of a project stabilizing the majority of a site is more rewarding than struggling through a small, highly degraded section.

Restoration 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, whereas the planting of seedlings is best done in the

late winter and early spring. If labor is first available in the spring, then it is best to plant seedlings in moderately to heavily invaded forest areas first and wait until the fall to cut the invasive trees in lightly to moderately invaded areas.

Two points should be noted while planning an invasive species control program. First, invasive plant removal must be done properly or it can have catastrophic impacts to the health of natural lands and its wildlife. Removing trees such as Norway maple and groundcovers such as English ivy opens up the canopy and scarifies the soil, conditions that are ideal for the rapid establishment from seed of opportunistic species, a category that includes most invasive plants. Removing understory shrubs such as exotic shrub honeysuckles, privets, or linden viburnum can transform a forest stand that was a haven for migratory and resident birds and other animals to one devoid of understory cover and thus no longer a viable refuge (from predators), feeding, or breeding habitat for many species. Removal without replacement has numerous subtle effects but some effects can be dramatic, such as a striking decline in birds that were once common. In general, the restoration of a degraded community, particularly forest, should be done in a manner that removes only a small fraction (less than 10%) of the total biomass of any vegetation layer (canopy, subcanopy, shrub, ground) leaving wildlife plenty of space to find refuge and time to adjust to changing cover and food conditions. If the amount of invasive material is light and widely scattered throughout a forested area, the entire forest can be treated at the same time. However, if the shrub layer, for example, is heavily dominated by invasives it is best to treat the area over several years, waiting for existing native shrubs to fill in the available growing space or planting new ones. Invasive vines are the exception to this rule, because they grow on and not in place of native species and can weaken, kill, or topple trees. All invasive vines should be treated as soon as possible.

Invasive plant removal must be done properly or it can have catastrophic impacts.

Replacement planting should be undertaken in the same year as invasive species removal. This will provide the native species with an edge in recapturing the growing space made available by weeding out invasive species. (It should be emphasized that successfully establishing native species after treating invasives will hinge on proper deer management—either restricting access to the plantings or establishing and maintaining the appropriate deer density.) Any site where plants to be removed comprise more than 25% of the cover within their forest layer (canopy, subcanopy, tall shrub and sapling, ground) will probably require planting to augment any natural regeneration. Removal should be undertaken at times of year when direct disturbance of wildlife is minimal, preferably late fall or winter. Replacement plantings should precede the onset of the spring breeding season

In general, the restoration of a degraded community, particularly forest, should be done in a manner that removes only a small fraction of the total biomass of any vegetation layer leaving wildlife plenty of space to find refuge and time to adjust to changing cover and food conditions.

because many birds return to the same sites year after year to reestablish territories and renest. To insure their survival and to maintain ecosystem integrity, replacement plants must be of native tree, shrub, or herbaceous species carefully selected to be appropriate to soil conditions and the community type at each individual restoration site within the natural area *(see* **Native Plant Materials**, *pages 172–200)*.

Replanting after removing invasive plants accomplishes several objectives. It replaces vertical forest structure and bird cover where they had been provided mainly by the invasive species (e.g., where exotic shrub honeysuckles, privets, or linden viburnum are removed). Where invasive species have eliminated entire forest layers (e.g., Norway maple and English ivy, which eradicate native shrub and herbaceous layers in forests), replanting after removal restores long-lost vertical forest structure and bird cover. Where invasive plants are removed from streambanks or floodplains (especially Japanese knotweed) or from steep slopes, replanting renews protection against soil erosion. In all cases, the planted native species restore lost components of the indigenous food web; invasive species' leaves and stems are little utilized as food by native wildlife, which is one of the reasons they succeed so well here.

It must be emphasized, however, that planting should be viewed as only one component of forest restoration where invasive species are removed. The goal of maintaining natural lands as a set of natural communities dominated by native species will be met only by reducing the deer population to a level that allows natural regeneration from seed produced by native species already growing on the natural lands. Once natural regeneration is restored, a healthy crop of seedlings and saplings of native species will be poised to assume the growing space vacated by the natural decline and mortality of native species or the deliberate removal of invasive species.

The second point is that any invasive species management program must be undertaken in concert with a serious effort to restore "natural" low deer density if deer are overabundant, that is, if ecosystem degradation by deer overbrowsing is evident. Without sufficient native regeneration, any long-term effort to restore native plant communities will be futile. If the deer density is not restored and maintained at a low enough level, perpetual reliance on planting will be a severe drain on stewardship resources and will require permanent, extensive use of unsightly measures (fencing, tree shelters) to protect plantings from deer browsing.

Management Options

There are many management options for controlling invasive vegetation. These include physical removal, cutting, planting, herbicides, and fire. Usually, the control of invasives on any given site requires a combination of two or more methods. The most effective mixture and timing will be unique to each site. What is 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, native biodiversity, and ecosystem function of the affected site.

Physical Removal

The most effective practice is the selective removal of invasive species without disturbing the surrounding native vegetation. The invasive plant is denied growing space and the surrounding desirable (native) vegetation is well-positioned to occupy the vacated growing

INVASIVE INTRODUCED SPECIES OF PLANTS, *currently associated with the greatest harm to native biodiversity in southeastern Pennsylvania*

COMMON NAME	SCIENTIFIC NAME	DESCRIPTION	RECOMMENDED CONTROL TECHNIQUES BEFORE REPLACEMENT PLANTING
ailanthus; tree-of-heaven	*Ailanthus altissima*	tree	physical removal (small seedlings); herbiciding bark; avoid cutting, which stimulates prolific root suckering
akebia, five-leaved	*Akebia quinata*	woody vine or creeping shrub	physical removal; herbiciding bark or cut stem
angelica-tree, Japanese	*Aralia elata*	tree	physical removal (small seedlings); herbiciding bark or cut stem
autumn-olive	*Elaeagnus umbellata*	shrub	physical removal; herbiciding bark or cut stem
bamboo, garden	*Pseudosasa japonica*	upright shrub	mowing; herbiciding young foliage
bittersweet, oriental	*Celastrus orbiculatus*	woody vine	cutting; herbiciding bark or cut stem
burning-bush	*Euonymus alatus*	shrub	physical removal; herbiciding cut stem
celandine, lesser	*Ranunculus ficaria*	perennial spring-ephemeral herb	physical removal (small areas); herbiciding foliage
cherry, bird	*Prunus avium*	tree	physical removal (small seedlings); herbiciding cut stem
corktree, amur	*Phellodendron amurense*	tree	physical removal (small seedlings); herbiciding cut stem
crownvetch	*Coronilla varia*	herbaceous plant aggressively spreading in open areas	mowing; herbiciding foliage
garlic mustard	*Alliaria petiolata*	biennial herb	physical removal
gill-over-the-ground	*Glechoma hederacea*	herbaceous plant aggressively spreading in the forest	mowing; herbiciding foliage
goutweed	*Aegopodium podagraria*	perennial herb	mowing; herbiciding foliage
honeysuckle, amur	*Lonicera maackii*	shrub	physical removal; herbiciding bark or cut stem
honeysuckle, Japanese	*Lonicera japonica*	creeping shrub or woody vine	physical removal; herbiciding foliage
honeysuckle, Morrow's	*Lonicera morrowii*	shrub	physical removal; herbiciding bark or cut stem
hops, Japanese	*Humulus japonicus*	herbaceous plant aggressively spreading in open areas, particularly on floodplains	mowing; herbiciding foliage
jetbead	*Rhodotypos scandens*	upright shrub	physical removal; herbiciding bark or cut stem
ivy, English	*Hedera helix*	prostrate or climbing woody vine	physical removal; herbiciding foliage or cut stem

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INVASIVE INTRODUCED SPECIES OF PLANTS, *currently associated with the greatest harm to native biodiversity in southeastern Pennsylvania*

COMMON NAME	SCIENTIFIC NAME	DESCRIPTION	RECOMMENDED CONTROL TECHNIQUES BEFORE REPLACEMENT PLANTING
knotweed, giant	*Fallopia sachalinensis*	very large Eurasian perennial herb	physical removal; herbiciding foliage
knotweed, Japanese	*Fallopia japonica*	very large Eurasian perennial herb	physical removal; herbiciding foliage
loosestrife, purple	*Lythrum salicaria*	herbaceous plant aggressively spreading in wet open areas	herbiciding foliage
maple, Norway	*Acer platanoides*	tree	physical removal (small seedlings); herbiciding bark or cut stem
mile-a-minute	*Persicaria perfoliata*	herbaceous plant aggressively spreading in open areas	physical removal; herbiciding foliage
multiflora rose	*Rosa multiflora*	upright or often climbing shrub	physical removal; herbiciding bark or cut stem
periwinkle	*Vinca minor*	creeping shrub	physical removal; herbiciding foliage
phragmites; common reed	*Phragmites australis*	very large perennial herb; the species is native to both North America and Eurasia, but the invasive form is thought to be descended from Eurasian populations	physical removal; herbiciding foliage
plumegrass, Japanese	*Miscanthus sinensis*	herbaceous plant aggressively spreading in open areas	physical removal; herbiciding foliage
porcelainberry	*Ampelopsis brevipedunculata*	woody vine	cutting; herbiciding foliage, bark, or cut stem
privet, border	*Ligustrum obtusifolium*	shrub	physical removal; herbiciding bark or cut stem
privet, common	*Ligustrum vulgare*	shrub	physical removal; herbiciding bark or cut stem
spurge, Japanese	*Pachysandra terminalis*	creeping shrub	physical removal; herbiciding foliage
stiltgrass, Japanese	*Microstegium vimineum*	herbaceous plant aggressively spreading in forest areas	physical removal; herbiciding foliage
strawberry, Indian	*Duchesnea indica*	herbaceous plant aggressively spreading in forest areas	physical removal
viburnum, doublefile	*Viburnum plicatum*	upright shrub	physical removal; herbiciding bark or cut stem
viburnum, linden	*Viburnum dilatatum*	upright shrub	physical removal; herbiciding bark or cut stem
viburnum, Siebold	*Viburnum sieboldii*	upright shrub	physical removal; herbiciding bark or cut stem
wisteria, Chinese	*Wisteria sinensis*	woody vine	herbiciding bark or cut stem
wisteria, Japanese	*Wisteria floribunda*	woody vine	herbiciding bark or cut stem

space. This approach is preferable wherever possible, although it may be limited as a practical alternative by the availability of workers and equipment relative to the size, quantity, and type of invasive species 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 by one manufacturer a Weed Wrench. It is designed to clamp to the base of a tree or shrub and lever 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 tool called a Brush Brute—a 4–6-foot steel frame with 18-inch "teeth." With this tool the operator simply drives into the unwanted shrub or small tree until the base of the plant is impaled between the teeth and then lifts 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. In individual cases the success of these methods depends on the thoroughness with which the plant is removed and the speed at which native vegetation can occupy newly available growing space.

Dan Barringer

An efficient method for removing unwanted shrubs or small trees involves replacing the loader bucket on a tractor with a Brush Brute to impale the base of the plant and then lift it out of the ground. When using this method, care must be taken to minimize soil disturbance.

It should be noted that physical removal, especially involving heavy equipment, can create soil conditions that favor the reestablishment of the species being removed or other invasives. For this reason, it is best to limit disturbance as much as possible and to be prepared to monitor the site and address any new invasive species problems promptly.

Cutting

Removing some or all of the photosynthetic (food-producing) area of an invasive 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 aboveground 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 add an herbicide application (refer to **Herbicides**, below, for further details).

This option is most appropriate for controlling invasive species in forested areas. In this situation, the surrounding vegetation is most often trees and their leaves are usually situated above the target plant material. Because the surrounding trees limit the sunlight needed for food production, a cut plant is forced to rely on stored root reserves to maintain the remaining parts of the plant and support new leaf growth. Although invasives are usually able to survive cutting, they may be weakened sufficiently to slow their full recovery for an extended period.

Cutting is less effective in open areas. Typically, resprouting and rapid growth allow invasives to quickly reoccupy 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 or lawns meet forests) 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 host trees.

Dan Barringer

Cutting vines low to the ground and as high as possible at edge sites or within hedgerows will maximize the delay in their movement back into the canopy .

Mowing

Mowing removes most of the photosynthetic material from both desirable (native) and undesirable (non-native and invasive) plants. It effectively puts all plants on an equal basis in regards to the availability of aboveground growing space. This is, however, only a temporary situation. Because species vary greatly in their response to mowing, a mowing treatment will favor those species that can refoliate (occupy the available growing space) faster. Repeated mowings favor grass species (which grow from the base of the stem) and non-grass species that grow close enough to the ground to escape severe defoliation. Given the vigor of invasive plants, repeated treatments are usually necessary to make this method an effective control strategy.

Mowing is often the most cost-effective method to control invasives in large open areas where physical removal is beyond the manpower available. The initial treatment may require the physical removal of plants (especially multiflora rose) too large to mow, which would interfere with future mowing operations and act as a seed bank from which the species could spread. For this same reason, it is advisable to remove any obstructions, such as fallen trees or rocks, around which invasive plants can become established and spread.

In most cases it is sufficient to combine invasive species control with annual meadow mowing. Areas heavily infested with vines may require more frequent mowing for several years to weaken the invasives and encourage competitive

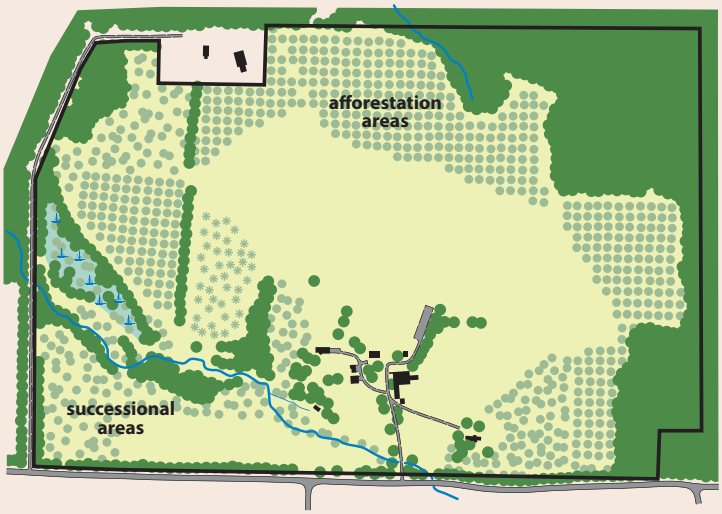
native grass species. Meadow areas heavily affected by invasives may warrant herbicide application (refer to **Herbicides**, below, for further details), followed by planting of natives.

Planting

Another option to take away growing space from invasive species is by planting native trees and shrubs to increase their density and shade out invasive plants. It is particularly important to minimize the amount of interior and exterior edge of a forest (high light areas where invasive plants thrive) by encouraging native species growth in forest gaps and rounding off sinuous or concave edges *(see plan at right)*.

In areas where invasive species are a significant component of the vegetation, it is desirable to plant trees and shrubs where invasives have been removed. Killing or removing the invasives often disturbs the soil surface, giving a strong advantage to opportunistic species as plants colonize the newly vacated growing space. Invasives will quickly reoccupy such a site 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 native species highly adapted to a site's conditions (particularly light and soil water availability) should be planted.



At Natural Lands Trust's Binky Lee Preserve we are using afforestation (planting in previously open areas) and natural succession to reduce edge.

Dan Barringer

Herbicides

In most cases the use of herbicides alone is not an effective long-term solution for controlling invasives. Difficulties in delivering adequate amounts to the target plants at the correct time in their growth cycle, the near-impossibility of avoiding collateral damage to native plants and other organisms, and the potential health risks to workers are all 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. Inappropriate use of herbicides can degrade soil and water resources and harm humans and wildlife, particularly amphibians and aquatic animals. Used appropriately, however, herbicides can be an important tool for land managers in certain situations. *Herbicides should be applied in natural areas only by qualified applicators trained in both the safe use of each herbicide and the identification of desirable (native) versus undesirable (invasive) species*. Training and licensing for herbicide application is provided by the Pennsylvania Department of Agriculture.

To safely administer herbicides to the target plant it is best to cut it back as much

Dan Barringer

While the exclusive use of herbicides is not an effective long-term solution for controlling invasives, used appropriately, they can be an important tool in many situations.

as possible and wait for it to resprout prior to herbicide application. To control small trees, shrubs, or vines, an herbicide with glyphosate should be applied to the fresh sprouts two weeks after cutting. Larger plants can be most effectively controlled by applying an appropriate formulation of the herbicide triclopyr or glyphosate directly to the freshly cut stump or to the uncut stems of shrubs and trees with smooth bark (ailanthus, young Norway maple). This second method works best in fall when sap flow is into the roots. It should be noted, however, that there is some risk to nearby desirable trees from herbicide application. Research has shown that herbicides can be translocated through root grafts (a relatively common occurrence) into other trees. Care should be exercised in treating invasive trees in close proximity to highly desirable trees.

Fire

Fire has played an important part in shaping local plant and animal communities for thousands of years. Fire was a frequent occurrence within forests, following major disturbances such as windfalls or insect defoliation, and on the open grasslands, shrublands, and barrens scattered throughout the region. In addition, Native Americans living in the region used fire for thousands of years for numerous reasons, for example, to drive game, to rejuvenate food resources such as berry patches and pasture for game species, and to make travel easier and safer. Fire exclusion over the last century has modified the plant composition of forest communities. Many eastern forests are now in transition from an oak- and hickory-dominated canopy to a fire-sensitive red maple- and beech-dominated canopy.

The use of fire to control invasives by giving an advantage to native, fire-tolerant 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 or improper application. Local governments and fire companies are often not receptive to the use of fire to restore and maintain native biodiversity and ecosystem function. If you plan to use fire to manage natural lands, you will need to prove to these authorities that you are properly trained and equipped *(see* **Prescribed Fire**, *page 145)* to undertake this activity.

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 (the burn prescription). In this region it is usually best to burn in early spring—mid-March to mid-April for herbaceous invasives, late April to early May for woody invasives—a time when many natural fuels reach a peak of flammability but weather conditions typically make containment simpler. Furthermore, invasives usually sprout earlier than native species, making them

vulnerable to fire at a time when many natives are highly fire-tolerant. Before undertaking a burn it is also crucial to acquire any necessary permits, notify neighbors, and coordinate with local and state authorities and, of course, the local fire company.

Recommended Techniques and Procedures

The following are techniques and procedures for addressing different types of invasive plants. For more information, see *Invasive Plant Species* under **Additional Information Sources**, *page 217*.

Herbaceous Plant Removal

Equipment: Mower, herbicides, backpack sprayer

Herbaceous invasives (e.g., garlic mustard, Japanese stiltgrass, mile-a-minute, miscanthus, Japanese knotweed, giant knotweed) are probably the most difficult to control because they are mostly available for treatment during the growing season when desirable (native) plants are growing nearby. They also quickly colonize disturbed areas, including areas where invasive shrubs and trees have been removed. Small areas of herbaceous invasives can be pulled, dug, or mowed until they stop resprouting. In some cases they can be treated in late winter or early spring before native herbs appear. For example, the basal leaves of garlic mustard (an herbaceous biennial) can be sprayed with glyphosate on warm (above 40° F) days (see discussion of appropriate use of herbicides, *page 133*); early sprouts of mile-a-minute can be treated similarly. Large areas of invasive herbaceous plants can be sprayed with glyphosate during the growing season although care must be taken to avoid collateral damage to native species. Also, some evidence suggests that applying a pre-emergent (a chemical that prevents seed sprouting) can be helpful in heavily affected areas of mile-a-minute and Japanese stiltgrass.

Darin Groff

The use of prescribed fire can control invasives by giving an advantage to desirable native species as seen here in the restoration of a serpentine woodlands.

Groundcover and Vine Removal

Equipment: Pruners, pruning saws, loppers, blade weedwhips, chainsaws, herbicides, backpack sprayer, wick applicator

Groundcovers can be pulled on a regular basis or herbicides can be used to control or eliminate patches (see discussion of

appropriate use of herbicides, *page 133*). Care must be given not to spray non-target species. For evergreen groundcovers (e.g., English ivy, pachysandra), a mixture of triclopyr and diesel fuel has been used successfully as a foliar spray on warm (above 45°) winter days.

The first priority in invasive species control is to remove vines affecting canopy trees. Cut woody vines both at ground level and at least 5 feet above ground level and remove from trees if removal won't cause damage. Immediately following cutting, large stumps should be painted with a systemic herbicide such as glyphosate or triclopyr.

It should be noted that even though invasive vines pose a significant threat to the forest, there may be native vine species within a natural area that have high food value for wildlife. Poison-ivy, Virginia creeper, and the five grape species native to our region should not be cut from trees unless they begin to seriously compromise the health of the tree. Among native vines, this is likely to happen only with grapes, which can eventually overtop the canopy of a tree. If overtopping or threatening to overtop a native tree, a grape vine should be cut but not treated with herbicide so that it can resprout. (The non-native wine grape and its hybrids occasionally escape from cultivation in our region, mainly in highly disturbed areas, but it is rarely seen in the wild and is not invasive.)

Shrub and Sapling Removal

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

Eliminate or control invasive shrubs and saplings by manually or mechanically pulling or by cutting. Stumps cut manually should be immediately painted with a systemic herbicide such as glyphosate or triclopyr (best done in late summer or fall when sap is flowing into plant roots). Thin-barked shrubs can also be treated with a 20–30% mix of triclopyr in basal oil applied in a band around the base of the trunk (best applied during the growing season). See discussion of appropriate use of herbicides, *page 133*.

Tree Removal

Equipment: Pruners, pruning saws, loppers, Weed Wrench, chainsaws, front-end loader, herbicides, backpack sprayer, wick applicator

In areas adjacent to structures or high-use locations, drop invasive and hazardous trees without damage to surrounding desirable trees and either let them lie or cut them into pieces to create brush piles for wildlife habitat *(see below)*. Trunks and limbs of Norway maple or black locust (considered invasive in some communities such as meadows and savannas) that are large (> 6-inch diameter) and straight (> 8-foot sections) may be useful for trail stabilization and restoration. Some other invasive tree species such as ailanthus will decay rapidly and are not useful for this purpose. Stumps of felled trees should be immediately treated with a systemic herbicide such as glyphosate or triclopyr (see discussion of appropriate use of herbicides, *page 133*). Ailanthus and black locust will root-sprout vigorously following cutting, even with herbicide treatment. Do not cut, but apply basal herbicide as described above. Other thin-barked trees such as young Norway maple can also be treated this way. Smaller limbs and related debris should be left to rot or fly-chipped on-site. In appropriate areas, larger (> 6-inch) trees can be girdled to create snags for cavity-nesting 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 forest should be left in place for their wildlife habitat benefits.

To create a ***brush pile***, first build a base by placing four large logs, set 1 foot apart and parallel to each other, and then place 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 feet high and 6 feet wide.

Planting

It is particularly important to establish trees in forest gaps where invasives have been removed. This can be done through natural or artificial (planting) regeneration. The former is the preferred method because new seedlings are more likely to be derived from a gene pool that has evolved under the environmental conditions of the region over thousands of years. However, the prevalence of overabundant deer throughout the region often necessitates planting to more quickly establish desirable species.

Planting design should include enough space between planted trees to allow access to control competing vegetation, but close enough to quickly provide enough shade to help inhibit the regrowth of invasives. It should also be naturalistic in form, that is, straight lines or rows should be avoided, except when large equipment is required for maintenance. For best results, follow guidelines under **Planting Trees**, *page 168*.

Planting should continue on an as-needed basis to assure that sufficient advance regeneration is available to replace canopy trees as they die.

Schedule

In general, late fall and winter are the most efficient and least arduous times to perform invasive species control. Problem areas are more easily traversed and cool-weather clothing gives added protection to the work crew. Systemic herbicides are also most effective in the fall when sap is flowing into the roots. The exception to this rule is for herbicide applications that target the foliage of invasives, such as spraying to control herbaceous plants (Canada thistle, mile-a-minute, common mugwort) in meadows or small shrubs (young autumn-olive, exotic honeysuckles, privets) in meadows or forests. Any heavy equipment use should be conducted when the ground is dry or frozen.

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 (2–3 inches in diameter) to withstand buck rubs.

Darin Groff

When planting to fill forest gaps, the trees and shrubs should be only wild-type (no cultivars) native species appropriate to the site conditions and they should be protected from deer damage with fencing, tree shelters (shown here), or flexible tree wraps.

Ongoing Management

Following initial treatment, an annual or biennial inspection and control schedule should be adopted to prevent initial conditions from recurring. After a thorough first treatment, regular but small-scale treatments are often sufficient to preserve the native diversity, ecosystem integrity, and aesthetic quality of a site.

Until natural regeneration becomes adequate in forest areas, the planting of trees and shrubs should continue on an as-needed basis to ensure that sufficient advance regeneration is available to replace canopy trees as they die. Reduce plant competition through selective cutting or herbicide application (see discussion of appropriate use of herbicides, *page 133*) on neighboring plants around the bases of trees during successive growing seasons until the canopy reaches 60% cover.

MEADOW MANAGEMENT

Most grasslands and meadows in eastern North America are short-lived ecosystems. Without repeated disturbance, woody cover (trees and shrubs) quickly returns. It is now believed that agriculture and burning by Native Americans, coupled with the more recent agriculture of European settlers, maintained extensive herbaceous openings in this region for thousands of years, and that feeding, wallowing, and trampling by now-extinct "megaherbivores"—mammoths, mastodons, giant ground sloths, horses, tapirs, peccaries, and others—created and maintained a patchwork of meadows and grasslands for millions of years before that, until their demise upon arrival of humans to our region about 13,000 years ago. As a result, numerous native plant and animal species, particularly birds and butterflies, are completely dependent upon these habitats and are now threatened as they decline.

Most meadows in southeastern Pennsylvania have an agricultural past—old hayfields or pasture—and are dominated by non-native cool-season grasses planted for centuries as fodder, such as tall fescue, perennial ryegrass, Kentucky bluegrass, orchard grass, and timothy. Cool-season grasses, so named because

Most grasslands and meadows in eastern North America are short-lived ecosystems. Without repeated disturbance, woody cover (trees and shrubs) quickly returns.

Bill Moses

Grasslands and meadows are historical components of the regional landscapes that offer food, cover, and nesting sites for small mammals, butterflies, and several threatened bird species.

they grow best during spring and fall, have photosynthetic machinery like most other kinds of plants, a system called C_3 for short. Warm-season grasses, which grow mainly in the heat of the summer, have specialized system called C_4, which works in a manner similar to a turbocharger in a car engine, delivering carbon dioxide much more efficiently (using far less water) to the sunlight-powered parts of the plants' cells that combine CO_2 with H_2O to produce sugars, which fuel growth. The C_4 system enables warm-season grasses to continue photosynthesizing and growing when most plants are forced by heat or dry soil conditions to shut down.

The cool-season grasses' new leaves emerge in late winter or early spring and they generally flower and set fruit in spring or early summer. In warm-season grasses emergence is usually delayed until late spring or early summer and they generally flower and set fruit in late summer or fall. Native cool-season and warm-season grasses *(see* **Native Plant Materials**, *pages 172–200)* can perform well together in mixture because competition between grasses of the two types is reduced, due to differences in rooting depth (cool-season species tend to have shallower roots than warm-season species) and the separation of peak growth and photosynthesis to different parts of the growing season. Native warm-season grasses thrive on marginal soils and survive periods of low rainfall due to their C_4 photosynthetic system and deep, fibrous root systems, which can penetrate the soil to a depth of 5–10 feet. In native meadow plantings, a reasonable goal is to achieve 50–75% cover of warm-season grasses (e.g., little bluestem, big bluestem, Indian-grass, broomsedge, switchgrass), with the remainder in native cool-season grass and forb cover.

Two misconceptions are widespread: one is that most cool-season grasses are non-native, and the other, that most native grasses are warm-season. Considering the state's flora as a whole, the facts are somewhat the opposite. Of the 173 grasses (165 species, plus varieties and subspecies) native to Pennsylvania, 105 are cool-season (C_3) grasses and 68 are warm-season (C_4) grasses. The higher diversity of cool-season grasses also holds

Unlike the shallow roots of turf grasses like Kentucky blue grass, the deep roots of native warm-season grasses help them tolerate marginal soils and, in turn, protect these soils from water and wind erosion.

when considering species only native to the Piedmont and Coastal Plain areas of southeastern Pennsylvania. There are a total of 149 grasses considered to be native to this region with 83 cool-season and 66 warm-season representatives. The table below summarizes the distribution of native grasses by type. The table further classifies them by habitat preference, showing that in the Piedmont and Coastal Plain of Pennsylvania there are 68 native cool-season and 64 native warm-season grasses that are mainly or facultatively open-meadow dwellers (leaving 15 cool-season and 2 warm-season grasses as mainly restricted to forests).

Wildlife Benefits

Declines in populations of neotropical migrant birds that breed in the forests of eastern North America have received much attention, but grassland and meadow birds in the region are in even greater peril. Since the first European settlement, native grasslands and meadows have steadily diminished in size and species diversity. These plant communities were once composed of hundreds of native plant species that provided the highest quality food and habitat for native meadow wildlife. The typical grassland or meadow today is an abandoned field invaded by a few introduced species—multiflora rose, autumn-olive, Japanese honeysuckle, Amur honeysuckle, Canada thistle, mile-a-minute, and Japanese stiltgrass are examples—that crowd out most native plants and degrade the habitat for native animal species.

Declines are especially devastating of *interior* grassland and meadow species, that is, those that need blocks of contiguous habitat, usually greater than 50 acres, where there are large areas at least 100 meters (about 300 feet) from any forest edge or other non-meadow land cover. Analyses of breeding bird survey data show that 16 of the 19 species that breed in interior grasslands and meadows in the East have been losing ground and 12 of them have declined steeply. Populations of birds such as bobolink, eastern meadowlark, grasshopper sparrow, savannah sparrow, vesper sparrow, upland sandpiper, and northern bobwhite have fallen off drastically in recent years due to the loss of habitat and the fragmentation

Pennsylvania Native Grasses, *including varieties and subspecies*

COVER TYPE PREFERENCE	ENTIRE STATE		PIEDMONT AND COASTAL PLAIN	
	Cool-season (C_3)	*Warm-season (C_4)*	*Cool-season (C_3)*	*Warm-season (C_4)*
Mainly open	*30*	*48*	*20*	*46*
Mainly tree dominated	*19*	*2*	*15*	*2*
Open or tree dominated	*56*	*18*	*48*	*18*
SUBTOTAL	105	68	83	66
TOTAL	**173**		**149**	

of remaining habitat into pieces that are too small to meet their needs. Most of this loss is from residential and commercial development and from changes in farming practices, such as earlier mowing times and, ironically, the widespread use of conservation tillage which largely eliminates bare soil conditions used by some of these birds.

There is an ongoing effort by scientists and resource managers to better understand what makes ideal habitat for grassland and meadow birds. Over the past decade, there has been wide promotion of native warm-season grasses as the ideal habitat. Warm-season grasses are a key part of prime habitat for grassland birds because they are bunch grasses, in contrast to the sod-forming growth habit of the common non-native cool-season grasses, such as those planted for hay, pasture, or turf *(see illustration on page 139)*. This means that they grow upright with bare ground between clumps. This characteristic provides high-quality nesting sites and materials and allows grassland birds to move more easily and better protected from avian predators in their search for food. The open space between clumps also provides space for wildflowers to become established.

In spring, ground-nesting birds utilize the cover afforded by the grasses and wildflowers to brood and rear their young. Flowers attract insects, which constitute 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.

Bill Moses (all except top right)

Birds of large open landscapes: bobolink *(top left)* **and eastern meadowlark** *(bottom left)* **are two birds that prefer cool-season grasslands; savanna sparrows** *(bottom right)* **prefer warm-season grasslands; and horned larks** *(top right)* **are "dirt birds," using bare soil in cultivated fields.**

Despite the great benefits of native warm-season grasses, research is showing that they do not fit the needs of all grassland birds. While savannah and grasshopper sparrows prefer warm-season grasses, bobolink and meadowlark do best in cool-season grasslands. And some birds, e.g., horned larks, are full- or part-time "dirt" birds, using the bare soil created by traditional cultivation (moldboard plowing) and heavy grazing, which mimics the trampling, wallowing, and grazing by megaherbivores that occurred during most of the evolutionary history of native grassland and meadow plant and animal species. There is a growing consensus that a large open landscape (hundreds of acres) with diverse cover types in patches of various sizes, including warm- and cool-season grasslands and forb-dominated

meadows, is best. Agriculture (row crops, pasture, hay fields) without hedgerows can be a compatible economic land use within a mosaic of native grasslands and meadows intended to provide habitat for grassland-interior birds. Structural diversity—created by planting a patchwork of meadow types, each with a mix of species—produces preferred cover for the greatest variety of grassland and meadow wildlife species.

Little is known about the effects of declining native grassland habitat to other kinds of wildlife in Pennsylvania, including small mammals, snakes, lizards, turtles, insects and other arthropods, and various animals that live in the soil. But we can get some idea of the probable magnitude of the problem from surveys of one of the few groups that has been studied—moths—in the native grasslands of the State Line Serpentine Barrens along the southern borders of Chester and Lancaster Counties. These ancient grassland remnants harbor, according to discoveries so far, at least three dozen moth species listed as endangered, threatened, or rare in Pennsylvania.

Many butterfly species have also developed close relationships with native meadow wildflowers, which they use for the nectar (adults) and the leaves and stems (larvae). As our few remaining undisturbed habitats continue to be lost to suburban development, many native plants are becoming increasingly rare. The implications for 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.

Meadow establishment through spraying *(top)* **and then planting with a no-till drill** *(bottom)*.

Paul Claypoole (both)

Establishment

Conversion to native grasses and forbs is best achieved by eliminating existing vegetation that can aggressively compete for nutrients and water, particularly turf grass species, trees, shrubs, and invasive vines. Trees and shrubs can also obstruct mowing and other future maintenance activities. Remove all woody stems manually or by cutting (chainsaw, field mower). If the larger stumps cannot be removed they should be flush-cut or ground down even with the surrounding soil surface and treated with a systemic herbicide to prevent resprouting (see discussion of appropriate use of herbicides, *page 133*). Turf grasses can be eliminated either by physically removing the sod (digging small areas; plowing and disking larger sites) or treating the area with an herbicide and seeding with a no-till drill.

Because a meadow is typically a short-lived successional stage, it must be periodically disturbed to prevent woody vegetation from becoming established. This can be accomplished either by **mowing annually** *or* **prescribed burning** *every few years.*

(An herbicide should not be used within 50 feet of a stream unless it is a formulation approved for aquatic use.) Spring (before the beginning of June) and late summer or early fall are the preferred times to plant meadows. If a rapid conversion to native grasses is not an option for lack of funding or equipment, the landowner can encourage a gradual change from exotic to native grass dominance through the timing of management. Certain bird species, particularly bobolinks and meadowlarks, can thrive in large open areas dominated by exotic turf grasses created simply by reducing the mowing frequency of turf, pasture, or hay field to once per year.

One of the challenges of meadow establishment and management is a tendency for the planted native grass species to become over-dominant. This is particularly true of the warm-season "tallgrasses," notably big bluestem, Indian-grass, and switchgrass. It is best to mass forb plantings and separate them spatially from the tallgrass plantings. This type of patchiness is common in nature and should be imitated to the extent possible in new meadow establishment. Grasses should be planted in rates not exceeding 1–2 pounds per acre in order to achieve high species diversity.

Initial failure of meadow and grassland plantings, especially of warm-season grasses, is not uncommon. Weather and other factors are beyond the control of even an experienced practitioner. Such setbacks are temporary and should not be a cause to give up on efforts to establish native meadow vegetation. Often, where initial plantings do not produce the desired result, a follow-up attempt a year later is successful.

Management

Because a meadow is typically a short-lived successional stage, it must be periodically disturbed to prevent woody vegetation from becoming established. This can be accomplished either by mowing annually or prescribed burning every few years.

The frequency and timing of mowing has a dramatic affect on the composition of a meadow and its wildlife residents. When and how often to mow will depend upon your conservation priority and the environmental conditions of the grassland or meadow *(see table on page 144)*. In general it is best to mow when wildlife is less vulnerable to disturbance, that is, during the non-growing season (roughly mid-November to mid-March in southeastern Pennsylvania). A late winter or early spring mowing (prior to April 1st) is best. Mowing at this time conserves winter cover for wildlife and avoids disturbing nesting and feeding wildlife (birds, small mammals, butterflies) in spring and summer. If wet soil conditions prohibit mowing in late winter/early spring a fall mowing (after the first hard frost) when these areas are dry or a winter

mowing when the ground is frozen are other preferred options. Sometimes a second mowing is needed to control undesirable plants during the growing season; a mid-July to early August mowing will help control woody and invasive plants, encourage warm-season grasses, and provide sufficient time to establish winter cover. The only case where this would not be appropriate is in larger (>50 acres) grasslands and meadows (or smaller meadows in a larger open landscape), which can support threatened interior grassland and meadow birds. These birds can nest into mid-August. In this situation it is best to mow only one-third to one-half of the grassland or meadow each year to minimize disturbance of ground-nesting birds.

It is best to mow meadows when the ground is dry or frozen. They should be cut at a height of 8–12 inches. Meadows must also be monitored for intrusion by invasive plants. Invasives in meadows can be eliminated by spot mowing, spot-spraying or wick application of an appropriate herbicide (see discussion of appropriate use of herbicides, *page 133*), or manual or mechanical pulling.

To emphasize that a meadow is intentional and managed, it is often beneficial to maintain a mowed turf swath around the public edges and consider incorporating a trail network. Well-maintained trails encourage people to get into the meadow and discover its beauty up close. However, care should be taken to minimize the extent of trails to prevent

Recommended Mowing Regimen

ENVIRONMENTAL CONDITIONS	CONSERVATION PRIORITY	
	Most Meadow Wildlife (<50 acres of total habitat)*	*Grassland/Meadow-Interior Birds (>50 acres total contiguous habitat*)*
Dry or frozen in late winter/early spring	Mow in March	
Wet in late winter/ early spring	Mow after first hard frost (mid-November)	
Heavy invasives	Mow entire area in March; mow one-third to one-half the area in mid-**July**, alternating in subsequent years	Mow entire area in March; mow one-third to one-half the area in mid-**August**, alternating in subsequent years

*** To determine the extent of meadow habitat, individual meadows must be connected on at least one side and can have no more than a few sparse trees (no shrubs or vines under the trees) in order to be connected enough to function as a single meadow.**

undue disturbance of wildlife. This is especially true in meadows that support grassland-interior birds where trails can fragment the habitat and provide easy access for predators.

Another tool for managing meadows is prescribed fire. Native Americans used fire to manage the landscape for thousand of years, which selected fire-adapted species to dominate native grasslands and meadows. Periodic spring fires (with at least 3–5 years between burns in a given area), rotating among sections of the meadow landscape to maintain a refugium from which insects can re-colonize the treated area (for meadows less than 50 acres only 10–20% should be burned in any year; for larger meadows one-third to one-half can be treated), will effectively discourage invasion by woody plants. Prescribed burning should be done only by well-trained personnel and in accordance with federal, state, and local laws.

Where tallgrasses become overdominant, crowding out most other kinds of plants, sites may require post-planting maintenance to reduce the grass cover and make room for forbs. Prescribed burning and tillage have been used to reduce grass cover, as has selective herbiciding. Though still uncommon in the East as an ecosystem management tool, grazing at low density (less than 0.5 "animal units"—1,000 pounds of grazer—per acre) should be considered as an alternative, especially in meadows. Grazing is widely used in Europe as a tool for the conservation management of native grasslands, meadows, and shrublands.

PRESCRIBED FIRE

Prescribed fire is the controlled application of fire to achieve specific conservation or land management goals. This technique is accepted within the scientific and natural resource management communities as a way to perpetuate a natural and historic influence on local ecology in a manner that minimizes and often reduces threats to persons or property. The goal of a fire management program is to utilize prescribed fire in a manner that perpetuates and enhances desired plant communities within natural lands.

A prescribed fire is defined as fire applied in a knowledgeable manner to fuels (live and dead vegetation) on a specific land area under selected weather conditions, to accomplish predetermined, well-defined, management objectives.

Dan Barringer

Fire has played an important part in shaping local plant and animal communities for thousands of years. Fire was a frequent occurrence within forests (especially following major perturbations such as wind events or insect defoliation), native grasslands, and on the open barrens (serpentine, scrub oak, heath, and pine barrens) scattered throughout the region. Before European settlement, wildfires set by lightning or Native Americans were frequent and widespread. Native Americans used fire for many reasons, including driving game, rejuvenating food resources such as berry patches and pasture for game species, and making travel easier and safer.

Fire exclusion over the last century has modified the plant composition of forest, grassland, and barrens communities, threatening important historic natural ecosystems and allowing the potentially dangerous build-up of organic fuels. Eastern forests are now in transition from an oak-hickory dominated canopy to a fire-sensitive red maple canopy. On the barrens, the lack of fire has resulted in the buildup of organic duff and invasion by woody vegetation, conditions that decrease the viability of plant species adapted to the mineral soil and full sunlight conditions maintained by periodic fires. At the same time, maintaining abandoned agricultural land as meadow (artificially maintained representatives of ephemeral forest openings) has become very problematic due to the growing presence of exotic, invasive vegetation. Left unchecked, invasive species such as Canada thistle, multiflora rose, and Japanese honeysuckle outcompete the native grasses and wildflowers that can tolerate periodic fires. Through displacement of native vegetation, invasive plants homogenize the structural and food resources of the site, thereby reducing the habitat value for native fauna.

There are two conditions that will need to be met to permit the greater use of prescribed fire in our region. The first is to implement programs that safely and effectively apply this powerful tool. Use of prescribed fire will require the support of both the general public and local authorities, particularly fire management personnel. Careful use and clear communication between owners of natural lands and neighbors and local authorities is essential in maintaining their support.

The second condition is a better understanding of the biological and ecological effects of fire in this region in order to intelligently guide its use to achieve natural resource management goals. To date, most research has been undertaken in western states, which contain different plant species (both natives and undesirable invasives) and site conditions. Detailed knowledge of

Plant communities that benefit from prescribed fire

- **Grassland and meadow**
- **Shrubland**
- **Serpentine barrens**
- **Oak-hickory and mixed oak forest**

plant responses to different fire regimes (frequency, season of application) is needed to make the best use of this stewardship tool.

A prescribed fire is defined as fire applied in a knowledgeable manner to fuels (live and dead vegetation) on a specific land area under selected weather conditions, to accomplish predetermined, well-defined, management objectives. Safely fulfilling this definition requires extensive preparation, proper training, and specialized equipment. The following are critical components of a successful prescribed fire program.

Program Organization

Required guidelines should be established for all burns and include the following:

Organizational commitment

- Commit the staff time, equipment, and resources necessary for a quality program.

Ecological justification and research

- Develop an ecological justification for each burn unit, including benefits to species of special concern.
- Develop a site fire management plan, including standard operating procedures for all prescribed burns and expected effects on all natural resources.
- Photodocument the burn area before and after the burn.
- Conduct appropriate research and monitoring as needed and share results with other practitioners.

Training and equipment

- Designate a fire leader/burn boss with advanced training (in order to meet required state qualifications).
- Increase the general level of training and fire experience for all participants.
- Obtain all necessary fire-fighting personal gear, tools, and equipment.

Pre-burn fire management/stewardship staff activities and public relations

- Develop a burn prescription.
- Establish burn plots and create firebreaks.
- Coordinate burn activities with appropriate fire and police groups, local and state government officials, and state and federal environmental organizations.
- Notify neighbors.

Equipment

Safe application of prescribed fire requires proper equipment to protect both participants and the property of neighbors. On the following page is the current inventory of Natural Lands Trust's specialized equipment for our 14-person fire management team.

Training

Prescribed fire should only be used by trained staff or contractors. Training is currently available from:

- DCNR, Bureau of Forestry District 17, 610-582-9660
- New York Wildfire and Incident Management Academy, 631-444-0276, cthamilt@gw.dec.state.ny.us
- Eastern Area Training: Partners in Wildlife Management, www.nationalfiretraining.net/ea

Natural Lands Trust's Fire Management Equipment

QTY	EQUIPMENT	USAGE
3	drip torches (w/brackets)	fire ignition
6	collapsible backpack pump	fire suppression
3	Indian backpack pump	fire suppression
12	Nomex jumpsuits	personal protection
12	helmets	personal protection
12	plastic face shields or goggles	personal protection
12	Nomex neck and face guards	personal protection
12	fire shelter	personal protection
12	leather gloves	personal protection
1	fire weather kit	monitor weather
12	radio harness	communication
12	portable radios	communication
1	mobile Ritron radio	communication
1	radio organizer	communication
1	radio cloning cable	communication
3	wire rakes	fire control/prepare
3	council rake	fire control/prepare
1	turbo meter (anemometer)	monitor weather
1	tool box	repair/parts
9	personal protective equipment bags	gear bags
1	radio gang charger	communication
20	1½" x 100' hose	fire control
11	1" x 100' hotline hose	fire control
18	⅝" x 50' mop up hose	fire control
6	1" x 1" x 1" gated wyes*	fire control
3	1½" x 1½" x 1½" gated wyes*	fire control
7	1" nozzle	fire control
15	¾" nozzle	fire control

QTY	EQUIPMENT	USAGE
1	mini-striker portable pump	water pump
2	200-gallon slip-on unit	fire control
1	2" foot valve	water supply
4	1½" x 8' suction hose	water supply
13	1" to ⅝" reducers	water supply
13	1½" to 1" reducers	water supply
2	2" to 2½" increaser	water supply
1	2" to 1½" reducer	water supply
6	1", 1½" & 2½" double male & female fittings	water supply
12	headlamps	safety
7	hotshields and bags	safety
3	practice fire shelters	safety
2	replacement goggle lens	safety
1	case of fusee	ignition
2	fusee holders	safety
1	extra fuel can 5-gallon	ignition
1	1991 fire trailer	haul equipment
2	work lights	fire control at night
1	window protector	mount on light
1	brush bar system	safety
1	Warn Trans4mer brush truck winch system	safety
1	5-gallon pail of class A foam	fire control
1	foam inductor and nozzle	fire control
1	spool of pea cord	safety
2	2" suction hose, 10' each	water supply
2	500-gallon portable tank	water supply
1	75-gallon relay tank	water supply
2	firefighter portable pump	water pump

** fire hose Y-splitter*

Minimum requirements for all participants (always check for updated requirements) in a prescribed fire program should be:

- S-130 and/or PA-130 (Firefighter Training)
- S-190 (Introduction to Wildland Fire Behavior)
- I-100 (Introduction to Incident Command System)
- L-180 (Human Factors on the Fireline)

The fire leader should have extensive training including:

- S-290 (Intermediate Fire Behavior)
- S-390 (Introduction to Fire Behavior Calculations)
- RX-300 (Federal Prescribed Fire Burn Boss)

In addition, all participants in a prescribed fire program should meet the federal standard for physical fitness. Participants should be tested annually prior to the burn season and pass the most current standard. At this time, the minimum standard is for all participants to walk 2 miles with a 25-pound backpack within 30 minutes.

Photodocumentation

It is often helpful to establish fixed points from which to periodically take photographs to monitor and help evaluate the relative success of the fire management program. Ideally, photos should be taken before and after burns and in the middle of the growing season.

STORMWATER MANAGEMENT

Managing stormwater runoff from impervious surfaces is an essential aspect of land and water stewardship. To assist in measuring the "ecological footprint" of a given project, ask: "How close to the pre-development condition are its runoff rate, quality, and quantity?" It is important to consider each project not individually, but rather as one of a series of sites contributing cumulatively to the flooding, erosion, sedimentation, water pollution, and drought effects in each watershed. With careful attention to the ecology and hydrology of each site and each watershed, and with the use of innovative best management practices (BMPs), project designers can minimize a site's "stormwater footprint" by re-creating the conditions of the site in its natural state. When designing a subdivision, the natural areas and greenway lands provide excellent opportunities to work "on-contour" with broader systems of berms, swales, and vegetated filter strips and better utilization of natural soils and vegetation than more concentrated suburban development sites.

Natural lands typically retain far greater volumes of stormwater than agricultural or developed areas. This translates to fewer and less severe floods and more consistent stream baseflows during drought periods. When a new site is converted

Stormwater Best Management Practices **(BMPs) are innovative management practices designed to re-create natural hydrology and so reduce flooding and increase groundwater recharge.**

Ask: *"How close to the pre-development condition are the runoff rate, quality, and quantity?" It is important to consider each project not individually, but rather as one of a series of sites contributing cumulatively to the flooding, erosion, sedimentation, water pollution, and drought effects in each watershed.*

to residential or other intensive use, innovative stormwater systems may be used to recreate the natural hydrology by infiltrating and retaining stormwater runoff on-site during storm events and discharging it more slowly; this also helps to maintain a more natural stream hydrologic regime. By eliminating unnecessary clearing, grading, and impervious coverage and by promoting groundwater recharge, each project can minimize its watershed impacts. The technique of handling runoff in many small systems close to where it is generated on the site is a major improvement over concentrating runoff in a few large basins at the lowest areas of the site (often with the poorest soils for recharging groundwater). Because new suburban development often exploits on-site groundwater resources while reducing groundwater recharge, these techniques are fundamental toward protecting water supply.

The need to manage stormwater runoff on the site provides numerous opportunities for the land steward to address some of the major water quality issues facing local watersheds. Incorporating current stormwater BMPs can reduce non-point-source pollution and flooding, and increase baseflow.

The last generation of stormwater systems provided virtually no means of filtration for contaminants found in stormwater runoff, other than by allowing suspended solids to settle out in detention or retention basins. In contrast, new stormwater BMPs filter runoff to improve water quality. Simply recharging runoff into soil rather than discharging it to wetlands and streams allows the soil and vegetation to remove excess nutrients, chemicals, sediments, and salts from paved areas, rooftops, and lawns. If carefully designed, these systems will not contaminate wells with non-point-source pollutants. With the addition of innovative techniques such as vegetated filter strips, vegetated swales, sediment forebays, and constructed wetlands, the filtration effects on runoff from each site are significantly enhanced.

The stormwater planning and design strategies proposed here are comprehensive and include evaluating the entire project from a stormwater perspective, taking into consideration such factors as:

- amount and location of vegetation clearing and soil grading,
- amount and location of impervious cover to be constructed,
- integrating stormwater management systems throughout the site and early in the design process,
- type and location of stormwater best management practices (BMPs) employed on the site, and
- amount, location, and type of vegetation to be planted as part of the landscaping plan.

When compared to conventional stormwater management systems, projects designed using this approach can ***reduce runoff volume and peak rate*** reaching streams, ***maintain recharge*** of groundwater aquifers, and ***enhance the quality*** of runoff water. If designed properly, the result is less downstream flooding and erosion, cleaner water, healthier aquatic life, and more baseflow for streams and wetlands. The techniques proposed here are also generally consistent with the National Pollution Discharge Elimination System (NPDES) Phase II requirements.

Vegetation Clearing and Soil Grading

- Evaluate the grading plan to minimize unnecessary clearing, cutting, and filling.
- Retain the natural soil mantle and vegetation wherever possible to reduce the amount of stormwater runoff that must be controlled.
- Carefully delineate limits of disturbance in woodlands, around specimen trees, and in open areas that could be converted to meadow or reforested areas.
- Avoid clearing vegetation anywhere within 100 feet of streams.

Impervious Cover

- Evaluate the building program to minimize the amount of unnecessary paved area and rooftop.
- Minimize road widths and utilize localized parking pull-offs instead of full on-street parking.
- For lower-traffic areas, overflow parking, and walkways utilize porous paving, gravel, or paving blocks.
- Evaluate the potential for utilizing green roofs.
- Where impervious cover does exist, incorporate vegetated "islands" to enhance opportunities for recharge.

Stormwater Management Systems

- Integrate stormwater systems throughout the site and early in the design process, and avoid shoehorning them into the open space as a final step.
- Make sure system design treats the first flush of runoff that carries the highest amount of pollutants.
- Avoid collecting, piping, and rapidly sending untreated stormwater to the lowest areas of the site.
- Instead, disconnect, disperse, and slow down stormwater runoff, managing it with localized BMPs to maximize recharge within each micro-watershed, close to the impervious cover source where it is generated.
- Utilize non-structural, vegetation-based BMPs wherever possible.
- Merge the landscaping plan and natural lands/greenway lands management with stormwater management systems wherever possible.

New stormwater BMPs filter runoff to improve water quality. Simply recharging runoff into soil rather than discharging it to wetlands and streams allows the soil and vegetation to remove excess nutrients, chemicals, sediments, and salts from paved areas, rooftops, and lawns.

- Recommended BMPs:
  - ~ ***Rain gardens*** are small infiltration beds, depressed slightly below grade, and planted with wet-soil-tolerant native trees, shrubs, and herbaceous plants to serve multiple functions: landscape features as well as biofilters to improve water quality, promote recharge, and provide habitat for plants and wildlife. Rain gardens can be incorporated into site plans within median strips, cul-de-sac islands, road shoulders, adjacent to parking lots, and in front lawns to handle roof and driveway runoff.
  - ~ ***Vegetated swales and infiltration trenches*** can be included along road shoulders to disperse and recharge sheet flow from roads. This technique requires certain sections of road to be designed without curbs or with periodic curb cuts. Road shoulders can be planted with native warm-season ornamental grasses and wetland shrubs to serve as natural check dams to reduce velocities and promote recharge.
  - ~ ***Roof drains*** can be added to direct roof runoff from downspouts into subsurface infiltration beds, including rain gardens.
  - ~ ***Level spreaders and infiltration trenches*** can be designed to handle runoff at the rear lot lines and in protected open space. Runoff can be directed to these areas with carefully designed berms and swales, then discharged through an overflow designed to disperse sheet flow into open space.
  - ~ ***Constructed wetlands*** and wet ponds can be incorporated as landscape features and planted with native wetland vegetation to serve as living filters for runoff, areas of visual interest for residents, and habitat for aquatic life. These should be designed with sediment forebays.

Landscaping Plan

- Incorporate revegetation stormwater BMPs into the overall landscaping plan for each site, rather than treating them separately. Pay careful attention to the use of native trees, shrubs, and plants to blend the function and aesthetics of the site and its stormwater systems into any adjoining or nearby natural areas and open spaces.
- Go beyond typical street tree plantings and maximize the planting of native canopy trees throughout the site that will mature over time to recreate a forest canopy that reduces runoff volumes and velocities, contributes to regional air quality enhancements and reduces energy costs for home heating and cooling.
- Reduce the amount of turfgrass throughout the site and maximize the amount of reforested area, wildflower meadow, and native plant gardens. Encourage homeowners to use natural landscaping and planting practices as alternatives to lawn.

STREAMBANK STABILIZATION

Stream channels can be restored to a state that reduces bank erosion and reaches a new equilibrium.

Stream channels can be restored to a state that reduces bank erosion and reaches a new equilibrium. Often, the reason why streams experience accelerated bank erosion and in-stream habitat loss is because of poor stormwater management from upstream land use. This constraint should always be considered in order to set realistic expectations of success from a stream restoration project. If there is a high proportion of impervious cover upstream, with few opportunities to better manage runoff using BMPs or through redesign and redevelopment, the potential for stream restoration to a natural state is limited. In such a case, it may make more sense to stabilize a stream in its existing degraded state in the short term and attempt incremental improvements over the long term.

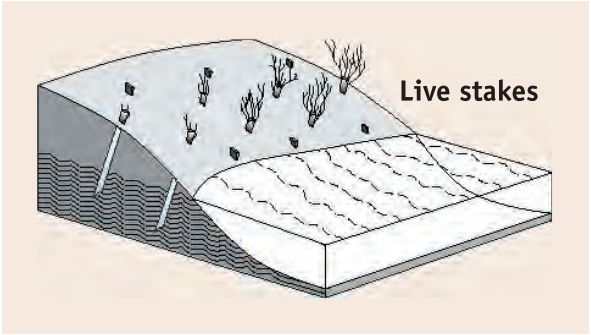
To restore streams that are constricted within their channels from this downward cycle of undercutting and bank destabilization, the following techniques should be considered.

Bioengineering Techniques

"Hard engineering" is an approach that emphasizes installation of retaining walls and gabions to lock streams into place in areas where space is limited and in-stream erosion is severe. These devices do little to dissipate energy from accelerated runoff, will likely experience undercutting, and often transfer erosion problems downstream to another site. Therefore, preferred techniques encourage natural systems to function to restore streams and protect habitats. Bioengineering includes a variety of uses of natural material to mimic natural conditions and stabilize streambanks:

- ***Live stakes*** – Live stakes are a dependable, cost-effective way to introduce stabilizing vegetation to under-vegetated streambanks. A number of native shrub species are available that will grow from live stakes, mainly various species of willows and shrubby dogwoods. These species have fibrous root systems that help hold soils together and are specifically adapted to a stream-side environment. Their flexible stems bend and dissipate energy from floodwaters and protect banks from damaging ice flows. They can also be integrated into gabion construction.

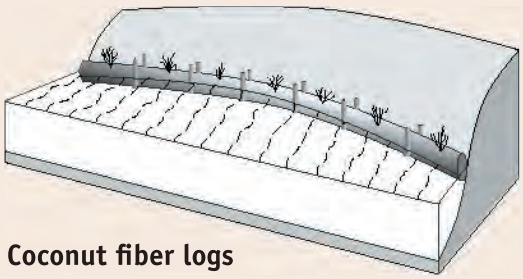
  Stakes can be purchased commercially or selectively harvested from nearby sources. They are often 18 inches long, at least 1-inch caliper, and are sometimes scarred on the lower end to encourage rapid root growth. Planting should occur in early spring when plants



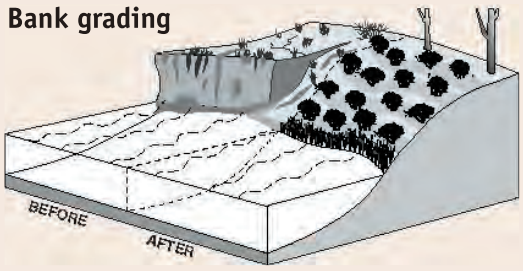
Federal Interagency Stream Restoration Working Group

are dormant. A pilot hole is made in the bank using a dibble bar and sledge. Using a rubber mallet, the stake is then driven into the bank at least 12 inches. Stakes should be planted at a 45° angle facing downstream so that currents and debris do not rip them out. The lower ends of stakes should be within 12 inches of the normal water line in the stream. Stakes are most successful when invasive species and low-hanging tree branches are removed so they receive sufficient sunlight.

- ***Coconut fiber (coir) logs*** – These serve as a short-term bank stabilization tool as well as a growing medium for live stakes and other streamside-stabilizing plants such as soft rush. Made from coconut tree fiber, these logs (18 inches x 10 feet) are staked in at the toe of the slope at the water line. They fill with sediment, which becomes an excellent area in which to grow species with strong fibrous root systems.



Coconut fiber logs



Bank grading

Federal Interagency Stream Restoration Working Group (both)

- ***Live fascines*** – Fascines are bundles of live cuttings from shrubs at least 6 feet long and 12 inches in diameter. They are staked into a streambank at or below the waterline, similar to coconut fiber logs. Sometimes a trench can be made at the toe of the bank where a fascine can be staked. The live material will then grow roots and stems while the space between the cuttings will allow sediment to collect to help stabilize the bank.

  Fascines without live cuttings can also be used solely to buffer streambanks and collect sediment. These are useful below the water line when erosive voids exist under trees along the bank.

- ***Plantings*** – Where conditions are too dry to plant live stakes, the same species should be planted several feet above the water line using container-grown stock.

Channel Modifications

Bioengineering techniques can help stabilize a mildly degraded stream. However, where a bank approaches a slope of 90°, the erosion potential is greater than the ability of bioengineering techniques to stabilize the bank. In these cases, the streambank, or the channel itself, may first need to be sculpted. In Pennsylvania, any earthwork in or near a stream will require a General Permit from the Pennsylvania Department of Environmental Protection.

- ***Bank grading*** – Where a streambank's slope approaches 90°, bank regrading can be considered as long as it is

accompanied by effective bioengineering practices. The simplest form of bank regrading entails pulling a bank back from the water line to a 3:1 slope. Erosion-control fabric is installed along with new seeds, plantings, and stakes. However, when trees exist on the slope or the working area is limited, the technique must be modified. Every stream is different and one method does not fit all conditions. All streambank modifications should consider upstream land use changes and the long term success of the project as well as downstream effects of new flow patterns.

- ***Geomorphology*** – Fluvial geomorphology is a multidisciplinary field of study that analyzes local topography, soils, and climate to select specific stream geometry. The recommended geometry based on such a study includes specifications on entrenchment and sinuosity of the stream in order to mimic natural stream patterns.

  In extreme cases, modifying stream geometry may lead to actual earthwork within the stream to help restore equilibrium. This could include a variety of methods including J-hooks, check dams, and log diversions. The purpose of these techniques is to redirect water and encourage areas of sedimentation to protect eroding banks.

TRAIL DESIGN AND MAINTENANCE

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 that offer a more aesthetically pleasing and varied recreational experience, a more stable trail that can be maintained with less expense, and a safer and more enjoyable outdoor experience for users. The more time and thought that is put into the trail planning phase, the better the trail is likely to be. Well-designed trails take advantage of natural features, are low maintenance, and meet the needs of the user. The trail should meander around trees and rocks, follow the shape of the land, and otherwise take advantage of natural land features. The best trails show little evidence of the work that goes into them. A little extra effort spent widely scattering cut vegetation, blending slope cuts, or raking leaves back over fillslopes pays off in a more natural-looking 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. Main trails should bypass these resources where possible, with only secondary trails providing access to them.

- Trails should be buffered from the sight, sound, and hazards associated with man-made features, including roadways, buildings, and urban or suburban land uses.
- The trail designer should make creative use of vegetation to enhance the hiking experience.
- The trail designer should route trails through varied types of plant cover, avoiding alignments through continuous stands of similar vegetation.
- Trails should not have long straight sections that 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, except where switchbacks are needed to negotiate a long steep slope.
- Planting showy native plants and butterfly or hummingbird-attracting plants in a naturalistic style in key areas along trails can greatly improve user enjoyment.
- Locating resting areas (benches or access to large, flat-topped boulders) near features such as streams and ponds will allow users opportunities to pause and 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 special features of the landscape into its design with minimal environmental impact.
- When locating a trail, primary emphasis should be placed upon characteristics of soils and topography that control trail stability.
- Trails should follow 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 (e.g., steps).
- Soils that 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—cutting a notch and sometimes filling to form a narrow bench—should be used to reduce erosion and improve surface drainage.
- Switchbacks should be used when going up steep gradients where sidehilling cannot gain elevation fast enough.
- Switchback segments 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. Visual anchors should be used to encourage users to follow the trail.
- Trail layout should minimize impact on sensitive resources, such as wetlands. 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 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 urban or suburban land uses, they should have a buffer as wide as possible and sight lines as long as possible to keep potential conflicts with adjacent landowners to a minimum.

Trail Construction

Constructing good, easily maintained trails and their associated structures is somewhat complicated. The basic concepts are described below, but please refer to **Additional Information Sources**, *page 217*, for detailed reference manuals on the subject.

Trail Clearing

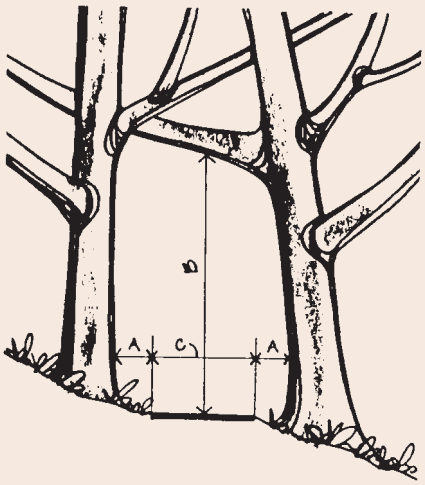
When rerouting an old trail or establishing a new trail, the general alignment should be walked and flagged to determine exactly how the treadway should wind and dip, which rocks should be removed, and which trees might need to be cut. This is a critical step in the trail building process, as slight 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, an 18–24-inch wide treadway should be cleared with all projecting limbs cut back an additional 1 foot. For equestrian trails, a 3-foot-wide treadway should be cleared with all projecting limbs cut back an additional 2½ feet for a total horizontal width of 8 feet. The trail should be cleared to a vertical height of 6–8 feet for a hiking trail and 10 feet for an equestrian trail.

TRAIL CLEARING DIMENSIONS

Hiking
A = 1′
B = 6′–8′
C = 1½′–2′

Equestrian
A = 2½′
B = 10′
C = 3′

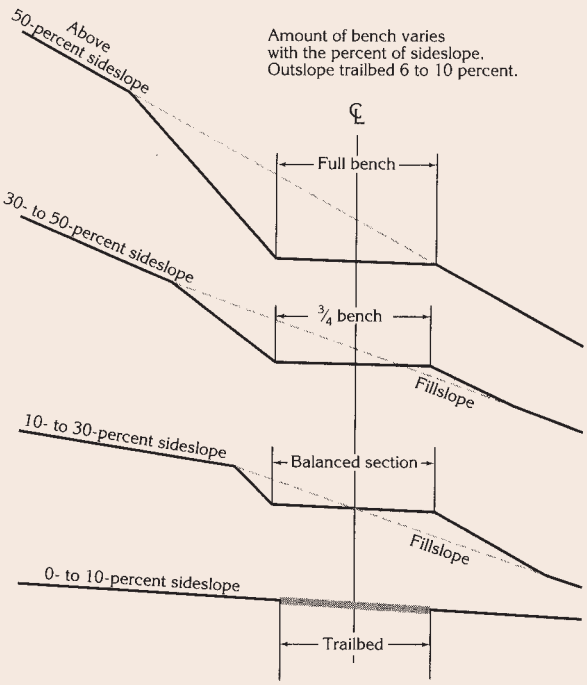


PA DER, Bureau of State Parks, Division of Outdoor Recreation, The Pennsylvania Trails Program, 1980.

In clearing trails all shrubs, vines, low-hanging branches, blowdowns, small trees, and fallen logs should be removed. Logs and rocks can be used along the trail edges and as anchors and points of interest. 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. Large trees fallen across the trail should be left in place by making two cuts and removing a 4-foot-wide section from the trunk across the trail. If motorbikes or mountain bikes are a potential problem, the logs can be notched to provide a flat surface for hikers, yet prohibit the passage of wheeled vehicles.

When clearing is completed, cuttings should in general be scattered in areas adjacent to the trail and left to decompose. It may be necessary to collect

TYPICAL TRAIL CROSS SECTIONS



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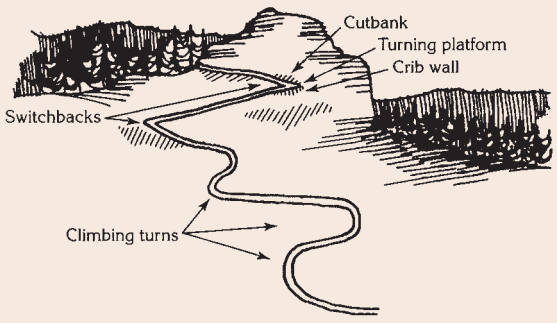
SWITCHBACKS AND CLIMBING TURNS



Climbing turns can be built on gentler slopes, usually not more than 15–20%. Switchbacks are needed on steeper slopes.

US Forest Service, Technology and Development Program

the cuttings and remove them from the immediate trail area where the trail runs through more formally landscaped areas such as along public roads and through suburban developments.

In the first year of a trail's use, repeated clearing is required to deter continued vegetation growth. In subsequent years, clearing will probably be necessary only two or three times a year. An exception would be in open fields and grassy areas where mowing is required to maintain a clearly visible treadway.

Treadway Stabilization

The type of tread surface on trails will ultimately be determined by the rate of use, the terrain through which the trails pass, and the underlying soils. Initially, once a trail has been cleared, it should be surveyed to ascertain where special measures should be taken to stabilize the treadway, mainly treadway hardening and erosion control measures. Most problems are likely to occur where a trail traverses steep slopes or 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 delineated by sweeping herbaceous and trailing plants and leaf litter off the path. If, with time and use, initially stable areas begin to show signs of erosion, then some stabilizing type of material, such as crushed stone, should be integrated into the soil of the treadway.

Trails on Slopes

Where a trail cuts across a slope greater than 10% (1 foot rise for every 10 feet of run), a slightly outsloped or sidehill

treadway should be excavated to prevent trail widening and erosion *(top far left)*. Depending on the slope, the amount of excavation and the use of the excavated material varies. On steeper slopes, excavated soil is not used at all in the fillslope. This soft material is likely to erode away quickly, creating dangerous soft spots on the downhill edge of the trail. As the slope decreases, it becomes more feasible to use fill material as part of the treadway.

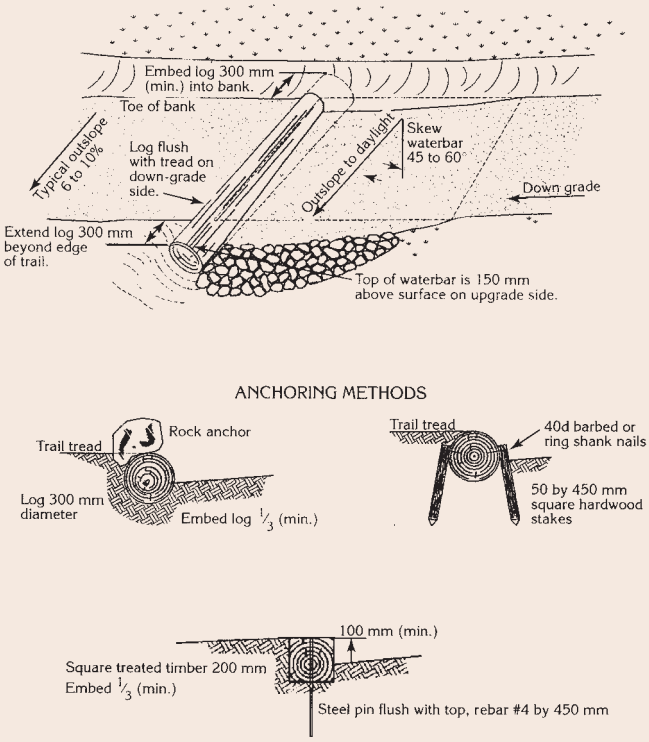
Switchbacks and climbing turns are used on steep slopes where sidehill trails alone cannot provide the needed rise in elevation in a limited distance. A climbing turn is a reversal in direction that maintains the existing grade going through the turn without a constructed landing. A switchback is also a reversal in direction, but has a relatively level constructed landing *(bottom far left)*. Switchbacks usually involve special treatment of the approaches, barriers, and drainages. Long sections of trail between these turns are usually better than short ones; fewer will need to be built and there will be less of a temptation to shortcut them. Both switchbacks and climbing turns take skill to locate and are relatively expensive to construct and maintain, therefore, every effort should be made to minimize their use when designing a trail.

Surface Water Control

Diverting surface water off the trail is one of the first priorities in designing and maintaining trails. Running water erodes the treadway and support structures and can even lead to loss of the trail itself. The first choice to address surface water is to enhance the natural drainage by outsloping the treadway and creating grade dips such as Coweeta dips, bleeders, or drainage dips. The aim is to take advantage of the natural topography wherever possible, making sure the water won't return to the treadway. A Coweeta dip uses a reversal in grade on sidehill trails to shed water continuously all along the trail segment. A bleeder is a shallow graded depression across the treadway. A drainage dip, appropriate only on grades less than 8%, is a channel reinforced with earthen mounds running diagonally across the treadway.

Waterbars are the second most common drainage structure after outsloping. They are diagonal rock or log barriers that divert water off the treadway *(above)*. Even though waterbars have been standard practice in the past, they should be avoided where it is feasible to use some form of a grade dip. By design, water hits the

LOG OR TREATED TIMBER WATERBAR AND ANCHORS



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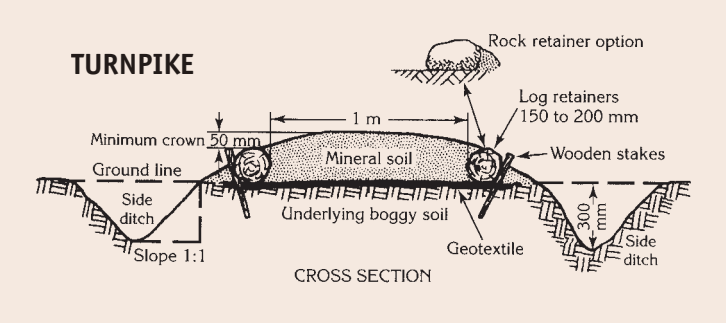
waterbar and is turned. The water slows down and sediment drops in the drain. The number one cause of waterbar failure is sediment filling the drain until the water tops the bar and continues down the trail, rendering the waterbar useless. A good grade dip can be built more quickly, works better, requires less maintenance, and is less obtrusive on the landscape.

Waterbars are useful on trails where there isn't much soil to work with, in areas that experience torrential downpours, and where a tripping hazard is acceptable. They may also be necessary when repairing older trails where no provision was made during design or construction for proper drainage.



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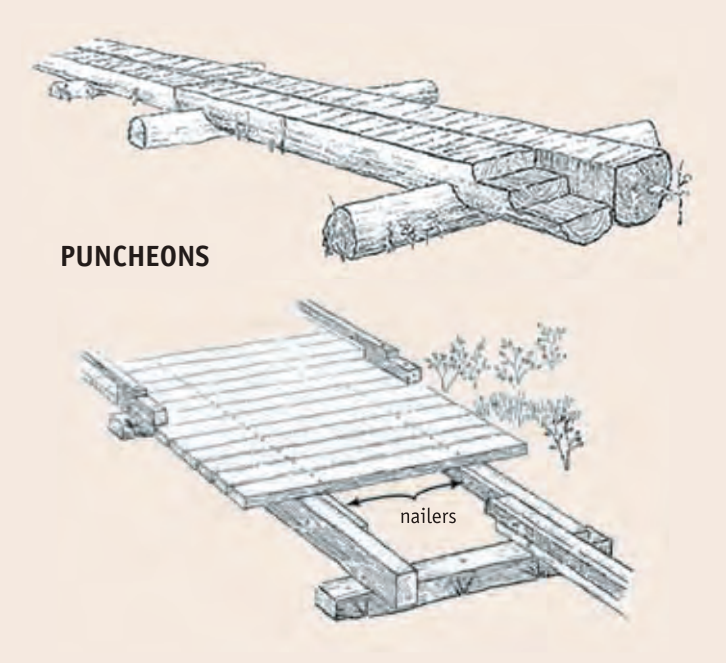


US Department of Transportation, Federal Highway Administration

Correctly installed, a waterbar must be constructed of rock or a rot-resistant type of wood. Logs should be a minimum diameter of 6–8 inches at the small end—greater if water flow is heavy—and all bark must be removed. It should be placed at a 30°–45° angle and extend at least 1 foot past the outside edge of the treadway on both sides. If the natural topography would allow water to return to the trail, it is essential that the situation be remedied by extending an outlet trench beyond the end of the rocks or log. 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.

Drainage ditches are trenches along the side of a trail to collect water seeping from a hillside or runoff entering a trail that can't be immediately removed with a grade dip. The water can then be diverted across the treadway at appropriate points with a dip or water bar.

Trails in Wet Areas

Trails should be designed to avoid wet areas. Equestrian trails in particular should avoid small streams and wetlands if at all possible to prevent water degradation from erosion and excrement. Where this is impossible or an existing trail has developed a drainage problem, several options exist. Because nearly every technique for fixing trails in wet areas is expensive and needs to be repeated periodically, relocating the problem section of trail should be considered first.

Using stepping stones is a simple and relatively inexpensive technique for crossing small drainage swales and muddy

areas. The stones should be large, fairly flat on top, and buried such that they rise above standing water, but don't rock. Space the stones for the average stride, remembering that trails are for children, too.

Turnpikes are used to elevate the trail above wet ground. The technique uses fill material from parallel side ditches and from off-site, if necessary, to build up the treadway higher than the surrounding water table *(top far left)*. The most important consideration is to lower the water level below the treadway base and carry the water under and away from the trail at frequent intervals. Turnpike construction is used to provide a stable trail base in areas of high water table and fair to well drained soils. They are practical up to 10% grades.

A puncheon, or bog bridge, is a wooden walkway used to cross muddy areas *(bottom far left)*. It can be used where lack of tread material makes turnpike construction impractical or firm mineral soil cannot be easily reached; puncheons can be supported on muddy surfaces better than turnpikes, which require good drainage. They consist of decking made from flat-topped logs, called stringers, notched into base logs, or mud sills, set into firm ground. If firm footing is not available, use rock and fill to solidify the bottom of the trench they're set in, increase the length of the sill to give it better flotation, or use more sills for the needed flotation.

Crossing Drainage Swales, Streams, and Wetlands

For minor crossings of small streams and drainage swales, there is no need for construction of elaborate bridges. Natural stream crossings using stepping stones are ideal where the stream flow is generally low and there are not significant fluctuations, except following major storm events. The stepping stones should be large and flat-topped. They should be placed approximately 2 feet apart across the stream. Ideally, the bottom on which the stones are laid should be stone in order to prevent movement.

As an alternative to stepping stones, a simple bridge could be constructed of a single or double stringer with two base logs similar to the puncheon described above. The base logs should be placed on each bank above the flood level on a flat stone or ledge, secured with pins if possible. The stringer(s) should be secured to the base log on each end using 10-inch or 12-inch spikes or large bolts. Both the base logs and the stringers should be of rot-resistant wood, such as black locust, eastern red-cedar, or white oak, from which all the bark has been removed. To facilitate construction, crossing sites for bridges should be selected where the banks are the same height and midway between turns. A handrail is needed for safety only if the top of the stringer is more than 3 feet above the stream. The stringer surface should be randomly scored to provide safer footing when wet.

Any new stream crossing that involves a structure requires a permit from the Pennsylvania Department of Environmental Protection, Bureau of Dam Safety, Obstruction, and Stormwater Management.

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- or water-based

wood preservative such as creosote, pentachlorophenol, chromated copper arsenate, or zinc chloride. These wood preservatives are toxic to the natural environment and can be harmful to human health. They do, however, add longevity and structural safety. Two alternatives are posts made from recycled plastics that do not release harmful chemicals into the ground or water 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 inches, rails are recommended.

Permits may be required for a boardwalk. The US Army Corps of Engineers (for the Delaware River watershed: Philadelphia District, 215-656-6729; for the Susquehanna River watershed: Baltimore District, 410-962-3670) requires a permit for any discharge of fill within wetlands.

Abandoning Trails

When it becomes necessary to abandon a trail, it should be done effectively and with sensitivity. Restoring abandoned trails to a natural state requires as much attention and planning as constructing new trails. The goal is to reduce the continuing impact abandoned trails have on the landscape. Simple restoration may consist of blocking new shortcuts and allowing the vegetation to recover. "Planting" old tree stumps and placing rocks naturalistically within the old treadway helps give the trail immediate closure. Complex restoration projects include obliterating the trail, recontouring, and revegetating the treadway with appropriate plant species (*see* **Native Plant Materials**, *pages 172–200*). Careful monitoring and follow-up are necessary to ensure that eventually almost all evidence of the trail is gone.

Each abandoned trail should be closed. If the trail is not blocked to prevent further use, the trail may persist indefinitely. Closure is particularly important if stabilization and revegetation are being attempted. The abandoned treadway should be blocked to all traffic, recontoured, and disguised to prevent users from being tempted to take it. This work should be accomplished for all segments visible from trails that remain open.

If the section of trail to be abandoned is short, it is simplest to just pile brush along its entire length. If it is long, brush should be placed far enough along from its intersections with trails in current use to obscure the path. Extending the brush a few feet on either side of the entrance will help deter users from going around the blockage. If there are any areas of active erosion, these should be stabilized to restore the natural contour and drainage patterns. Revegetation can be accomplished passively or actively. Passive revegetation allows surrounding vegetation to colonize the abandoned trail. This works when erosion has been stopped, adequate precipitation occurs, and adjacent vegetation consists of desirable (native) species that spread and grow rapidly. Active revegetation ranges from transplanting onsite vegetation to planting seeds or propagated plants of appropriate native species (*see* **Native Plant Materials**, *pages 172–200*). Successful revegetation almost never is complete within a single season.

Trailheads and Parking Facilities

Determine where trailhead and parking should be located, taking into consideration safe vehicular access, site conditions suitable for construction of a parking area, proximity of neighbors, and ease of policing. Try to avoid locating parking facilities and trailheads in areas where the trail would deteriorate under heavy use. Before you finalize the site location, you should contact Pennsylvania One Call (1-800-242-1776) to determine if there are any underground utility lines near the site.

The most critical element in the design process is accurately projecting the number of parking spaces that should be constructed at a trailhead. Parking should be provided for the average high day of trail use. This would be a typical weekend day in the spring or fall. Do not attempt to design for a peak day.

The second most important step in the design process is the development of standard construction specifications for trailheads and parking areas. Functional, aesthetic, and maintenance considerations are important to establishing these specifications. The trailhead areas should be simple, well built to minimize maintenance needs, and attractive, blending in with the natural setting as much as possible, with a minimum of grading and vegetation disturbance. The entrance drive and parking areas should be properly constructed with crushed stone laid over a base suitable for soil and drainage conditions on the site. Asphalt paving should not be used except to stabilize high-traffic entrance and parking areas. Along the perimeter of the parking areas and where there has been clearing for construction, native plant species should be planted to restore the area after construction. Place a signboard or kiosk to provide users with rules and regulations, management information, maps, and other important information (see below).

Trail Signage

Trail signage is used to guide trail use and to provide information about features along the trail. Trailhead signage and kiosks provide basic information (e.g., name of property, property map), orient visitors to trail rules and regulations, such as the uses allowed on the trails and the times when the trails are open or closed, and present information about the property and the organization that owns and manages it. The trailhead is also an excellent location for distributing trail maps.

Along the trail, signage can be used to highlight natural features (e.g., large tree, unique geology), historical uses (e.g., old stone walls) of the property, or to illustrate the complex interactions in natural ecosystems. They are also a good way to inform visitors of ongoing restoration activities—such as riparian buffer plantings—and how it will improve the conservation value of the property. Although there are endless amounts of information that can be communicated on any property, interpretive signage should be: (1) limited in number and (2) concise (if possible, include illustrations or photos to make the intended point more clearly).

Other appropriate types of signage for trails indicate the distance to other locations, points of interest, or improvements (e.g., office, shelters) and inform users where they are leaving the property.

Trail signage should be constructed of materials that are in harmony with the natural environment and are sufficiently rot-resistant. Options include wood (black locust, white oak for posts; cedar for the sign), recycled plastic, metal, fiberglass embedded, laminated, or for very short-term temporary signs, paper. Wood signs should be ¾–1½ inch in thickness with wording inscribed using a router or sandblaster. The sign can either be left unpainted or painted with one or two contrasting colors.

If possible, the signs should be installed on 4-inch x 4-inch posts with zinc-plated, galvanized, or stainless steel hardware. To make it easier to read the sign, the top end of the post should be cut at a 45° angle; to prevent it from being uprooted, attached a cross-piece (wood, rebar, spikes) to the bottom of the post before backfilling the hole. Locate the sign carefully, keeping it off the pathway, but close enough that visitors notice it. Signs located near roads (particularly those in the right-of-way) may require a permit or be subject to size limitations. Check with the municipality (if a township road) or PennDOT (if a state road) to determine any restrictions.

If a sign is destroyed or removed by vandals, temporary signs made of laminated paper or paperboard can be used where critical information needs to be conveyed. These types of signs are also appropriate in cases where there is a temporary hazard or obstacle soon to be remedied (e.g., fallen tree, landslide, gully).

Trail Marking

Trail markers include cut or painted blazes on trees; wood, plastic, or metal marker tags; and marker posts. These markers are used to help travelers identify the trail corridor when the treadway is indistinct, the ground is covered with snow, or when the path is confused by multiple trails or obscured by weather such as dense fog. They should be used only when the trail is not obvious, there is a sudden change in direction, and at trail junctions.

As with signage, standards should be developed for marking a trail system. This includes color, placement, frequency, and form of the markers. A common system is to use a primary color for each major trail and to have a standard color for all secondary trails. This enables users to know when they have diverged from a main trail whenever they see that color, regardless of which of the major trails they may be following. Colors considered most visible by experienced trail builders include blue, red, yellow, white, and orange. Keep in mind the use of the trail when selecting a color—white might not be a good choice for a trail used in the winter.

Markers should be placed carefully. They should be as close to the trail alignment as possible and plainly visible when walking the trail in all seasons, preferably without the need for routine clearing of foliage. Eye level is generally considered most effective, slightly higher if the trail is used in winter. Large trees

should be used in preference to smaller ones and never use a dead tree. If markers are light-colored, dark trees should be used, and vice-versa. Markers should not be placed on trees or features that are important elements of a view or setting; they should be visible but not mar the visual character of the trail.

The frequency of marker placement is a balance between reassuring, not confusing, the user and maintaining the natural character of the trail. If part of a trail has markers, all of it should be marked, but abrupt changes in spacing should be avoided, as they are confusing to users. Be conservative. It's better to improve tread visibility than to rely on markers.

The marking decisions should be based on traffic traveling in both directions. Where a trail has a clearly defined treadway, markers should be placed only at points of possible uncertainty. Markers should be clearly visible from any point where the trail could be lost. When a trail turns into or off another trail or road, a double mark should be placed, one directly above the other. Then, after the change in direction, another marker should be placed so that it can be clearly seen from the turning point. Markers should also be placed immediately after road crossings in a location where it will not be affected by street maintenance or snow clearing activities and where it is unlikely to be vulnerable to vandalism.

HAZARD TREE MONITORING PROGRAM

All landowners are required to make a reasonable effort to prevent trees within their property from causing injury or property damage (real or pretended ignorance does not diminish your responsibility or liability). This is best accomplished through a regular program of monitoring areas of high use such as public roads, adjacent properties with structures, and sites used for recreational (play areas, benches, boardwalk, bird blind, sleeping platforms, cabins) or educational (pavilion, bleachers, rustic amphitheater) activities. These areas should be monitored at least once each year and after major storm events. Ideally, the landowner should hire a certified arborist (list available from the International Society of Arboriculture, *see* **Resources**, *page 211 for contact information)* to perform the inspection. Private landowners who cannot afford an arborist or who wish to augment this annual inspection with their own

Holly Harper

A hazard tree situation

NATURAL LANDS TRUST HAZARD TREE PROGRAM

Policy

The Natural Lands Trust will make a reasonable effort to minimize the potential for injury and property damage associated with hazard trees on the properties it owns and manages. It is our understanding that as a landowner we are responsible for the maintenance of trees outside the public right-of-way. The Trust will strive to eliminate, in a timely fashion, any tree deemed hazardous. Because the Trust has extensive land holdings and limited fiscal and staff resources, each year we will address the most hazardous trees to the limit of our dedicated resources.

Implementation

All NLT properties will be inspected on a periodic basis using standardized criteria for identifying hazard trees. The standard for rating the potential risk of a tree will be the hazard evaluation system used by the National Park Service. The Trust's Arborist will administer this program and have final judgment concerning the mitigation measures to be taken to address any tree identified as a hazard. All trees identified as a hazard will be treated (monitored, pruned, removed) according to the degree of hazard and their value to the Trust and the local community. The degree of hazard is a function of the likelihood of tree failure and the presence of people or built resources (targets) near each tree. Trees along trails will be evaluated according to different criteria than trees along public roads and other high target areas (including next to trail structures). Because of the Trust's desire to provide wildlife habitat and the relatively low frequency of use of the trails, only those trees that have failed and are either obstructing the trail or hanging over the trail will be removed, if reasonably possible.

Type of Area	*Implementation Strategy*
Public road borders Property borders adjacent to structures and lawns NLT estate and programmatic areas Internal roads, parking lots, and trails to buildings	Monitor on foot every 12 months (1st quarter of each year) Monitor after major storms* Remove hazard trees
Trails and trail structures (bridges, benches, signage)	Monitor as part of trail inspection program Monitor after major storms* Remove hazard trees

* *Because storm events can be very localized, the preserve manager will need to make a reasonable determination of the need for hazardous tree assessment on a preserve by preserve basis. For the purpose of this policy, a "major storm" is one that results in downed trees or large (> 4-inch diameter) limbs in the surrounding area.*

Documentation

For each tree that shows some degree of hazard the monitor will complete a hazard tree form that catalogs its size, location, current condition, degree of hazard, and recommended course of action. The completed forms for each property will be sent to the Trust's Arborist who will coordinate the appropriate action (further review by Trust Arborist, monitoring, pruning, or removal) for each tree. A sheet will be completed for each preserve that summarizes all related activities. A master summary of all hazard tree activities on Trust preserves will be completed each year by the Trust's Arborist.

ongoing monitoring can attend workshops on hazard trees. Morris Arboretum *(see* **Resources**, *page 211 for contact information)* holds workshops on hazard trees on a regular basis. Public landowners could also consider training one or more staff members in the identification of hazard trees to reduce monitoring costs.

Of course, once a hazard tree is identified the landowner should make a reasonable effort to address the hazard as soon as possible. The first course of action is to make sure that the tree is within your property boundary. Along public roads, trees within the public right-of-way (for this purpose it is the base of the tree that matters) are usually the responsibility of the municipality or state. Contact your municipality to determine the width of the right-of-way along your property. If the tree is completely within the right-of-way, notify the municipality or state of the hazard tree. Although it may be technically their responsibility (hazard tree law is still evolving), often municipalities will not address the hazard tree due to lack of resources or other priorities. In this case you will need to weigh the cost of removing the tree against the possibility of being sued, along with the municipality, if injury or damage occurs. If the tree is outside the right-of-way the landowner should engage a qualified contractor to eliminate the hazard through pruning or felling the tree.

For trees along a common boundary, if any part of the base is within your property you are jointly responsible for the tree; a tree with its base entirely within your property is, of course, your sole responsibility.

Often, when a landowner initiates a hazard tree program, a large number of trees are identified as hazards. This reflects the maturing of the forests in our region and the fact that few landowners are aware of their responsibility and as a result have not addressed hazard trees in the past. Unless your resources are unlimited, you or your contractor will need to prioritize your actions in addressing hazard trees, removing the most hazardous trees first.

Regular monitoring followed by reasonable action will not only prevent potential injury or damage, it will help to significantly reduce the landowners liability if a tree does cause injury or damage.

Regular monitoring followed by reasonable action will not only prevent potential injury or damage, it will help to significantly reduce the landowner's liability if a tree does cause injury or damage. Although the landowner is responsible for any injury or damage regardless of the actions taken, showing that you have made a reasonable effort to identify and address hazard trees will help preclude any charge of negligence.

The final key to an effective hazard tree program is documentation. All activities related to the program should be cataloged, including monitoring (when, where, and by whom) and actions taken and by whom. This will be the proof that the landowner made a reasonable effort to identify and address hazard trees in the unfortunate occurrence of injury or damage.

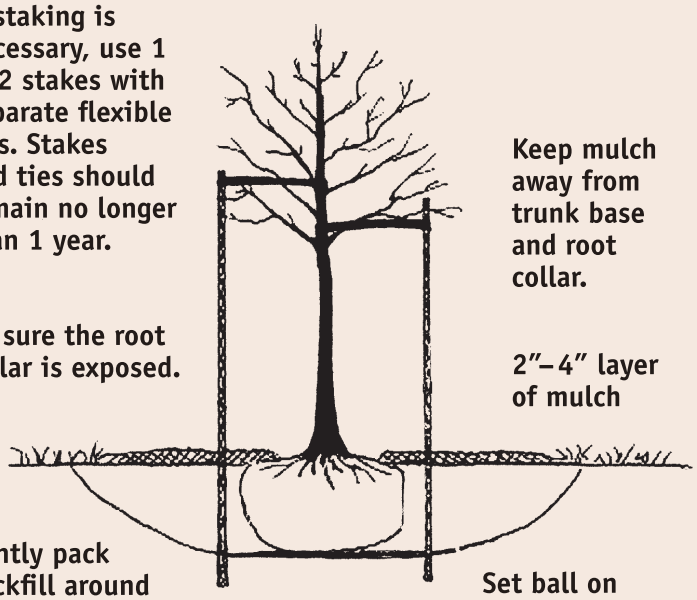
On the previous page is the hazard tree program used by Natural Lands Trust on its 42-property preserve system in southeastern Pennsylvania and southern New Jersey.

PLANTING TREES

Use the following guidelines for planting balled and burlapped (B&B), containerized, and bare-root trees. Videos are also available on the Pennsylvania Horticultural Society website (www.pennsylvaniahorticulturalsociety.org).

- Use only native tree species (ordinary, wild-type species, no hybrids or cultivars) appropriate to site conditions (*see* **Native Plant Materials**, *pages 172–200*). Ideally, they should be grown from local seeds or cuttings.
- All plants should be nursery grown in accordance with the American Standards for Nursery Stock, latest edition.
- All plants should be typical of their species or variety and should have a normal habit of growth (avoid chlorotic, dwarf, "weeping," or other atypical selections). They should be sound, healthy and vigorous, well branched, and have dense foliage. They should be free of disease and insect pests, eggs, or larvae. They should have healthy, well-developed root systems.
- All plants should be balled and burlapped (B&B), containerized, or properly handled bare-root seedlings or saplings.
- Unless protected from deer browsing, trees should be 6–8 feet tall at planting to help ensure that they can outcompete invasives and so that some of their foliage and the terminal bud(s) of the central branch are above the reach of browsing deer. Bare-root trees are less expensive than container trees but their survival rates are lower, although bare-root trees now are often shipped with their roots coated in a hydrogel—a synthetic water-absorbing compound—to protect them from dessication. Container trees are easier to plant and have a much greater survival rate than bare-root trees, especially if soil conditions in the planting area become dry.
- Bare-root stock must be planted in fall or early spring, preferably when most deciduous trees are leafless or nearly so; using container or balled and burlapped trees extends the planting season by several weeks at both times.
- Roots of all transplant plants should be adequately protected at all times from sun, drying winds, and frost. The roots of bare-root seedlings should be kept moist at all times until planting.
- Forest gaps and afforestation areas should be planted with trees on a 10-foot x 10-foot spacing (if resources are

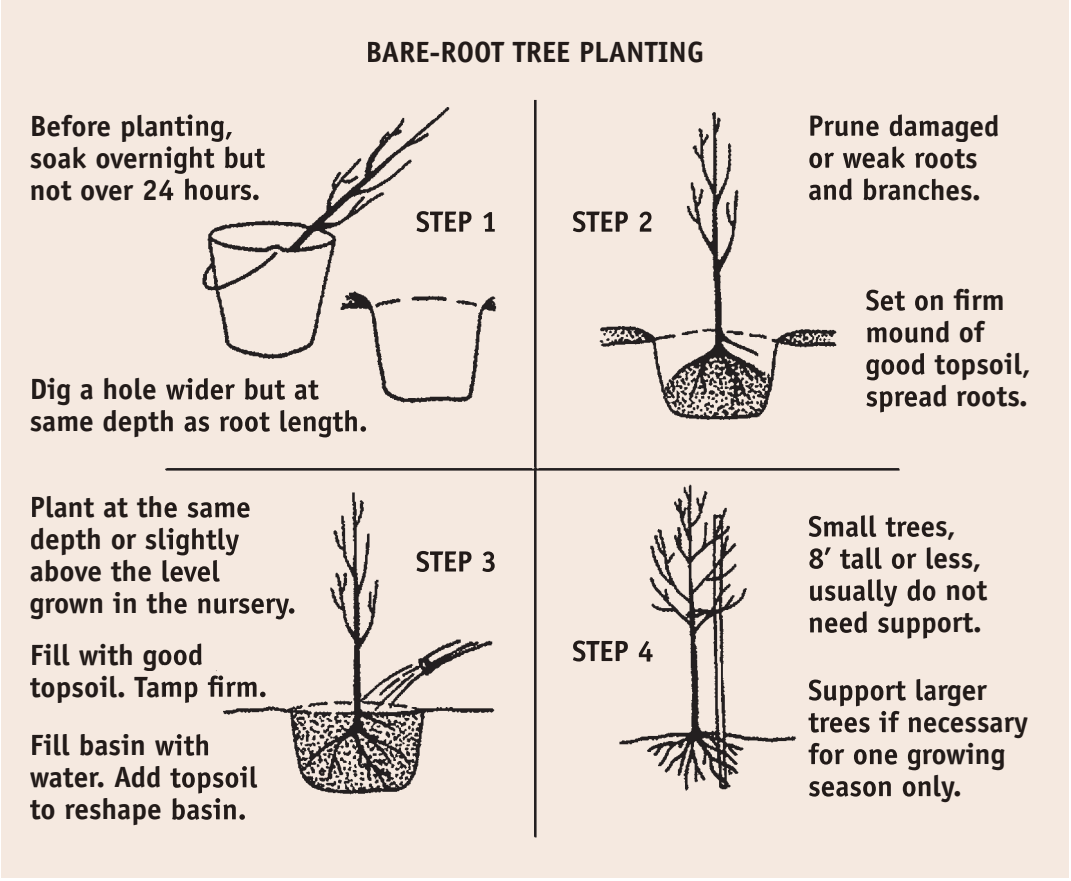
BALLED AND BURLAPPED TREE PLANTING



US Forest Service, Northeastern Area

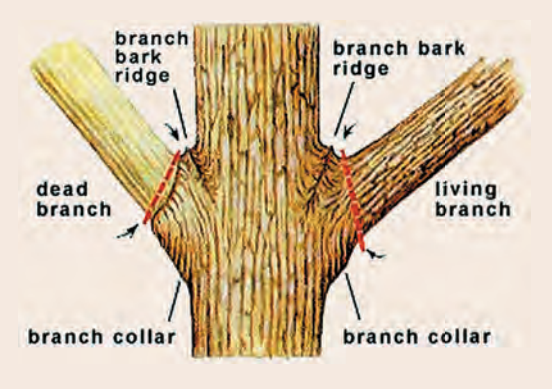
limited, spacing can be increased to as much as 15-feet x 15-feet) and protected from deer damage with fencing, tree shelters, flexible tree guards, or rigid stakes. Fencing and tree shelters prevent deer from browsing leaves and buds. The tree wraps and stakes minimize damage to the bark and cambium layer of young trees caused by antler rubbing. The wraps should cover the trunk from 1–5 feet 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 feet tall (above ground level).

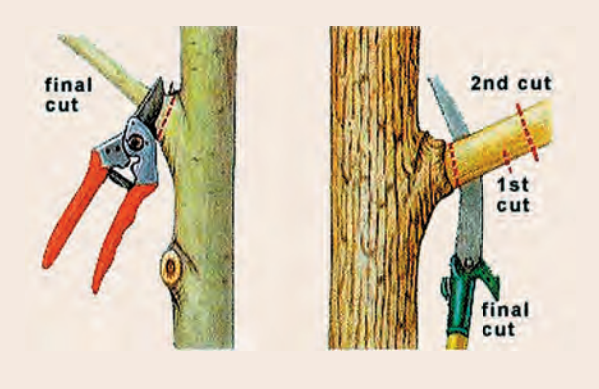
- The planting hole should be 2–3 times as wide as the diameter of the root ball or spread of roots, but not deeper than the root ball. As necessary, mound soil in the hole so that the top of the plant's root ball will be at or slightly above ground level.
- All burlap, twine, and wire should be removed from at least the upper half of the ball and laid flat in the hole or cut away completely after the plant has been set in place. It is essential to completely remove all synthetic string and fabric from around the root ball (natural fiber burlap will decompose in time).
- Backfill with soil and lightly tamp soil surface.
- If space permits, temporarily mound soil into a collar 4–5 inches high surrounding the perimeter of the root ball to help retain water until the tree is established.



NDSU Extension Service, North Dakota State University

- If planting on a slope, mound the soil downslope to level the ground above the root ball and help keep runoff from washing soil away.
- Watering at the time of planting is recommended, especially if the plant is not dormant or planted during warm or dry weather. If water is easily accessible, water all plants at the time of planting to help remove air pockets from backfilled soil. Ideally, the planting hole should be backfilled ¾ full with soil, watered well, filled the rest of the way with soil after the water has been absorbed, rewatered, and tamped lightly. Monitor the plantings for at least the first summer, watering them if conditions become dry. A little maintenance goes a long way. If available, put a layer of mulch 2–3 inches thick over the planting area, but no closer than 2 inches from planted trees' trunks.
- Stakes and flexible ties should not be used unless the tree is planted with a loose root ball or later found to be displaced. If they are required, use one or two hardwood stakes, no less than 2 inches x 2 inches across, driven into the ground outside the root ball. The stakes should be tall enough to provide the firm support necessary for proper root development, but not too tall to permit the tree to flex in the wind. The stakes should all be the same height for uniform support. All stakes and ties should be removed from the tree after one year.
- Heavy equipment should be used only in extreme situations, for instance, when large trees are transplanted using a tractor-mounted tree spade. If it is necessary to use heavy equipment in a planted area, protect trees and shrubs by staying as far away as possible (at least outside the drip line) to prevent soil compaction and trunk scarring.
- Mow or hand-trim as necessary within the drip line to maintain any herbaceous vegetation at a height no greater than 6 inches until areas are permanently reestablished with new plantings. If trees are planted in fields covered by sod (old pasture, meadow), it is best to kill the grass in the planting area before planting trees. This is especially important for small seedlings which have difficulty competing with sod grasses for water and nutrients. If spraying is needed after planting, tree shelters can protect seedlings from herbicides.





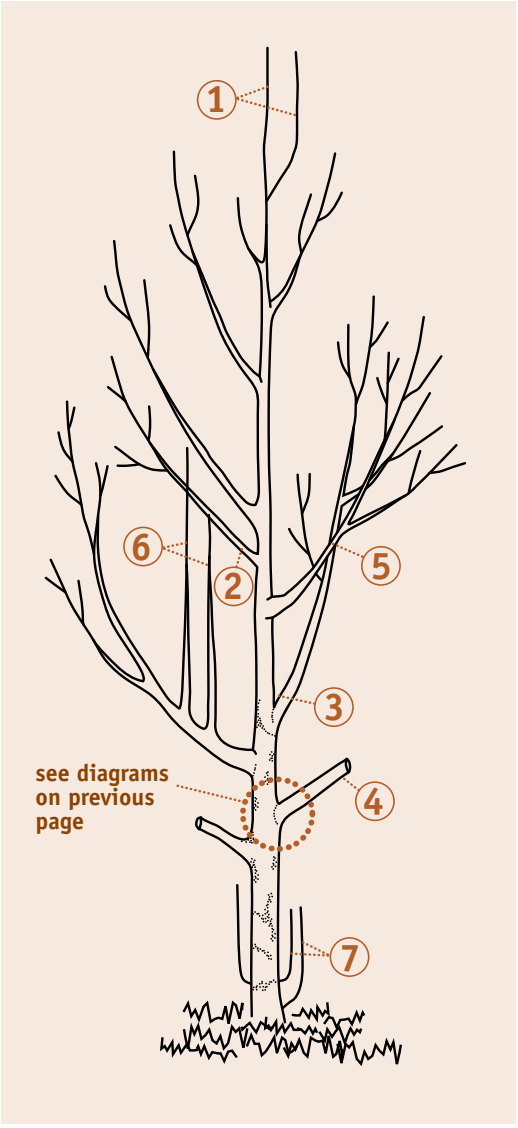
US Forest Service, Northeastern Area (both)

PRUNING TREES

- Although it may occur in conjunction with the removal of invasive plants or other undesired vegetation, pruning within forests should be minimized and selective.
- Branches that pose a safety hazard should be pruned.
- No cleats should be used in climbing healthy trees.
- All cuts should be made close to the trunk or parent limb without cutting into the branch collar (*see below far left*).
- Avoid slitting or peeling the bark by precutting all branches that are too heavy to handle (*see below left*).
- Cuts and wounds should not be treated with wound dressing.
- Any girdling roots at the base of a tree's trunk that are visible at or above the ground surface should be severed.
- Any pruned limbs or related debris should be spread thinly on the ground to be left to rot, used to create brush piles for wildlife habitat, or fly-chipped on-site.
- Heavy equipment should be used only in extreme situations, for instance, when a crane is necessary to safely remove a large limb (or the entire tree). If it is necessary to use heavy equipment, protect trees and shrubs by staying as far away as possible (at least outside the drip line) to prevent soil compaction and trunk scarring.

What to Look For

1. Forked top. If left as is, this will cause the development of two leaders, thus wasting growth energy. Later, as the two leaders get larger, the fork may split and damage the tree.
2. Parallel branch.
3. Branch growing at a sharp angle. When such a branch becomes larger, it may rub on the trunk, split out, or even cause rot to develop by giving water a chance to collect.
4. Temporary branch.
5. Crossing branches. These interfere with each other's growth and create bad form.
6. Water sprouts.
7. Basal sprouting from the root crown. This drains energy from the tree.



Native Plant Materials

Nearly 1,600 vascular plant species are known to be native to the greater southeastern Pennsylvania region (the roughly 15 counties that lie south and east of Blue Mountain or Kittatinny Ridge). They include almost 1,350 herbaceous species (wildflowers, grasses, sedges, rushes, ferns), 133 shrubs, 102 trees, and 19 woody vines. Here we suggest a relatively small fraction of those species for use in natural land restoration and landscaping. For natural land restoration we highlight 134 wildflowers; 48 grasses, sedges, and rushes; 19 ferns; 68 shrubs; 62 trees; and 2 woody vines in tables on pages 173–190. A shorter list of plants that provide wildlife benefits and horticultural values can be found on pages 191–198. All species were selected for their ability to thrive under a range of environmental conditions and for their commercial availability (see sources of native plants on page 198), mainly from nurseries and seed suppliers who specialize in plants that are native to southeastern Pennsylvania and immediately adjacent areas of Pennsylvania, New Jersey, Delaware, and Maryland. Don't be discouraged if the availability of some of these plants is limited. Your interest will encourage nurseries to increase their supply.

The plants we recommend for restoration projects are sorted into three major habitat categories: ***forest***, ***shrubland***, and ***meadow***. Within each major category are separate lists of trees, shrubs, and herbaceous species, and each of those groups is further broken down into height classes, based on the maximum height that each species could attain under ideal growing conditions. Maximum height is particularly important in meadow plantings. Most native meadow species have low tolerance of shade and require full sun for at least a part of every day to survive. If species of markedly different heights are planted together, the shorter species are likely to fail due to shade suppression. In any given patch of meadow, the mix of species planted from seeds or plugs should range across no more than two consecutive size categories (the overall planting can be a mosaic of patches of different heights).

All of the shrub and herbaceous species listed under "Native Forest Plants" have intermediate to high tolerance of shade. The list of upper canopy trees includes a mixture of species with low, intermediate, and high shade tolerance, but all native upper canopy tree species—including those that are highly shade tolerant—should be planted where they will get at least some full sun every day. (Subcanopy trees species generally are more tolerant of shading, but will also benefit from some direct sun exposure while they become established; a few have low shade tolerance and thrive best in savannas or open woodlands, including pitch pine, Virginia pine, black jack oak, post oak, sassafras, and black willow.) Seedlings and saplings of even

the most shade tolerant tree species tend to grow extremely slowly or not at all in deep shade. Shade tolerance does not allow young trees of upper canopy species to grow to full size in the shade; it merely enables them to survive many years in a suppressed state until adult trees in the canopy above them die. The natural course of forest canopy renewal takes place when old trees fall or die, opening up a canopy gap that admits enough sunshine to fuel a growth spurt of the advance regeneration (established seedlings and saplings), which soon fill the gap. If the gap is large enough to provide sufficient sunlight, it often becomes a race to fill the gap between shade tolerant tree species, which are already established and have a head start but have slower maximum growth rates, and shade intolerant tree species, which must start from seed but generally grow much more rapidly. Owners or managers of natural lands can choose the winners in this race by judicious weeding and by planting tree seedlings or saplings of upper canopy species far enough apart that none will shade or otherwise interfere with each other's growth.

FOREST TREES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
*maximum height: 70–140 feet or more (**upper canopy**)*		
Acer rubrum	red maple	dry to wet
Acer saccharinum	silver maple	moist to wet
Acer saccharum	sugar maple	dry to moist
Betula lenta	sweet birch, black birch	dry to moist
Betula nigra	river birch	moist
Carya cordiformis	bitternut hickory	moist
Carya laciniosa	shellbark hickory	moist to wet
Carya ovata	shagbark hickory	dry to moist
Carya tomentosa	mockernut hickory	dry to moist
Celtis occidentalis	common hackberry	dry to moist
Fagus grandifolia	American beech	moist
Fraxinus americana	white ash	moist
Fraxinus pennsylvanica	red ash, green ash	moist to wet
Gleditsia triacanthos	honeylocust	moist
Juglans nigra	walnut	moist
Liquidambar styraciflua	sweetgum	moist to wet
Liriodendron tulipifera	tuliptree	moist
Nyssa sylvatica	blackgum, sourgum, tupelo	dry to wet
Pinus echinata	shortleaf pine	dry

FOREST TREES, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
*maximum height: 70–140 feet or more (**upper canopy**)*		
Pinus strobus	white pine	dry to wet
Platanus occidentalis	American sycamore	moist to wet
Prunus serotina	black cherry	moist
Quercus alba	white oak	dry to moist
Quercus bicolor	swamp white oak	moist to wet
Quercus coccinea	scarlet oak	dry to moist
Quercus falcata	southern red oak	dry to moist
Quercus montana [=*Quercus prinus*]	chestnut oak	dry
Quercus palustris	pin oak	moist to wet
Quercus phellos	willow oak	moist to wet
Quercus rubra	northern red oak	dry to moist
Quercus velutina	black oak	dry to moist
Tilia americana	basswood	moist
Tsuga canadensis	eastern hemlock	moist
Ulmus americana	American elm	moist to wet
Ulmus rubra	slippery elm	moist to wet
*maximum height: 30–65 feet (**subcanopy**)*		
Amelanchier arborea	shadbush, serviceberry, juneberry	dry to moist
Amelanchier laevis	shadbush, serviceberry, juneberry	dry to moist
Aralia spinosa	devil's walking-stick, Hercules'-club	moist
Asimina triloba	pawpaw	moist
Carpinus caroliniana	American hornbeam, musclewood	moist
Cercis canadensis	redbud	rich
Cornus florida	flowering dogwood	moist
Diospyros virginiana	persimmon	dry to moist
Ilex opaca	American holly	moist
Juglans cinerea	butternut	moist
Magnolia virginiana	sweetbay magnolia	moist to wet
Malus coronaria	sweet crabapple	dry to moist
Morus rubra	red mulberry	moist

FOREST TREES, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
*maximum height: 30–65 feet (**subcanopy**)*		
Ostrya virginiana	hop-hornbeam	dry to moist
Pinus rigida	pitch pine	dry
Pinus virginiana	Virginia pine	dry
Quercus marilandica	blackjack oak	dry
Quercus stellata	post oak	dry
Salix nigra	black willow	wet
Sassafras albidum	sassafras	dry to moist
Viburnum lentago	nannyberry	moist

FOREST SHRUBS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 20–25 feet		
Alnus serrulata	smooth alder	wet
Amelanchier canadensis	shadbush, juneberry, serviceberry	moist
Cornus alternifolia	alternate-leaved dogwood	moist
Euonymus atropurpureus	wahoo	moist to wet
Prunus americana	wild plum	moist
Prunus virginiana	choke cherry	dry to moist
Viburnum prunifolium	black-haw	wet
maximum height: 10–15 feet		
Cephalanthus occidentalis	buttonbush	wet
Clethra alnifolia	sweet pepperbush	wet
Cornus amomum	silky dogwood	wet
Cornus racemosa	gray dogwood	wet
Cornus rugosa	round-leaved dogwood	dry
Corylus americana	American filbert	dry to moist
Corylus cornuta	beaked hazelnut	dry to moist
Hamamelis virginiana	witch-hazel	dry to moist
Ilex verticillata	winterberry, black-alder	wet

FOREST SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 10–15 feet		
Kalmia latifolia	mountain-laurel	dry to moist
Lindera benzoin	spicebush	moist
Photinia melanocarpa [=*Aronia melanocarpa*]	black chokeberry	dry to wet
Photinia pyrifolia [=*Aronia pyrifolia*]	red chokeberry	moist to wet
Physocarpus opulifolius	ninebark	moist to wet
Rhododendron arborescens	smooth azalea	moist
Rhododendron maximum	rosebay rhododendron	moist to wet
Rhododendron periclymenoides	pinxter-flower	dry to moist
Rhododendron viscosum	swamp azalea	wet
Salix discolor	pussy willow	moist to wet
Sambucus canadensis	American elder	moist to wet
Sambucus racemosa	red-berried elder	moist
Staphylea trifolia	bladdernut	dry to moist
Vaccinium corymbosum	highbush blueberry	dry to wet
Viburnum cassinoides	witherod	moist to wet
Viburnum dentatum	southern arrow-wood	wet
Viburnum recognitum	northern arrow-wood	wet
Viburnum trilobum	highbush-cranberry	wet
maximum height: 5–7 feet		
Amelanchier stolonifera	low juneberry, low shadbush	dry to moist
Dirca palustris	leatherwood	dry to moist
Euonymus americanus	hearts-a-bursting	moist
Gaylussacia frondosa	dangleberry	dry to wet
Hydrangea arborescens	sevenbark, wild hydrangea	dry to moist
Ribes americanum	wild black currant	moist to wet
Rosa palustris	swamp rose	wet
Rubus idaeus	red raspberry	dry to moist
Rubus occidentalis	black-cap, black raspberry	dry to moist
Spiraea alba	meadow-sweet	moist to wet

FOREST SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 5–7 feet		
Spiraea latifolia	meadow-sweet	moist to wet
Taxus canadensis	American yew	moist
Vaccinium stamineum	deerberry	dry
Viburnum acerifolium	maple-leaved viburnum	moist
maximum height: 2–4 feet		
Diervilla lonicera	bush-honeysuckle	dry
Gaylussacia baccata	black huckleberry	dry to wet
Spiraea tomentosa	hardback, steeple-bush	moist to wet
Vaccinium angustifolium	low sweet blueberry	dry to moist
Vaccinium pallidum	lowbush blueberry	dry to moist

FOREST VINES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
Lonicera sempervirens	trumpet honeysuckle	moist
Parthenocissus quinquefolia	Virginia-creeper	moist

FOREST PERENNIAL WILDFLOWERS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet)*		
Actaea racemosa [=*Cimicifuga racemosa*]	black cohosh	dry to moist
Aralia racemosa	spikenard	moist
Polygonatum biflorum	Solomon's-seal	dry to moist
maximum height: ***intermediate*** *(3½–5 feet)*		
Arisaema triphyllum	jack-in-the-pulpit	moist
Eurybia divaricata [=*Aster divaricatus*]	white wood aster	dry to moist

FOREST PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Eurybia macrophylla [=*Aster macrophyllus*]	bigleaf aster	dry to moist
Eurybia schreberi [=*Aster schreberi*]	Schreber's aster	dry to moist
Maianthemum racemosum [=*Smilacina racemosa*]	false Solomon's-seal, Solomon's plume	dry to moist
Medeola virginiana	Indian cucumber-root	moist
Polygonatum pubescens	Solomon's-seal	dry to moist
Sanicula odorata	yellow-flowered sanicle, fragrant snakeroot	moist
Solidago caesia	bluestem goldenrod	dry to moist
Solidago flexicaulis	zigzag goldenrod	moist
Symphyotrichum cordifolium [=*Aster cordifolius*]	blue wood aster	dry to moist
Triosteum aurantiacum	wild-coffee	moist
maximum height: ***short*** *(1½–3 feet)*		
Actaea pachypoda	doll's-eyes	dry to moist
Allium tricoccum	ramps, wild leek	dry to moist
Aquilegia canadensis	wild columbine	dry to moist
Aralia nudicaulis	wild sarsaparilla	dry to moist
Aristolochia serpentaria	Virginia snakeroot	dry to moist
Caulophyllum thalictroides	blue cohosh	dry to moist
Dicentra eximia	wild bleeding-heart	dry to moist
Geranium maculatum	wild geranium	dry to moist
Hybanthus concolor	green-violet	moist
Hydrophyllum canadense	Canadian waterleaf	moist
Hydrophyllum virginianum	Virginia waterleaf	moist
Lysimachia quadrifolia	whorled loosestrife	dry
Mertensia virginica	Virginia bluebells	moist
Oclemena acuminata	wood aster	moist
Osmorhiza claytonii	sweet-cicely	moist
Osmorhiza longistylis	anise-root	moist

FOREST PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***short*** *(1½–3 feet)*		
Phlox divaricata ssp. *divaricata*	eastern wild blue phlox	dry to moist
Podophyllum peltatum	mayapple	moist
Polemonium reptans	spreading Jacob's-ladder	moist
Scutellaria serrata	showy skullcap	moist
Thalictrum dioicum	early meadow-rue	moist
Trillium cernuum	nodding trillium	moist
Trillium erectum	purple trillium, wakerobin	moist
Trillium flexipes	declined trillium	moist to wet
Trillium grandiflorum	large-flowered trillium	moist
Uvularia perfoliata	bellwort	moist
Uvularia sessilifolia	bellwort	moist
Zizia aptera	golden-alexander	moist
Zizia aurea	golden-alexander	moist
maximum height: ***very short*** *(up to 1 foot)*		
Asarum canadense	wild ginger	moist
Hydrastis canadensis	goldenseal	moist
Iris cristata	dwarf crested iris	dry to moist
Jeffersonia diphylla	twinleaf	dry to moist
Maianthemum canadense	Canada mayflower	moist
Mitchella repens	partridge-berry	moist
Sanguinaria canadensis	bloodroot	dry to moist
Thalictrum thalictroides	rue anemone	dry to moist
Tiarella cordifolia	foamflower	moist

FOREST GRASSES, SEDGES, AND RUSHES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet)*		
Scirpus cyperinus	wool-grass	wet
maximum height: ***intermediate*** *(3½–5 feet)*		
Carex crinita	fringed sedge, short-hair sedge	wet
Carex folliculata	northern long sedge	wet
Carex gynandra	nodding sedge	wet
Carex lurida	lurid sedge, shallow sedge	wet
Carex scoparia	broom sedge	moist to wet
Carex stipata	stalk-grain sedge, owlfruit sedge	wet
Carex tribuloides	blunt broom sedge, bristlebract sedge	wet
Chasmanthium latifolium	Indian wood-oats	moist
Elymus hystrix	bottlebrush-grass	moist
Glyceria canadensis	rattlesnake mannagrass	wet
Glyceria melicaria	slender mannagrass	wet
Glyceria striata	fowl mannagrass	wet
Leersia virginica	whitegrass	moist to wet
maximum height: ***short*** *(1½–3 feet)*		
Carex intumescens	greater bladder sedge	wet
Carex pensylvanica	Pennsylvania sedge	dry to moist
Carex plantaginea	plaintain sedge	dry to moist
Carex platyphylla	broad-leaf sedge	dry to moist
Carex vulpinoidea	fox sedge, brown fox sedge	wet
Cyperus esculentus	yellow nutsedge	moist to wet
Juncus tenuis	path rush	dry to moist

FOREST FERNS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Athyrium filix-femina	lady fern	moist
Dennstaedtia punctilobula	hay-scented fern	moist
Deparia acrostichoides	silvery glade fern	moist
Diplazium pycnocarpon	narrow-leaved glade fern	moist
Dryopteris goldiana	Goldie's wood fern	moist
Dryopteris marginalis	marginal wood fern	moist
Matteuccia struthiopteris	ostrich fern	moist to wet
Onoclea sensibilis	sensitive fern	wet
Osmunda cinnamomea	cinnamon fern	wet
Osmunda claytoniana	interrupted fern	moist to wet
Osmunda regalis	royal fern	wet
maximum height: ***short*** *(1½–3 feet)*		
Adiantum pedatum	northern maidenhair fern	dry to moist
Asplenium platyneuron	ebony spleenwort	dry to moist
Dryopteris carthusiana	spinulose wood fern	moist to wet
Dryopteris intermedia	evergreen wood fern	moist
Polystichum acrostichoides	Christmas fern	dry to moist
Thelypteris noveboracensis	New York fern	moist to wet
Woodwardia areolata	netted chain fern	moist to wet

SHRUBLAND TREES AND SHRUBS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 30–40 feet		
Aralia spinosa	devil's walking-stick, Hercules'-club	moist
Asimina triloba	pawpaw	moist
Betula populifolia	gray birch	dry
Cercis canadensis	redbud	dry to moist
Chionanthus virginicus	fringetree	moist
Cornus florida	flowering dogwood	moist
Juniperus virginiana	eastern red-cedar	dry to moist
Malus coronaria	sweet crabapple	dry to moist
Pinus pungens	Table Mountain pine	dry
Quercus marilandica	blackjack oak	dry
Rhus typhina	staghorn sumac	dry
Salix bebbiana	long-beaked willow, gray willow	dry to moist
Viburnum lentago	nannyberry	moist
maximum height: 20–25 feet		
Alnus serrulata	smooth alder	wet
Amelanchier canadensis	shadbush, juneberry	moist
Cornus alternifolia	alternate-leaved dogwood	moist
Euonymus atropurpureus	wahoo	moist to wet
Prunus americana	wild plum	moist
Prunus virgininana	choke cherry	dry to moist
Rhus copallina	winged sumac, shining sumac	dry
Salix eriocephala	heart-leaf willow	moist to wet
Salix exigua	sandbar willow	wet
Salix lucida	shining willow	wet
Viburnum prunifolium	black-haw	wet
maximum height: 10–15 feet		
Celtis tenuifolia	*dwarf hackberry, Georgia hackberry*	*dry*
Cephalanthus occidentalis	*buttonbush*	*wet*
Clethra alnifolia	*sweet pepperbush*	*wet*
Cornus amomum	*silky dogwood*	*wet*

SHRUBLAND TREES AND SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 10–15 feet		
Cornus racemosa	gray dogwood	moist to wet
Cornus rugosa	round-leaved dogwood	dry
Corylus americana	American filbert	moist
Corylus cornuta	beaked hazelnut	dry
Hamamelis virginiana	witch-hazel	moist
Ilex verticillata	winterberry, black-alder	wet
Kalmia latifolia	mountain-laurel	dry to moist
Lindera benzoin	spicebush	moist
Photinia melanocarpa [=*Aronia melanocarpa*]	black chokeberry	dry to wet
Photinia pyrifolia [=*Aronia pyrifolia*]	red chokeberry	moist to wet
Physocarpus opulifolius	ninebark	moist to wet
Quercus ilicifolia	scrub oak, bear oak	dry
Quercus prinoides	dwarf chestnut oak, dwarf chinkapin oak	dry
Rhododendron maximum	rosebay rhododendron	moist to wet
Rhododendron viscosum	swamp azalea	wet
Rhus glabra	smooth sumac	dry
Salix discolor	pussy willow	moist to wet
Salix humilis	upland willow, sage willow	dry to moist
Salix sericea	silky willow	wet
Sambucus canadensis	American elder	moist to wet
Sambucus racemosa	red-berried elder	moist
Staphylea trifolia	bladdernut	dry to moist
Vaccinium corymbosum	highbush blueberry	dry to wet
Viburnum cassinoides	witherod	moist to wet
Viburnum dentatum	southern arrow-wood	wet
Viburnum recognitum	northern arrow-wood	wet
Viburnum trilobum	highbush-cranberry	wet

SHRUBLAND TREES AND SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 5–7 feet		
Amelanchier stolonifera	low juneberry, low shadbush	dry to moist
Comptonia peregrina	sweet-fern	dry
Dirca palustris	leatherwood	dry to moist
Euonymus americanus	hearts-a-bursting	moist
Gaylussacia frondosa	dangleberry	dry to wet
Hydrangea arborescens	sevenbark, wild hydrangea	dry to moist
Myrica pensylvanica	bayberry	dry to moist
Ribes americanum	wild black currant	moist to wet
Rosa palustris	swamp rose	wet
Rosa virginiana	wild rose, pasture rose	moist
Rubus idaeus	red raspberry	dry to moist
Rubus occidentalis	black-cap, black raspberry	dry to moist
Spiraea alba	meadow-sweet	moist to wet
Spiraea latifolia	meadow-sweet	moist to wet
Taxus canadensis	American yew	moist
Vaccinium stamineum	deerberry	dry
Viburnum acerifolium	maple-leaved viburnum	dry to moist
maximum height: 2–4 feet		
Diervilla lonicera	bush-honeysuckle	dry
Gaylussacia baccata	black huckleberry	dry to wet
Rosa carolina	pasture rose	dry
Spiraea tomentosa	hardback, steeple-bush	moist to wet
Vaccinium angustifolium	low sweet blueberry	dry
Vaccinium pallidum	lowbush blueberry	dry

MEADOW PERENNIAL WILDFLOWERS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***very tall*** *(9–10 or more feet)*		
Coreopsis tripteris	tall tickseed	moist to wet
Eutrochium fistulosum [=*Eupatorium fistulosum*]	hollow-stemmed joe-pye-weed, trumpetweed	moist to wet
Helianthus giganteus	swamp sunflower	wet
Rudbeckia laciniata	cutleaf coneflower	wet
maximum height: ***tall*** *(6–8 feet)*		
Angelica atropurpurea	purple-stemmed angelica	moist to wet
Apocynum cannabinum	Indian-hemp	moist to wet
Asclepias incarnata	swamp milkweed	wet
Asclepias syriaca	common milkweed	moist to wet
Baptisia australis	blue false-indigo	moist to wet
Boltonia asteroides	aster-like boltonia	moist to wet
Eupatorium perfoliatum	common boneset	wet
Eutrochium purpureum [=*Eupatorium purpureum*]	joe-pye-weed, sweet-scented joe-pye-weed	dry to wet
Filipendula rubra	queen-of-the-prairie	moist
Helenium autumnale	common sneezeweed	moist to wet
Helianthus divaricatus	rough sunflower, woodland sunflower	dry
Heliopsis helianthoides	ox-eye	dry to wet
Hypericum pyramidatum [=*H. ascyron*]	great St. John's-wort	moist to wet
Lespedeza capitata	round-headed lespedeza	dry
Liatris spicata	dense blazing-star	moist
Lilium canadense	Canada lily	moist to wet
Lilium superbum	Turk's-cap lily	moist to wet
Lobelia cardinalis	cardinal-flower	wet
Lobelia siphilitica	great blue lobelia	moist to wet
Mimulus ringens	Allegheny monkey-flower	wet
Oenothera biennis	common evening-primrose	dry to moist
Penstemon digitalis	tall white beard-tongue	dry to moist
Polygonatum biflorum	smooth Solomon's-seal	dry to moist

MEADOW PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet)*		
Rudbeckia triloba	three-lobed coneflower	dry to moist
Senna hebecarpa	northern wild senna	dry to moist
Senna marilandica	southern wild senna	dry
Solidago canadensis	Canada goldenrod	dry to moist
Solidago gigantea	smooth goldenrod	moist to wet
Solidago rigida [=*Oligoneuron rigidum*]	stiff goldenrod	moist
Solidago rugosa	wrinkle-leaf goldenrod	dry to wet
Solidago speciosa	showy goldenrod	dry to moist
Symphyotrichum lanceolatum [=*Aster lanceolatus, A. paniculatus, A. simplex*]	panicled aster	dry to wet
Symphyotrichum novae-angliae [=*Aster novae-angliae*]	New England aster	dry to moist
Symphyotrichum novi-belgii [=*Aster longifolius*]	New York aster	moist to wet
Symphyotrichum pilosum [=*Aster ericoides var. pilosus, A. pilosus*]	heath aster	dry to moist
Verbena hastata	blue vervain, simpler's-joy	moist to wet
Verbesina alternifolia	wingstem	moist
Vernonia glauca	Appalachian ironweed, tawny ironweed	dry
Vernonia noveboracensis	New York ironweed	moist to wet
Veronicastrum virginicum	Culver's-root	moist
maximum height: ***intermediate*** *(3½–5 feet)*		
Asclepias purpurascens	purple milkweed	dry to moist
Eupatorium hyssopifolium	hyssop-leaved thoroughwort	dry
Gentiana andrewsii	bottle gentian, prairie closed gentian	moist to wet
Gentiana clausa	meadow closed gentian, bottle gentian	moist
Geum laciniatum	herb-bennet, rough avens	wet
Hypericum punctatum [=*H. maculatum*]	spotted St. John's-wort	moist

MEADOW PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Ludwigia alternifolia	seedbox, false loosestrife	wet
Monarda fistulosa	horsemint, wild bergamot	dry to moist
Monarda punctata	spotted bee-balm	dry
Physostegia virginiana	false dragonhead	moist
Pycnanthemum virginianum	Virginia mountain-mint	moist to wet
Rudbeckia fulgida	eastern coneflower	moist
Rudbeckia hirta	black-eyed-susan	dry to moist
Scutellaria incana	downy skullcap	dry to moist
Solidago bicolor	silver-rod, white goldenrod	dry
Solidago juncea	early goldenrod	dry to moist
Solidago nemoralis	gray goldenrod	dry
Symphyotrichum laeve [=*Aster laevis var. laevis*]	smooth blue aster	dry
Vicia americana	purple vetch	moist
maximum height: ***short*** *(1½–3 feet)*		
Allium cernuum	nodding onion	dry
Asclepias tuberosa	butterfly-weed	dry
Asclepias verticillata	whorled milkweed	dry
Chrysopsis mariana	golden aster	dry
Conoclinium coelestinum [=*Eupatorium coelestinum*]	mistflower, wild ageratum	dry to moist
Dodecatheon meadia	shooting-star, pride-of-Ohio	dry to moist
Geranium maculatum	wood geranium	moist
Iris prismatica	slender blue flag	moist
Juncus tenuis	path rush	dry to moist
Lupinus perennis	blue lupine	dry to moist
Oenothera fruticosa	sundrops, narrow-leaved evening-primrose	dry to moist
Packera aurea [=*Senecio aureus*]	golden ragwort	moist
Penstemon hirsutus	northeastern beard-tongue	dry
Phlox maculata	wild sweet-william	moist to wet

MEADOW PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***short*** *(1½–3 feet)*		
Phlox pilosa	downy phlox, prairie phlox	moist to wet
Pycnanthemum tenuifolium	narrow-leaved mountain-mint	moist
Sisyrinchium angustifolium	narrow-leaved blue-eyed-grass	moist to wet
Tradescantia ohiensis	Ohio spiderwort, blue-jacket	moist
Tradescantia virginiana	spiderwort, widow's-tears, Virginia spiderwort	dry to moist
Zizia aptera	golden-alexander	moist
Zizia aurea	golden-alexander, golden zizia	moist to wet

MEADOW PERENNIAL COOL-SEASON GRASSES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Calamagrostis canadensis	Canada bluejoint	wet
Deschampsia cespitosa	tufted hairgrass	moist to wet
Deschampsia flexuosa	wavy hairgrass, common hairgrass	dry
Dichanthelium clandestinum [=*Panicum clandestinum*]	deer-tongue, deer-tongue grass	moist
Elymus canadensis	Canada wild-rye	moist
Elymus riparius	riverbank wild-rye	moist to wet
Elymus virginicus	Virginia wild-rye	moist to wet
Leersia oryzoides	rice cutgrass	wet
Poa palustris	fowl bluegrass	wet
maximum height: ***short*** *(1½–3 feet)*		
Danthonia compressa	northern oatgrass	dry
Danthonia spicata	poverty grass, poverty oatgrass	dry
Hordeum jubatum [=*Critesion jubatum*]	foxtail-barley	dry

MEADOW PERENNIAL WARM-SEASON GRASSES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***very tall*** *(9–10 feet or more)*		
Andropogon gerardii	big bluestem, turkeyfoot	dry to moist
Tripsacum dactyloides	gammagrass	wet
maximum height: ***tall*** *(6–8 feet or more)*		
Andropogon glomeratus	bushy bluestem, bushy broomsedge	moist to wet
Andropogon virginicus	broomsedge, Virginia broomsedge	dry
Panicum virgatum	switchgrass	dry to moist
Sorghastrum nutans	Indian-grass	dry to moist
Spartina pectinata	prairie cordgrass, freshwater cordgrass	moist to wet
Tridens flavus	purpletop	dry to moist
maximum height: ***intermediate*** *(3½–5 feet)*		
Bouteloua curtipendula	side-oats grama, tall grama	dry
Muhlenbergia capillaris	hairgrass, short muhly	dry
Schizachyrium scoparium	little bluestem	dry to moist
Sporobolus cryptandrus	sand dropseed	dry
Sporobolus heterolepis	prairie dropseed	dry
maximum height: ***short*** *(1½–3 feet)*		
Andropogon gyrans	Elliott's beardgrass	dry to moist
Eragrostis spectabilis	purple lovegrass, tumblegrass	dry

MEADOW SEDGES AND RUSHES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet or more)*		
Scirpus cyperinus	wool-grass	wet
maximum height: ***intermediate*** *(3½–5 feet)*		
Carex lurida	lurid sedge, shallow sedge	wet
Carex scoparia	broom sedge	moist to wet
Carex stipata	stalk-grain sedge, owlfruit sedge	wet
Carex tribuloides	blunt broom sedge, bristlebract sedge	wet
maximum height: ***short*** *(1½–3 feet)*		
Carex intumescens	greater bladder sedge	wet
Carex vulpinoidea	fox sedge, brown fox sedge	wet
Cyperus esculentus	yellow nutsedge	moist to wet
Juncus tenuis	path rush	dry to moist

MEADOW FERNS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Dennstaedtia punctilobula	hay-scented fern	dry to wet
Onoclea sensibilis	sensitive fern	wet
Pteridium aquilinum	northern bracken fern	dry

NATIVE TREES AND SHRUBS FOR LANDSCAPING AND WILDLIFE

Large Trees

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Acer rubrum	red maple	Piedmont Coastal Plain	Height: 40'–60', Spread: same Habit is pyramidal in youth and rounded with age. Tolerant of most soils, but prefers slightly acid, moist conditions. Naturally occurs in wet area. Excellent fall color.	Buds, flowers, and leaves provide food for many birds and mammals. Chipmunks and squirrels eat seeds and some songbirds use twigs for nest building.
Acer saccharinum	silver maple	Piedmont Coastal Plain	Height: 50'–70', Spread: 40'–50' Has strong spreading branches which form a rounded crown. Tolerant of many soil types. One of the best trees for poor soils and wet conditions (often found on floodplains). Use of this tree should be limited to areas free of buildings and heavy human use as it is prone to internal decay and subsequent loss of branches. Provides fast shade.	See red maple.
Acer saccharum	sugar maple	Piedmont Coastal Plain	Height: 60'–70', Spread: 40'–50' Upright oval to rounded habit. Prefers moist, well drained soils. Tolerates some shade.	See red maple.
Betula nigra	river birch	Piedmont Coastal Plain	Height: 40'–70', Spread: 40'–60' Pyramidal in youth and rounded with age. Often grown multistemmed. Best adapted to moist soils (often found on floodplains). Used in areas that are alternately wet and dry.	Catkins are used by redpolls and pine siskins. Foliage is used by browsers.
Betula lenta	sweet birch	Piedmont Coastal Plain	Height: 40'–55'+, Spread: 35'–45' Pyramidal in youth, forming an irregular, rounded, sometimes wide-spreading crown at maturity. Best in deep, rich, moist, slightly acid soils, however, often found on rocky, drier sites. Flowers are catkins, 2"–3" long. Yellow leaves in fall are best among birches.	See river birch.

Large Trees, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Carya ovata	shagbark hickory	Piedmont Coastal Plain	Height: 60'–80', Spread: 40'–60' Straight trunk with an oblong crown. Bark breaks up in thin plates. Difficult to transplant, start as seedling. Good for woodland border.	Leaves are used by browsers. Nuts are also consumed by deer, turkey, foxes, wood ducks, and squirrels.
Celtis occidentalis	common hackberry	Piedmont Coastal Plain	Height: 40'–60', Spread: same In youth weakly pyramidal; in old age the crown is a broad top of ascending-arching branches. Medium to fast growth. Prefers rich, moist soils, but grows in dry, heavy, or sandy, rocky soils; withstands acid or alkaline conditions; moderately wet or very dry areas; tolerates wind; full sun. Fruit is fleshy, orange to dark purple, ripening in September to October. Leaves are yellow to yellow-green in fall. Useful tree for adverse growing conditions.	Fruit is popular with winter birds, especially cedar waxwing, mockingbird, and robin.
Fagus grandifolia	American beech	Piedmont Coastal Plain	Height: 50'–70'+, Spread: same Often has short trunk with wide-spreading crown. Likes moist, well drained soils. Can grow well in full sun or shade.	Beechnuts are eaten by birds and mammals and are important food for chipmunks and squirrels.
Fraxinus americana	white ash	Piedmont Coastal Plain	Height: 50'–80', Spread: same Pyramidal in youth and later developing an open rounded crown. Grows best on deep, well drained soils and full sun.	Moderate importance to wildlife. Seeds eaten by wood ducks, finches, and cardinals.
Fraxinus pennsylvanica	red ash	Piedmont Coastal Plain	Height: 50'–60'+, Spread: 25'–30' Pyramidal in youth, developing upright, spreading habit at maturity. Grows quickly in full sun and in a wide range of soil conditions. Naturally found on moist bottomlands	See white ash.
Gleditsia triacanthos	common honeylocust	Piedmont Coastal Plain	Height: 30'–70', Spread: same Usually has short trunk with open, oval crown. Fast grower. Withstands a wide range of conditions but prefers rich, moist bottomlands (often found on floodplains).	Limited wildlife value.

Large Trees, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Juglans nigra	black walnut	Piedmont Coastal Plain	Height: 50'–75', Spread; same Well-formed trunk with an oval crown. Prefers rich, moist soils. Often found on bottomlands. Difficult to transplant; should be started as seedling. Produces toxins which are poisonous to many plants giving it an advantage in open field situations but creating problems for gardeners.	Nuts are eaten by woodpeckers, foxes, and squirrels.
Juniperus virginiana	eastern redcedar	Piedmont Coastal Plain	Height: 40'–50', Spread: 8'–20' Densely pyramidal when young and slightly pendulous in old age. Medium rate of growth. Tolerant of adverse conditions. Prefers deep, moist soils. Will tolerate shade only in youth. Handsome reddish brown bark. Produces small fleshy blue cones. Useful for windbreaks, shelter belts, hedges.	Twigs and foliage eaten by browsers. Seeds are eaten most extensively by cedar waxwings. Evergreen foliage provides nesting and roosting cover for sparrows, robins, mockingbirds, juncos, and warblers.
Liquidambar styraciflua	American sweetgum	Coastal Plain	Height: 60'–75'+, Spread: 40'–50' Pyramidal in youth, rounded crown at maturity. Likes deep, moist, acid soils. Occurs naturally on bottomlands.	Goldfinches and purple finches eat winged seeds.
Liriodendron tulipifera	tuliptree	Piedmont Coastal Plain	Height: 70'–90', Spread: 30'–50' Long, straight trunk with a narrow canopy. Fast grower. Plant in full sun and a well drained loam. Wood somewhat weak.	Moderate wildlife importance. The purple finch and cardinal are principal users.
Nyssa sylvatica	black gum	Piedmont Coastal Plain	Height: 30'–50', Spread: 20'–30' Pyramidal in youth and irregularly crowned at maturity. Prefers moist, well drained, acid soils. Full sun or semi-shade. Deep taproot.	Fruit is relished by many songbirds. Users include wood ducks, robins, woodpeckers, thrashers, flickers, and mockingbirds.

Large Trees, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Pinus strobus	eastern white pine	Piedmont Coastal Plain	Height: 50'–80'+, Spread: 20'–40'+ Pyramidal in youth, crown at maturity has several horizontal and ascending branches. Fast grower. Grows best on fertile, well drained soils but is very adaptable.	Provides valuable cover and nesting sites for songbirds and mammals. Needles are used as nesting material. Seeds are eaten by quail, chickadees, grosbeaks, nuthatches, and woodpeckers.
Quercus alba	white oak	Piedmont Coastal Plain	Height: 100', Spread: 50'–80' Pyramidal in youth, becoming broad and rounded with wide spreading branches. Transplant as small tree. Prefers moist, well drained soils. Difficult to obtain from nurseries. Sometimes available as seedling.	Oaks, in general, are of major importance to wildlife. Acorns are at the top of the food preference list for wood ducks, pheasants, grackles, jays, nuthatches, thrushes, woodpeckers, rabbits, foxes, squirrels, and deer.
Quercus palustris	pin oak	Piedmont Coastal Plain	Height: 60'–70', Spread: 25'–40' Strongly pyramidal with ascending branches. One of the faster growing oaks. Full sun. Found naturally in wet soils but is adaptable to many soil types.	See white oak.
Quercus rubra	red oak	Piedmont Coastal Plain	Height: 60'–75'+, Spread: 40'–50' Habit is round-topped and symmetrical. Full sun. Prefers loamy, well drained soils. Fast growing.	See white oak.
Tilia americana	American linden	Piedmont Coastal Plain	Height: 60'–80', Spread: 35'–50' Pyramidal in youth, assuming a rounded shape with age. Full sun or part shade. Prefers deep, moist soils, but is tolerant of heavier soils.	Limited wildlife value.
Tsuga canadensis	eastern hemlock	Piedmont Coastal Plain	Height: 40'–70', Spread: 25'–35' Pyramidal in youth becoming more pendulous with age. Likes moist, well drained soils. Plant in sheltered area. Tolerates shade. Relatively fast growing. Excellent for screens, hedges.	Provides excellent cover for deer and songbirds. Nesting site for several warblers. Seeds are eaten by juncos, chickadees, and siskins.

Small Trees/Large Shrubs

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Amelanchier arborea/laevis	shadbush or shadblow serviceberry	Piedmont Coastal Plain	Height: 6'–20', Spread: 10' Erect stems, often clumped. Blends well on the forest edge.	Important berry producer during the early summer months. Fruit eaten by crows, bluebirds, cardinals, and tanagers. Foliage used by browsers.
Cercis canadensis	eastern redbud	Piedmont	Height: 20'–30', Spread: 25'–35' Small tree with rounded crown. Likes moist, well drained soils. Found naturally only on limestone or diabase soils in Pennsylvania. Full sun to light shade.	Limited wildlife value.
Chionanthus virginicus	white fringetree	Coastal Plain	Height: 12'–20', Spread: same Open habit, often wider than high. Prefers moist, fertile soils and full sun.	Limited wildlife value.
Cornus florida	flowering dogwood	Piedmont Coastal Plain	Height: 20', Spread: 15'–20' Small tree with flat-topped crown. Place in well drained soil. Full sun to partial shade. Has character in all four seasons.	Fruit is an important source for songbirds including evening grosbeak, cardinals, robins and cedar waxwings.
Hamamelis virginiana	common witchhazel	Piedmont Coastal Plain	Height: 20'–30', Spread: 20'–25' Small tree or multi-stemmed shrub. Prefers moist soils in full sun or partial shade.	Limited wildlife value.
Ilex opaca	American holly	Coastal Plain	Height: 15'–30', Spread: 18'–25' Dense, pyramidal in youth, opening up with age. Plant in moist, well drained soil. Full sun or partial shade. Use one male for every three females.	Used extensively by many songbirds including thrushes, mockingbirds, catbirds, bluebirds, and thrashers. Foliage provides cover for songbirds and mammals.
Magnolia virginiana	sweetbay magnolia	Coastal Plain	Height: 10'–20', Spread: same Multi-stemmed, open shrub. Likes wet, acid soils. Tolerates shade.	Wildlife value is low. Seeds are eaten by some mammals and birds. Foliage is used by several birds for nest building.

Small Trees/Large Shrubs, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Viburnum lentago	nannyberry	Piedmont Coastal Plain	Height: 15'–18', Spread: 6'–10' Shrub or small tree with open habit. Adapts to a wide range of soil conditions. Sun or partial shade.	Used by grouse, brown thrasher, cedar waxwing, squirrels, and deer.
Viburnum prunifolium	blackhaw virburnum	Piedmont Coastal Plain	Height: 12'–15', Spread: 8'–12' Round-headed tree or multi-stemmed shrub. Adaptable to many soil types. Sun or shade.	See nannyberry.

Shrubs

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Aronia arbutifolia	red chokeberry	Piedmont Coastal Plain	Height: 6'–10', Spread: 3'–5' Upright multi-stemmed shrub, somewhat open and rounded. Adaptable to many soil types. Full sun to half shade.	Fruit eaten by grouse, chickadees, and other songbirds.
Aronia melanocarpa	black chokeberry	Piedmont Coastal Plain	See red chokeberry.	See red chokeberry.
Clethra alnifolia	summersweet clethra	Coastal Plain	Height: 3'–8', Spread: 4'–6' Oval, round-topped, erect, dense, leafy shrub. Transplant into moist organic soils. Full sun or shade. Good plant for wet areas and heavy shade.	Limited wildlife value.
Cornus racemosa	silky dogwood	Piedmont Coastal Plain	Height: 10'–15', Spread: 10'–15' Erect, multi-stemmed shrub with short spreading branches. Suckers profusely and forms large colonies. Very adaptable, withstanding wet or dry soils, but prefers moist, well drained conditions. Full sun or shade.	High wildlife value for fruit and browse. Used by a wide variety of mammals and songbirds, including cardinals, evening grosbeaks, robins, thrush, vireos, and cedar waxwings.
Ilex glabra	inkberry	Coastal Plain	Height: 6'–8', Spread 8'–10' Upright, multi-branched, rounded shrub. Prefers moist, acid soils.	Berries used by a wide variety of wildlife.

Shrubs, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Ilex verticillata	winterberry	Piedmont Coastal Plain	Height: 6'–10', Spread: same Oval, rounded, deciduous shrub holly. Tends to form multi-stemmed clumps. Does well in light and heavy soils. Prefers moist, organic soils. Red fruit is beautiful in winter. A male plant is necessary for fertilization.	Used extensively by many songbirds, particularly thrushes, mockingbirds, robins, bluebirds, and thrashers.
Itea virginica	Virginia sweetspire	Coastal Plain	Height: 3'–5', Spread: 6'–8' Erect shrub with clustered branches. Prefers moist, fertile soils. Full sun or shade. Suited for wet areas. Excellent fall color.	Fruit capsules are used by some songbirds.
Kalmia latifolia	mountain laurel	Piedmont Coastal Plain	Height: 7'–15', Spread: same Large, robust shrub, becomes open with age. Requires moist, well drained soils in full sun or shade.	Mammals eat foliage and twigs. Utilized extensively by mammals and birds for winter shelter.
Myrica pensylvanica	northern bayberry	Coastal Plain	Height: 5'–12', Spread: same Tends to sucker to form large colonies. Deciduous to semi-evergreen. Upright, rounded, dense shrub. Adaptable to many soil conditions, including poor soils. Full sun to partial shade.	Fruit is eaten by a variety of birds in small quantities including tree swallows and myrtle warblers.
Rhododendron maximum	rosebay rhododendron	Piedmont Coastal Plain	Height: 4'–10', Spread: same Rounded, evergreen shrub. Plant in moist, well drained soil. Prefers partial shade.	Limited wildlife value except as browse for deer and winter cover for songbirds.
Rhododendron periclymenoides	pinxter-flower	Piedmont Coastal Plain	Height: 4'–6', Spread: 6'–8' Multi-stemmed, stoloniferous shrub. Adapted to dry, sandy, rocky soils. Useful for naturalizing.	Limited wildlife value except as browse for deer and grouse

Shrubs, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Vaccinium corymbosum	highbush blueberry	Piedmont Coastal Plain	Height: 6'–12', Spread: 8'–12' Upright, multi-stemmed shrub with spreading branches. Requires moist, well drained soils. Full sun or light shade.	Used heavily by grouse, scarlet tanager, bluebirds, thrushes, and other songbirds.
Viburnum acerifolium	maple-leaved viburnum	Piedmont Coastal Plain	Height: 4'–6', Spread: 3'–4' Low, sparsely branched shrub. Adaptable to dry soils. Extremely shade tolerant.	Twigs are eaten by deer and rabbits. Fruit is used by grouse.
Viburnum dentatum	southern arrow-wood	Piedmont Coastal Plain	Height: 6'–8', Spread: 6'–15' Multi-stemmed, dense, rounded shrub. Adaptable to most soil conditions, but prefers well drained. Suckers freely.	Used by grouse, brown thrasher, cedar waxwing, squirrels, and deer.

SOURCES

Nurseries Specializing in Native Plants

David Brothers Bean Road Nursery
P.O. Box 123
Whitehall and Bean Roads
Worcester, PA 19490
610-584-1550

Edge of the Woods Native Plant Nursery
2415 Route 100
Orefield, PA 18069
610-395-2570
www.edgeofthewoodsnursery.com

Natural Landscapes
354 North Jennersville Road
West Grove, PA 19380
610-869-3788

North Creek Nurseries, Inc.
388 North Creek Road
Landenberg, PA 19350
877-ECO-PLUG
www.northcreeknurseries.com

Octoraro Farm and Gardens
698 Lees Bridge Road
Nottingham, PA 19362
610-932-0225
www.octorarofarm.com

Octoraro Native Plant Nursery
6126 Street Road
Kirkwood, PA 17536
717-529-3160
www.octoraro.com

Pinelands Nursery
323 Island Road
Columbus, NJ 08022
609-291-9486
www.pinelandsnursery.com

Redbud Native Plant Nursery
1214 N. Middletown Road
Glen Mills, PA 19342
610-358-4300
www.redbudnativeplantnursery.com

Sylva Native Nursery and Seed Company
3815 Roser Road
Glen Rock, PA 17327
717-227-0486
www.sylvanative.com

Temple University/Ambler Nursery
580 Meetinghouse Road
Ambler, PA 19002-3994
215-283-1330
(Wholesale only)

Yellow Springs Farm
1165 Yellow Springs Road
Chester Springs, PA 19425
610-827-2014
www.yellowspringsfarm.com

Other Nurseries That Carry Native Plants

Buddies Nursery
P.O. Box 14
Birdsboro, PA 19508
610-582-2410

Moon Nurseries
P.O. Box 672
145 Moon Road
Chesapeake City, MD 21915
800-803-TREE
www.moonnurseries.com

Musser Forests
1880 Route 119 North
Indiana, PA 15701
800-643-8319
www.musserforests.com
(Seedlings only)

New Moon Nursery
13 Ways Lane
Kennett Square, PA 19348
888-998-1951
www.newmoonnursery.com

Princeton Nurseries
P.O. Box 185
Allentown, NJ 08501
800-916-1776
www.princetonnurseries.com

Shemin Nurseries
P.O. Box 649
100 Green Tree Road
Oaks, PA 19456
610-666-0595
www.sheminnurseries.com
(Wholesale only)

Wildflower Sources

Brandywine Conservancy
Box 141
Chadds Ford, PA 19317
610-388-2700

Ernst Conservation Seeds
9006 Mercer Pike
Meadville, PA 16335
800-873-3321
www.ernstseed.com

Prairie Nursery
P.O. Box 306
Westfield, WI 53964
800-476-9453
www.prairienursery.com

Sandy Wilson
Native Plants and Aquatic Nursery
834 Church Road
Harleysville, PA 19438
610-584-6302

Additional Sources for General Lists

Guide to Pennsylvania Nursery Stock
Pennsylvania Nurserymen's Association, Inc.
1924 North Second Street
Harrisburg, PA 17102

New England Wild Flower Society, Inc.
Garden in the Woods
180 Hemenway Road
Framingham, MA 01701
508-877-7630

Information Sources

Manual for Woody Landscape Plants
Michael Dirr
Stipes Publishing Company, 1990

American Wildlife and Plants: A Guide to Wildlife Food Habits
Alexander C. Martin, et. al.
Dover Publications, 1951

The Plants of Pennsylvania, An Illustrated Manual, 2nd Edition
Ann F. Rhoads and Timothy A. Block
University of Pennsylvania Press, 2007

Glossary

Acidic – Describes soil or water with a pH lower than 5.5.

Advance regeneration – Young trees in the forest ground and tall shrub/sapling layers, some of which will grow up into the forest canopy when a disturbance opens a gap in the existing canopy. Where white-tailed deer are extremely abundant, advance regeneration is often absent, or, if present, only the fraction that is above 6 feet in height (tall saplings) has a significant chance of one day reaching canopy height.

Afforestation – The establishment of forest trees by planting or seeding in an area not currently or recently forested. (Compare *reforestation*.)

Anaerobic – Describes processes that occur in the absence of molecular oxygen.

Annual – Describes an herbaceous plant that lives its entire life cycle, from seed germination to producing its own seeds, in one growing season and then dies. (Compare *biennial, perennial*.)

Barrens – Woodland, shrubland, grassland, or savanna communities on upland (mesic to xeric) sites where tree establishment or growth is suppressed by environmental conditions and the disturbance regime. Most often associated with thin or rapidly draining soils.

Baseflow – The water that percolates to the groundwater and reaches the stream slowly over long periods of time. Because it sustains streamflow during rainless periods it is also called dry-weather flow.

Bedrock – The solid rock that is exposed at the surface or underlies the soil or other unconsolidated material at the surface.

Best management practices (BMPs) – The current, most generally accepted way to perform a given management task. Examples include: how to establish a native meadow; how to plant a tree; how to harvest timber near water resources; how to manage stormwater.

Biennial – Describes an herbaceous plant that lives its entire life cycle in two growing seasons, germinating and establishing in the first year, then resprouting, flowering, fruiting and dying in the second year. (Compare *annual, perennial*.)

Biocide – A poisonous chemical substance that can kill living organisms, especially microorganisms.

Biodiversity – Biological diversity; the variety of plants, animals, fungi, bacteria, and other organisms, the communities they form, and the ecological functions they perform at the genetic, individual, patch or stand, landscape, and regional levels.

Biomass – The collective mass of living organisms and their residues (dead leaves, branches, logs, animal carcasses, excrement, etc.) in an ecosystem.

Blowdown – Tree that has fallen down across a trail.

Calcareous – Describes soil, groundwater, or surface water with high calcium concentrations, often derived from limestone, dolomite, marble, or calcium-rich glacial deposits.

Canopy – The upper level of a forest, consisting of branches and leaves of taller trees. A canopy would be complete (or has 100% cover) if the ground were completely hidden when viewed from above the canopy during the growing season.

Cavity tree – A tree with cavities in which birds, mammals, or insects such as bees may nest (also called a den tree).

Clearcutting – A harvesting and regeneration technique that removes all of the trees, regardless of size, on an area in one operation. Clearcutting is most often used with species like aspen or black cherry, which require full sunlight to reproduce and grow well, or to create specific habitat for certain wildlife species. Clearcutting produces an even-aged stand.

Codominant – Describes a species with relatively high abundance or percent cover in a community that is not overwhelmingly dominated by a single species; two or more species providing roughly equal cover, abundance, or influence in a community or stratum.

Community – An assemblage of populations of plants, animals, fungi, bacteria, and other organisms sharing a common environment and interacting with each other and with the physical environment.

Conifer, coniferous – Any of a large group of cone-bearing trees and shrubs, mostly evergreens such as pines, spruces, firs, cedars, and yews. Most of these species do not lose their leaves (needles) at the end of the growing season but retain them through the year (exceptions include tamarack and bald-cypress). Foresters often call them softwoods.

Conservation – The wise use and management of natural resources.

Conservation easement – A legally binding agreement between a landowner and a qualified conservation organization, such as a land trust, or government agency, such as a township, which ensures that the conditions of the easement are met over time. The easement permanently limits a property's use and binds all present and future owners of the land. The property remains in private ownership and does not need to be opened to the public. Tax benefits may apply to the donor.

Cover – The percentage of the ground surface that is covered or shaded by the leaves or stems of a plant species or a group of plant species during the growing season.

Cover type – General category of vegetation or human use used to classify the earth's surface (land and water); examples from this *Handbook* include forests, hedgerows, shrublands, meadows/grasslands, pasture/cropland, wetlands, streambanks/riparian areas, ponds, and lawns/landscaped areas.

Crown – The upper leaves and branches of a tree or shrub. Also, the swollen area of a shrub's trunk at or just below the ground surface from which the roots extend downward and the stem or stems extend upward.

Deciduous – Senescence of all leaves at the end of the growing season, leaves dropping before or during winter, and sprouting new leaves the following spring.

Deed restriction – A written stipulation contained within a deed that restricts certain future uses of the property, generally inserted at the time of transfer. A deed restriction may include restrictions similar to those contained within a conservation easement. However, enforcement may only be carried out by the prior owner or other parties to the transaction and the restrictions may be cancelled at any time by mutual written agreement.

Denitrification – The process by which nitrate in water or sediments is converted to nitrogen gas, which is then lost to the atmosphere.

Detritus – Organic material composed of dead plants and animals, or parts thereof (leaves, branches, grass clippings) that fall to the ground or settle to the bottom of a water body. Bacteria and fungi slowly decompose detritus, thus recycling nutrients and stored energy back into the soil or water body's ecosystem.

Dominant – A species with the greatest abundance, percent cover, or influence in a community or stratum.

Dormant – Resting, or non-growth, phase.

Ecology – Scientific study of interactions among living organisms and between organisms and their environment, and how those interactions determine the distribution and abundance of organisms.

Ecosystem – A natural unit comprising living organisms, their environment, and all of the interactions and their consequences, including the circulation, transformation, and accumulation of energy and matter.

Edge – The boundary between open land and woodland or between any two distinct ecological communities. Also, the zone roughly 100 meters (305 feet) wide on either side of the boundary. This transition area between environments provides valuable wildlife habitat for some species, but can be problematic for sensitive species, due to increased predation and parasitism. (See *interior species*.)

Emergent – Describes upright, rooted vegetation that may be temporarily to permanently flooded at the base, with the upper portions of the plant growing erect above the water surface; emergent plant species do not tolerate prolonged inundation of the entire plant.

Endangered species – Species in danger of extinction throughout all or a significant part of its range. Can be either on a federal or state list. Federally listed species are protected by the United States Endangered Species Act, 1973. Pennsylvania species of special concern are part of the environmental review in the permitting process for land development or disturbance.

Eutrophication – The process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a lake or reservoir, often resulting in proliferation of algae and submerged plants and conversion of water from clear to cloudy. If the process is accelerated by human influences, it is termed cultural eutrophication.

Evapotranspiration – The water transfer from the soil to the atmosphere by direct evaporation and by transpiration from the surfaces of plants.

Even-aged stand – A group of trees that do not differ in age by more than 10 to 20 years or by 20% of the rotation age; often a result of clearcutting or farmland abandonment. Young, even-aged stands are typically low in species and structural diversity due to crowding of canopy trees and lack of canopy gaps, resulting in dense shade at the forest floor.

Exclosure – An area fenced to exclude white-tailed deer.

Exotic – Refers to species not native to Pennsylvania, or to the area in which they occur; synonymous with non-native.

Fauna – The animals of a specified region or time.

Floodplain – The flat to nearly flat lowland adjacent to a river or lake subject to at least intermittent flooding. Floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain is covered, on average, once every 10 years and the 100-year floodplain, on average, once every 100 years.

Flora – The plants of a specified region or time.

Forb – A broad-leaved (not grass-like or sedge-like) herbaceous plant. (See *herb, herbaceous*.)

Forest – An area dominated by trees where the majority of tree crowns are overlapping, typically with between 60% and 100% leaf cover. (Compare *woodland*.)

Fragmentation – The segmentation of a large tract or contiguous tracts of forest into smaller patches, often isolated from each other by nonforest habitat. Fragmentation results from the collective impact of residential and commercial development, highway and utility construction, and other piecemeal land use changes.

Goods and services – In natural lands, this term refers to the products and functions that site features (soil, water resources) and native plant communities provide to human and wildlife populations. These include clean water and air, food, recreational opportunities, income-generating products (lumber, edible and medicinal plants), and beautiful viewsheds. Also called ecosystem services.

Grassland – Open area dominated by grass species, usually with an admixture of forbs and low shrubs. A grassland with scattered trees is often called a savanna.

Ground layer – The herbs, tree seedlings, small shrubs, and creeping vines within about 3 feet of the ground surface in a forest; or the lowest layer of vegetation in an open-canopy community.

Groundwater – Water underground in openings in rock strata and soils. (See *water table*.)

Growing space – The major resources and conditions—light, water, inorganic nutrients, temperature, humidity, soil structure, and other factors—that support plant growth in a given area.

Habitat – The geographically defined area where environmental conditions (e.g., climate, topography, etc.) meet the life needs (e.g., food, shelter, etc.) of an organism, population, or community.

Hardwoods – Trees that have broad leaves, produce a fruit (e.g., berry, drupe, winged samara, dry capsule, acorn, nut), and generally lose their leaves in the winter (a few hardwoods are evergreen, such as American holly). (Compare *softwoods*.)

Hazard tree – A tree with compromised structural integrity located near a "target," that is, an area of human use or a structure. A hazard tree has the potential to fall—in part or in whole—and injure people or damage property.

Herb, herbaceous plant – Plant with no woody stem above the ground that persists through the winter, as distinguished from trees, shrubs, and woody vines. (See *annual, biennial, perennial*.)

Herbaceous layer – The layer of vegetation in a forest or shrubland in which herbs are common or dominant, more accurately called the ground layer where it includes tree seedlings, low shrubs, and creeping vines.

Herbicide – Any chemical substance used to kill plants, especially weeds, or to check their growth.

Herbivore – Any animal that eats mainly plant leaves, twigs, shoots, or roots (e.g., white-tailed deer, most butterfly and moth larvae).

Hydric – Describes soils that are periodically wet and that support the growth of wetland vegetation. Wetlands are most often recognized and delineated by the presence of wetland-indicator plant species, but hydric soils have distinctive characteristics that make them a reliable indicator of wetlands even in the absence of visible vegetation, for instance, in herb-dominated communities in winter. (Compare *mesic, xeric*.)

Hydrology – The study or description of the way water is distributed in the landscape, moves over the ground surface and underground; includes precipitation, evaporation, transpiration, and flow.

Hydrophyte, hydrophytic – Describes any plant adapted to growing in water or on a substrate that is at least periodically deficient in oxygen as a r esult of water saturation.

Interior forest – A forested area at least 100 meters (305 feet) from the edge of any contrasting cover type.

Interior grassland or meadow – An area dominated by herbaceous plant species (with no trees or just a few sparsely scattered trees) at least 100 meters (305 feet) from a hedgerow or the edge of any contrasting cover type.

Intermittent – Refers to small streams that do not flow continuously throughout the year.

Invasive plants, invasives – Non-native plants that have the ability to usurp growing space from established native vegetation. Typically, they seed prolifically, grow fast, spread rapidly and aggressively, and lack the diseases, herbivores, or predators that keep their populations in check in their places of origin. Only a small minority—less than 5%—of the non-native plant species that have escaped to the wild in Pennsylvania have become invasive.

Litter – The uppermost layer of the forest floor consisting chiefly of decaying organic matter that still has recognizable fragments; it lies on top of the humus layer.

Marsh – A wetland dominated by herbaceous vegetation and usually having little or no peat accumulation.

Mast – All fruits of trees and shrubs used as food by wildlife. Hard mast includes nuts and nutlike fruits such as acorns, beechnuts, hickory nuts, walnuts, and chestnuts. Soft mast includes the fleshy fruits of black cherry, dogwoods, serviceberries, blackgum, and sassafras.

Meadow – Open area dominated by grass, sedge, and forb species.

Mesic – Describes soils with intermediate moisture content; moist but well drained. (Compare *hydric, xeric*.)

Mineral soil – Soil with little or no organic matter content; in undisturbed soils, describes the soil layers beneath the litter and humus layers and above solid bedrock.

Native – Describes species that occurred in Pennsylvania (or in the area in which they are found) prior to European settlement; not introduced by human activities. Synonymous with indigenous. (Compare *exotic*.)

Natural regeneration – The replacement of one forest stand by another through natural seeding or sprouting.

Non-point-source pollution – Consists primarily of polluted stormwater runoff from urbanized areas and agricultural fields, in contrast to point-source pollution, which is discharged from pipes at industrial facilities or sewage treatment plants.

Old growth – Forests that approximate the structure, composition, and functions of native forests prior to European settlement. They vary by forest type, but generally include more large trees, variation in tree size, vertical structure (layers), standing snags, canopy gaps, native species, and dead organic matter than do young, even-aged, or intensively managed forests. (See *even-aged stand, virgin forest*.)

Open area – An area dominated by shrubs or herbaceous plants and not by trees; may have scattered trees up to 25% canopy cover. (See *barrens, grassland, meadow, savanna, shrubland*.)

Outslope – The grade from the upslope edge of the treadway to the downslope edge. Trails, especially sidehill trails, should have an outslope of 3% to allow for proper sheet drainage.

Overseeding – The process of adding additional seed to an already established grassland or meadow either by broadcasting the seed or using a no-till drill to insert the seed into the ground.

Overstory – Trees in the upper level, or canopy, of the forest.

Palustrine – Describes wetlands; areas intermediate between aquatic and terrestrial habitats, supporting predominantly hydrophytic vegetation, where conditions are at least periodically wet enough during the growing season to produce anaerobic soil conditions and thereby influence plant growth.

Parent material – The underlying type of bedrock or unconsolidated material (e.g., sand and gravel deposited by rivers or glaciers or along ancient coastlines) from which a soil type is derived.

Patch – A small area of a particular ecological community surrounded by distinctly different ecological communities, such as a forest stand surrounded by agricultural lands, a small opening surrounded by forest, or an area dominated by forbs surrounded by grassland. (See *stand*.)

Perennial – A plant that persists and produces reproductive structures year after year; refers to streams and wetlands that contain water at or near the surface throughout the year. (Compare *annual, biennial*.)

Pioneer species – Species adapted to colonize and persist in open areas following major disturbances such as fire, flooding, or wind. They typically have light, wind-blown, long-lived seeds, and, once established, have a rapid growth rate.

Plug – A plant grown in a small (1–2 inches square) container that can be transplanted into a desired location.

Point-source pollution – Contaminated water discharged from pipes at industrial facilities or sewage treatment plants, in contrast to non-point-source pollution, which consists primarily of polluted stormwater runoff from urbanized areas and agricultural fields.

Preservation – A management philosophy or goal that seeks to protect indigenous ecosystem structure, function, and integrity from human impacts. Management activities are generally excluded from "preserved" lands.

Prime agricultural soils – Soils that are deep, well-drained, and moderately sloped that can support high yields of crops with little management.

Puncheon – Also known as a bog bridge. A simple bridge constructed of two base logs (or sills) set perpendicular to the trail and two stringers, parallel to the trail and spiked to the top of the base logs.

Rare species – Species that exist only in one or a few restricted geographical areas or habitats or occur in low numbers over a relatively broad area.

Recruitment – The addition of new individuals to a population.

Reforestation – The reestablishment of forest cover by natural or artificial means on areas recently supporting forest cover. (Compare *afforestation*.)

Regeneration – The replacement of one forest stand by another as a result of natural seeding, sprouting, planting, or other methods; also young trees in the forest ground layer, some of which will grow up into the forest canopy when a disturbance opens a gap in the existing canopy.

Riparian zone – An area adjoining a body of water, normally having soils and vegetation characteristic of floodplains or areas transitional to upland zones. These areas help protect the water by removing or buffering the effects of excessive nutrients, sediments, organic matter, pesticides, and pollutants.

Root graft – Physical union of the cambium, phloem, and xylem of two different roots. Root grafts are common and can occur between roots of the same tree, trees of the same species, or trees of different species. Water and nutrients, as well as toxic substances (herbicides) and pathogens (Dutch elm disease), can be transported through root grafts.

Sapling – A small tree, usually defined as being between 2–4 inches in diameter at breast height.

Savanna – Area dominated by herbaceous plants or shrubs with sparse, scattered trees between 10% and 25% canopy cover. (Compare *grassland, shrubland, woodland*.)

Seasonally wet – Areas with poorly drained soils or high water table that hold water during certain periods of the year, typically during the late winter and early spring.

Second growth – The forests reestablished following the removal of virgin (previously unharvested) or old growth stands. Most of Pennsylvania's forests are either second or third growth.

Seedling – A young tree originating from seed that is less than 4 feet tall and smaller than 2 inches in diameter at ground level; or a newly germinated plant of any kind originating from a seed.

Seep – A class of wetland created by a spring (emerging groundwater) on lower slopes forming small pools, usually covered and surrounded by vegetation. These create snow-free zones critical for wildlife feeding during winter.

Shade tolerance – The ability of a plant to grow under conditions of less than full sunlight. ***Shade tolerant***: having the ability to become established and survive in low light conditions for an extended period of time. ***Intermediate in shade tolerance***: able to become established under a forest canopy and persist for short periods if small, localized canopy openings, for instance, created by a fallen branch, provide sunlight for part of the day during the growing season. ***Shade intolerant***: requires full sun conditions to colonize a site and persist.

Shrubland – An area dominated by shrubs and small trees with less than 25% total cover by trees; herbaceous plants may be present. A shrubland with scattered trees totaling 10% to 25% cover is often called a shrub savanna.

Sidehill – Describes a trail, often literally cut out of the side of a hill, that gains elevation by moving up a slope, gradually following the contour.

Snag – A standing dead tree with few branches, or the standing portion of a broken-off tree. Snags may provide feeding and nesting sites for wildlife.

Softwoods – Conifers or cone-bearing trees, most of which are evergreen (a few softwoods are deciduous, including tamarack and bald-cypress). (Compare *hardwoods*.)

Species – The level of classification immediately subordinate to genus; reproductively isolated organisms that have common characteristics, such as eastern white pine or white-tailed deer. The scientific name of an organism consists of its genus and species names, sometimes followed by a subspecies or variety name.

Species richness – The number of species present in a community or a defined area.

Spring – Location of concentrated groundwater discharge.

Stand – A grouping of vegetation sufficiently uniform in species composition, age, and condition to be distinguished from surrounding vegetation types and managed as a single unit. (See *patch*.)

Stewardship – The wise management and use of natural resources to ensure their health and productivity for the future with regard for generations to come.

Stratum – A horizontal layer of vegetation. Forest strata consist of the ground layer (herbaceous plants, tree and shrub seedlings, small shrubs, and creeping vines), the tall-shrub and sapling layer, the subcanopy tree layer, and the canopy layer. (See *vertical structure, vegetation layers*.)

Stream order – A system of classification of perennial waterways according to their relationship to other streams. If a stream is seasonal or precipitation-dependent (an ephemeral or intermittent stream), it is not included in stream order. A perennially flowing stream whose only sources are upwellings of groundwater—that is, it is not fed by other streams—is a first-order stream. First-order streams join to form second-order streams. If two second-order streams join they form third-order streams, and so on, as the streams create a network of waterways.

Stress – An ongoing impact on an organism, population, community, or ecosystem (e.g., drought, browsing, competition for growing space) that does not cause immediate death or extirpation.

Structure – The spatial arrangement of vegetation layers within a community; also, the juxtaposition of patches of different species composition within a cover type. (See *patch, stratum, vertical structure*.)

Structural diversity – The number of different vegetation layers (canopy tree, subcanopy tree, tall shrub/sapling, ground) within a forest; also, the variety of patches of different species composition within a cover type. A structurally diverse forest provides habitat for the most wildlife species. This term can be used to characterize other plant communities, such as meadow or shrubland, for instance, a meadow with high structural diversity may be a patchwork of tall grasses and forbs, short grasses and forbs, and areas with sparse vegetation, with scattered tall shrubs and short shrubs and an occasional tree.

Succession – The natural series of replacement of one plant community (and the associated fauna and other organisms) by another over time and in the absence of disturbance.

Switchback – On a sidehill trail, a sharp turn in the opposite direction used to gain elevation.

Terrestrial – Describes uplands; where vegetated, supporting vegetation that is not predominantly hydrophytic.

Threatened species – A species likely to become endangered in the foreseeable future, throughout all or a significant portion of its range, unless protected.

Trailhead – Beginning of a trail or trail section, or an access point, sometimes with parking, information signs, etc.

Tread, treadway – That part of the trail that is walked upon; the footpath.

Turnpike – A low, linear, elevated earthen walkway across a flat wet area, with fill held in place by rock or log cribbing.

Understory – The vegetation beneath the tree canopy in a forest (herbaceous plants, low vines, shrubs, seedlings, saplings, small trees); collective term for the strata within the vertical zone between the canopy and the litter or soil surface of the forest floor. (See *stratum*.)

Uneven-aged stand – A group of trees of diverse ages and sizes growing together in a forested area.

Upland – An area with well-drained dry to mesic soils.

Vernal pool or pond – A small, shallow, temporary pool of water present in spring and fall, which typically does not support fish but is an important breeding ground for many species of amphibians. Some species, such as spring peepers, wood frogs, and mole salamanders, in many areas are totally dependent upon such ponds.

Vertical structure – The arrangement of plants in a given community from the ground layer (herbaceous plants, tree seedlings, low shrubs, and creeping vines), through the tall shrub-sapling and subcanopy layers into the main forest canopy; a complex vertical structure is characterized by lush undergrowth and successive layers of woody vegetation extending into the crowns of dominant and codominant trees. (See *stratum, structural diversity*.)

Virgin forest – A forest that has never been harvested or altered by humans. (See *old growth*.)

Water table – The uppermost level of groundwater. Where groundwater is within reach of plant roots, the level of the water table usually varies through the year, being highest just prior to the start of the growing season, and decreasing as plants transpire water. Plant roots will usually not grow below the water table due to insufficient oxygen.

Waterbar – Rock or log structure diagonally across the trail to divert water and mitigate erosion.

Watershed – A region or area defined by patterns of stream drainage. A watershed includes all the land from which a particular stream or river is supplied.

Wetland – An area that is either transitional between land and water (where the water table is at or near the land surface) or area of land covered by shallow water (such as a marsh, swamp, bog, or fen). These areas fulfill many essential roles in our landscapes by maintaining water quality, stabilizing shores and streambanks, controlling floods and erosion, and providing critical habitat to many plant and animal species.

Windthrow – The uprooting of trees by wind.

Woodland – An area dominated by trees, but having an open character with between 25% and 60% tree cover. (Compare *forest, savanna.*)

Xeric – Very dry; describes areas with dry, well drained to extremely well drained soils. (Compare *hydric, mesic.*)

Xerophyte – Describes any plant adapted to growing in xeric soils.

Resources

CONTACTS

	FOREST/TREE CARE	MEADOW	CROPLAND	WETLANDS	RIPARIAN	PONDS	STORMWATER	FINANCIAL ASSISTANCE
USDA Natural Resources Conservation Service (NRCS) www.nrcs.usda.gov Conservation Security Program (CSP) Environmental Quality Incentives Program (EQIP) Farm and Ranch Lands Protection Program (FRPP) Wetlands Reserve Program (WRP) Wildlife Habitat Incentives Program (WHIP) Agricultural Management Assistance (AMA) Conservation Reserve Program (CRP) Conservation Reserve Enhancement Program (CREP)								
Pennsylvania NRCS www.pa.nrcs.usda.gov/index.html *Bucks/Montgomery County* Perkasie Service Center Hilltown Executive Campus 1000 E. Walnut Street, Building 700 Perkasie, PA 18944 215-822-5840 *Chester/Delaware County* West Chester Service Center 601 Westtown Road West Chester, PA 19380-0990 610-696-0398	X	X	X	X	X	X	X	X

	FOREST/TREE CARE	MEADOW	CROPLAND	WETLANDS	RIPARIAN	PONDS	STORMWATER	FINANCIAL ASSISTANCE
US Fish and Wildlife Service Pennsylvania Field Office 315 South Allen Street State College, PA 16801-4850 814-234-4090 www.fws.gov/northeast	X	X			X	X		
US Forest Service www.fs.fed.us *Northern Research Station* 11 Campus Boulevard, Suite 200 Newtown Square, PA 19073 610-557-4017 *Publications Distribution* 359 Main Road Delaware, OH 43015 740-368-0120	X			X	X			X
PA DCNR, Bureau of Forestry 6th Floor, Rachel Carson State Office Building P.O. Box 8552 Harrisburg, PA 17105-8552 717-705-5194 www.dcnr.state.pa.us/forestry Valley Forge District Office *(Berks, Bucks, Chester, Delaware, Lancaster, Montgomery, Philadelphia counties)* 845 Park Road Elverson, PA 19520-9523 610-582-9660								
Pennsylvania Department of Conservation and Natural Resources (DCNR) 7th Floor, Rachel Carson State Office Building P.O. Box 8767 400 Market Street Harrisburg, PA 17105-8767 717-787-2869 www.dcnr.state.pa.us	X	X		X	X			X

	FOREST/TREE CARE	MEADOW	CROPLAND	WETLANDS	RIPARIAN	PONDS	STORMWATER	FINANCIAL ASSISTANCE
Pennsylvania Department of Environmental Protection (DEP) Southeast Regional Office 2 East Main Street Norristown, PA 19401 484-250-5900 www.depweb.state.pa.us/southeastro/site/default.asp				X	X	X	X	X
Pennsylvania Game Commission (PGC) Southeast Region *(Berks, Bucks, Chester, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Montgomery, Northampton, Philadelphia, Schuylkill, York counties)* 448 Snyder Road Reading, PA 19605 610-926-3136 Private Landowner Assistance Program	X	X	X	X	X	X		X
Penn State Cooperative Extension Southeast Region Penn State Berks-Lehigh Valley College Tulpehocken Road P.O. Box 7009 Reading, PA 19610-6009 610-378-4362 www.extension.psu.edu/seregion *Bucks County* Neshaminy Manor Center 1282 Almshouse Road Doylestown, PA 18901-2896 215-345-3283 *Chester County* 601 Westtown Road, Suite 370 West Chester, PA 19380-0990 610-696-3500 *Delaware County* 20 Paper Mill Road Springfield, PA 19064 610-690-2655 *... continued*			X			X		

	FOREST/TREE CARE	MEADOW	CROPLAND	WETLANDS	RIPARIAN	PONDS	STORMWATER	FINANCIAL ASSISTANCE
Penn State Cooperative Extension, continued *Montgomery County* 1015 Bridge Road, Suite H Collegeville, PA 19426-1179 610-489-4315			X			X		
Bucks County Conservation District 1456 Ferry Road, Suite 704 Doylestown, PA 18901 215-345-7577 www.bucksconservation.org **Chester County Conservation District** 601 Westtown Road, Suite 240 P.O. Box 2747 West Chester, PA 19380-0990 610-696-5126 www.chesco.org/conservation **Delaware County Conservation District** 1521 N. Providence Road Media, PA 19063 610-892-9484 http://delcocd.org **Montgomery County Conservation District** 143 Level Road Collegeville, PA 19426 610-489-4506 www.montgomeryconservation.org				X	X	X	X	
School of Forest Resources **Cooperative Extension Office** **The Pennsylvania State University** 7 Ferguson Building University Park, PA 16802-4302 814-863-0401 http://rnrext.cas.psu.edu	X							

	FOREST/TREE CARE	MEADOW	CROPLAND	WETLANDS	RIPARIAN	PONDS	STORMWATER	FINANCIAL ASSISTANCE
Association of Consulting Foresters of America, Inc. *(National Office)* 723 N. Washington Street, Suite 4-A Alexandria, VA 22314 703-548-0990 www.acf-foresters.com	X							
Hardwood Lumber Manufacturers' Association of Pennsylvania, Inc. 545 W. Chocolate Avenue Hershey, PA 17033 800-232-HLMA 717-312-1244 www.hlma.org	X							
International Society of Arboriculture 2101 West Park Court Champaign, IL 61821 888-472-8733 www.isa-arbor.com	X							
Morris Arboretum of the University of Pennsylvania 100 East Northwestern Avenue Philadelphia, PA 19118 215-247-5777 www.business-services.upenn.edu/arboretum	X							
The Nature Conservancy 4245 North Fairfax Drive, Suite 100 Arlington, VA 22203 703-841-5300 www.nature.org Pennsylvania Field Office 15 East Ridge Pike, Suite 500 Conshohocken, PA 19428 610-834-1323 pa_chapter@tnc.org	X	X		X				

	FOREST/TREE CARE	MEADOW	CROPLAND	WETLANDS	RIPARIAN	PONDS	STORMWATER	FINANCIAL ASSISTANCE
Pennsylvania Forestry Association 56 East Main Street Mechanicsburg, PA 17055 717-766-5371 http://pfa.cas.psu.edu	X							
Pennsylvania Horticultural Society 100 N. 20th Street, 5th Floor Philadelphia, PA 19103 215-988-8800 www.pennsylvaniahorticulturalsociety.org	X	X		X	X			X
Pennsylvania Tree Farm **(sponsored by the Pennsylvania Forestry Association)** Area 6 *(Berks, Bucks, Carbon, Chester, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Montgomery, Schuylkill counties)* 17 Weavers Road Pottsville, PA 17901 570-385-0172 http://patreefarm.cas.psu.edu	X			X	X	X	X	
Society of American Foresters 5400 Grosvenor Lane Bethesda, MD 20814-2198 301-897-8720 www.safnet.org	X				X			
Stroud Water Research Center 970 Spencer Road Avondale, PA 19311 610-268-2153 www.stroudcenter.org	X			X	X	X	X	

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Natural Lands Trust