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.

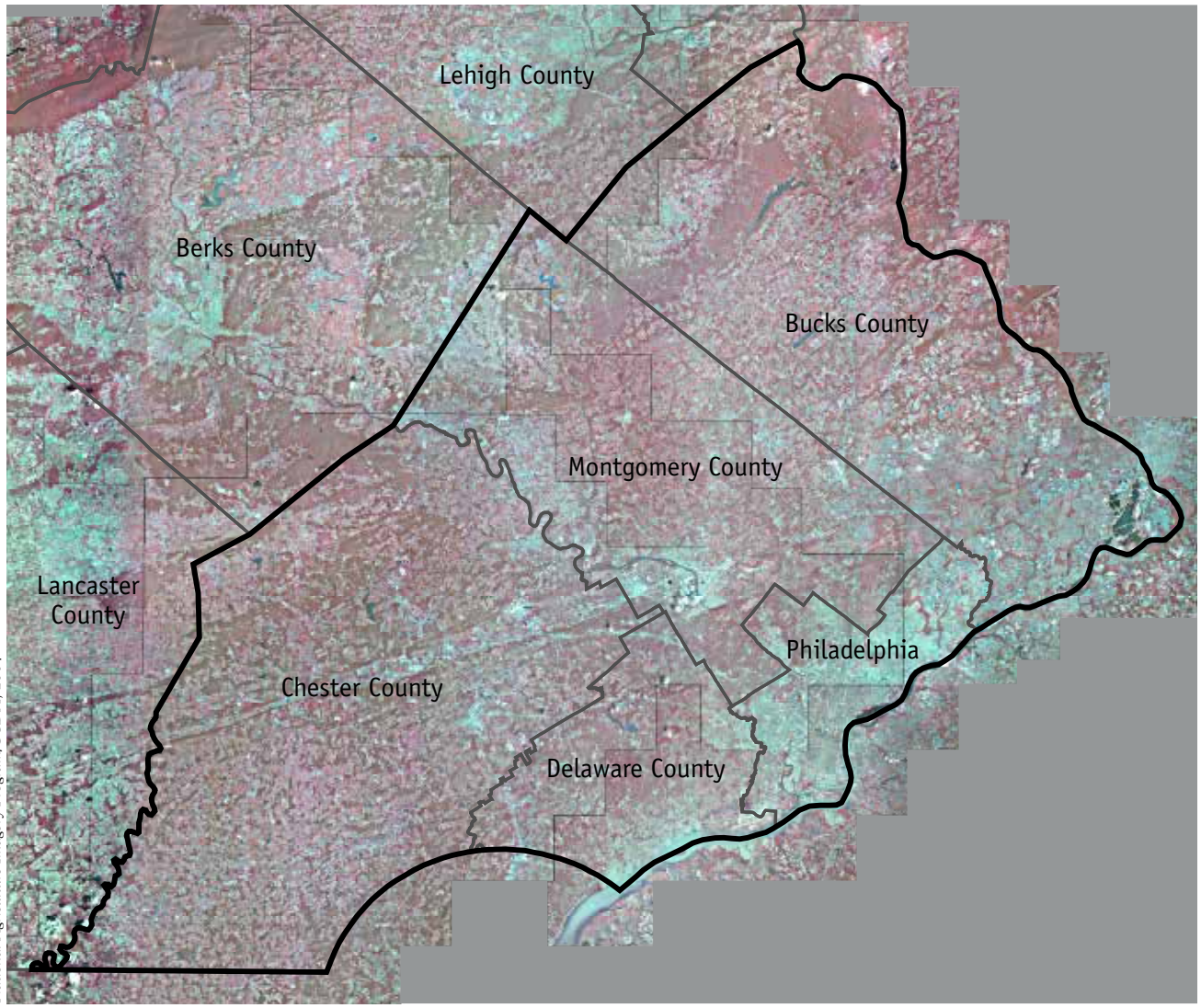
IN THIS SECTION

Historical and present-day importance of natural lands in the region

Role of land stewardship

The natural resources of natural lands:
- Water
- Rocks and soils
- Plant communities
- Wildlife

Issues that affect management of these natural resources



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.

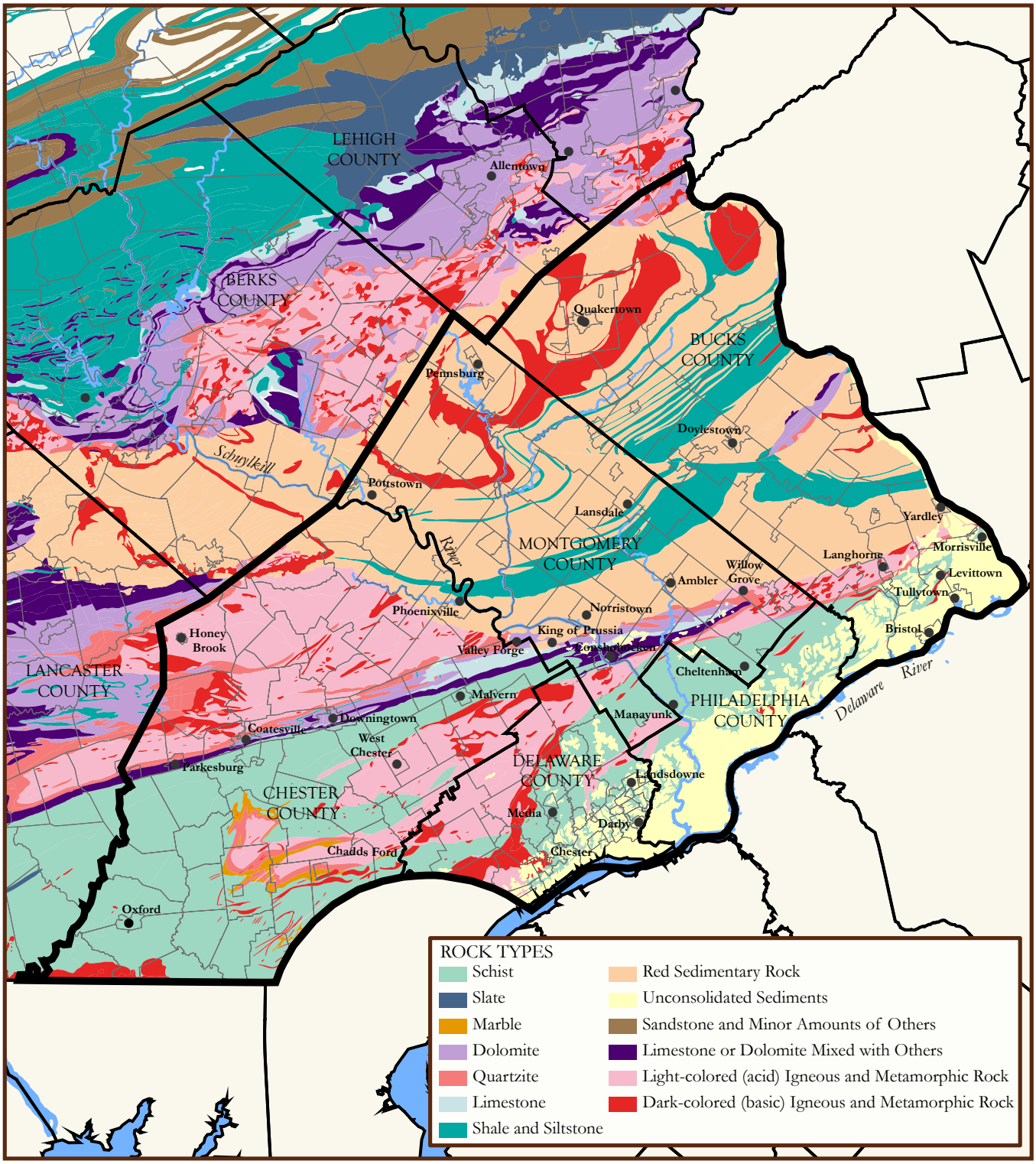
Much can be predicted about the types of plants that will grow on a site by understanding the type of soil occurring there. Extreme wetness or dryness in soils creates stress for plants and so specialized floras typically grow in these locations. In between the harsh conditions imposed by wetness or 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.

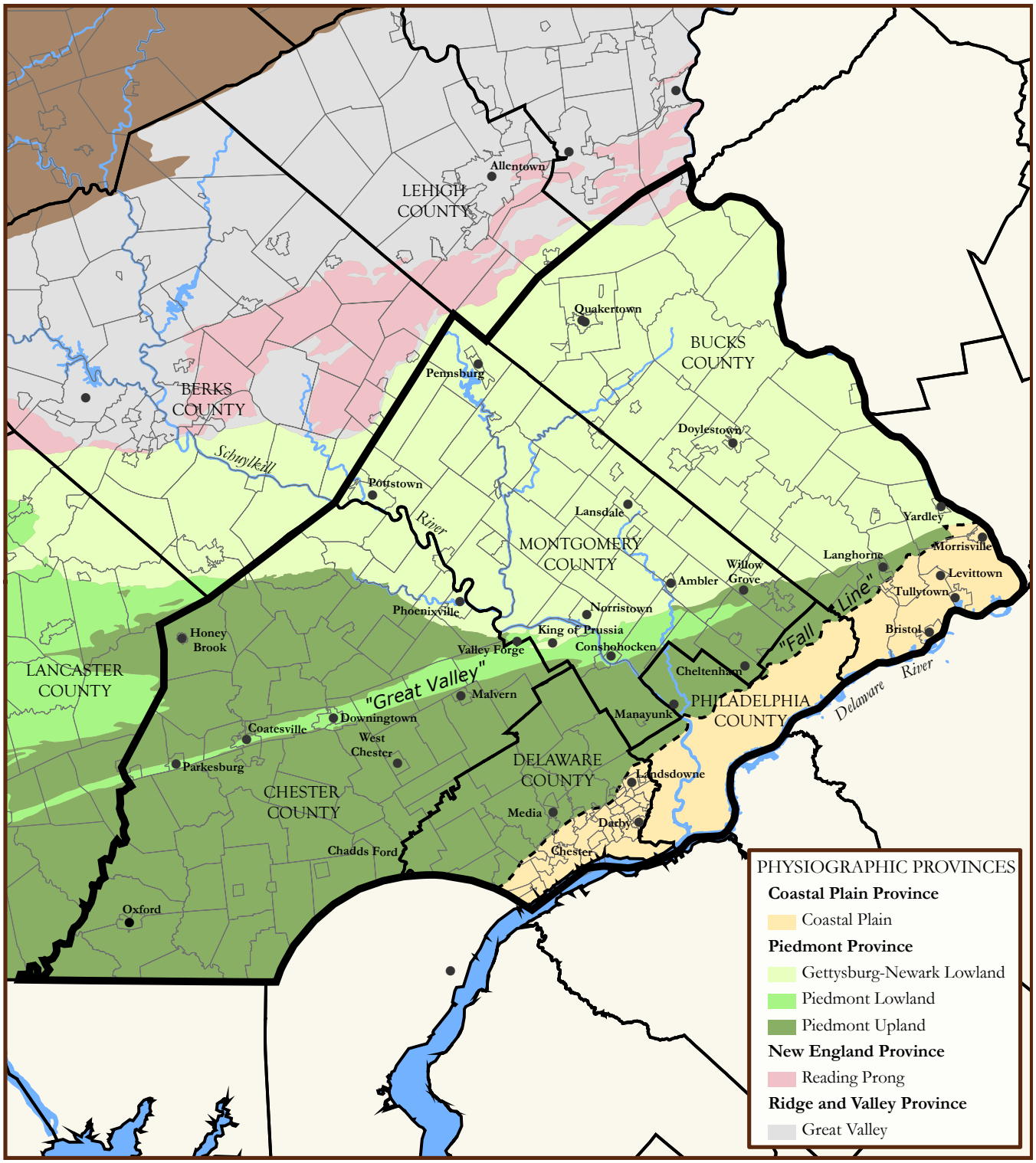
The ***Coastal Plain*** is a thin strip of land—roughly paralleling the Delaware River along the southeastern edge of the region—with no hard bedrock near the surface and soils composed of ancient sand, gravel, silt, and clay deposits. These soils can be very wet or very dry, depending on how close the 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.



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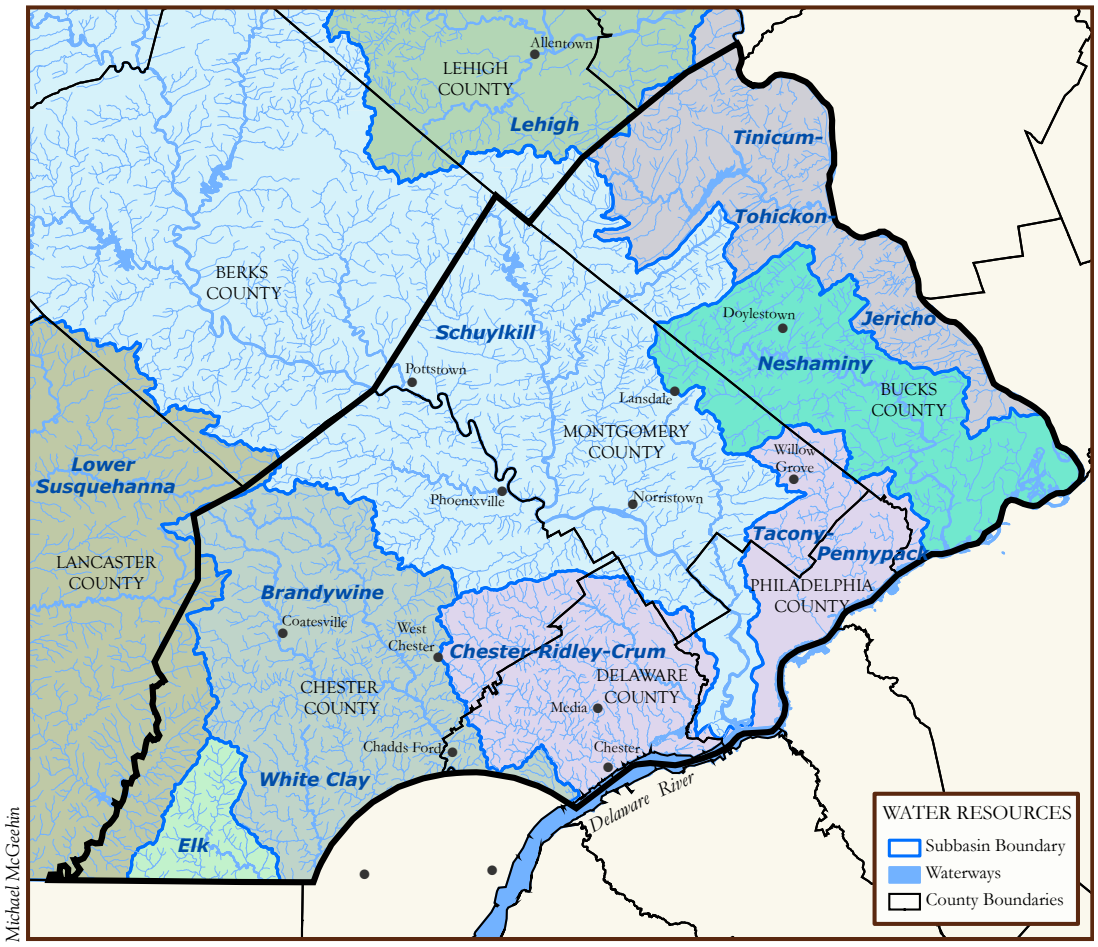
Most of the southeastern Pennsylvania region is part of the Piedmont physiographic province, with slow-draining moderately acidic clay soils, and hardwood-dominated forests. A small portion is coastal plain, which has sandy, usually well-draining soil; and another small portion is Ridge and Valley province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



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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

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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. *Land for Life* 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.

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

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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).

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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.

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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.

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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.

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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

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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"**

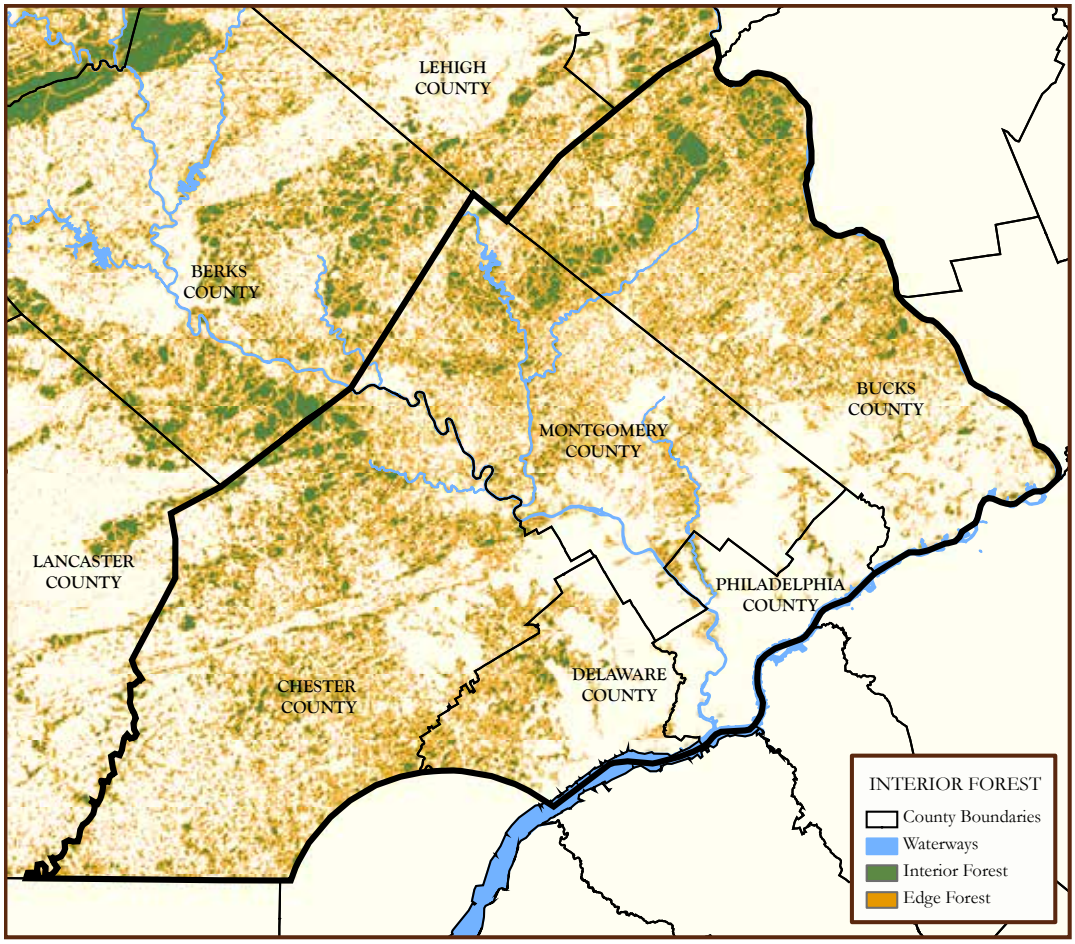
Fragmentation of our forests is second only to outright destruction and conversion of forestland to other uses as a cause of degradation of ecosystem function, habitat quality, and biodiversity. Forest fragmentation results in the local extinction of species and can lead to far lower overall species 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 south-eastern 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.

Dan Barringer

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

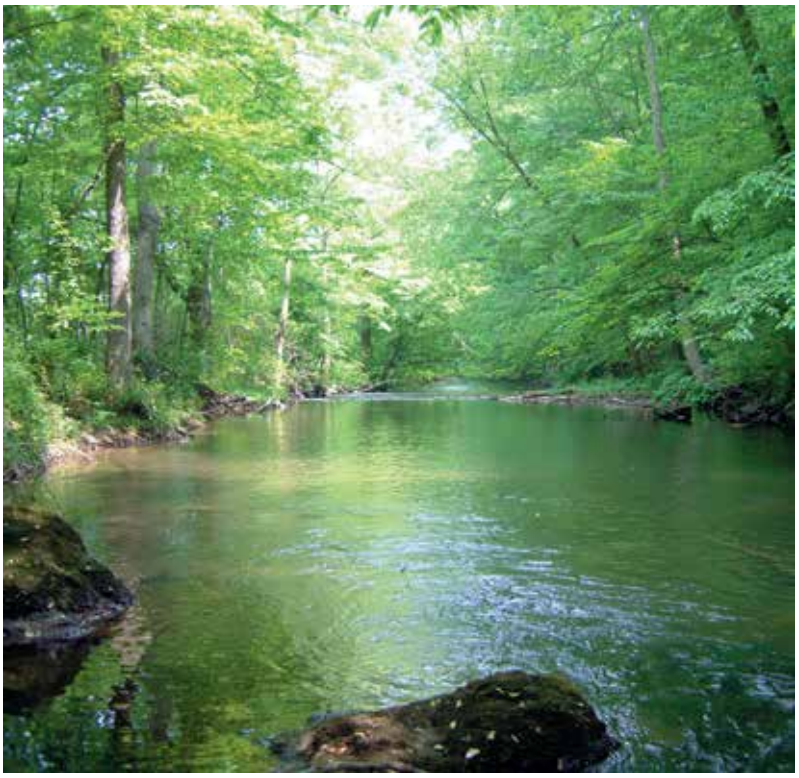
Multiflora rose *(Rosa multiflora)*: An upright shrub that was promoted as a "living fence," its proponents failed to understand its ability to spread rapidly via bird droppings.

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.

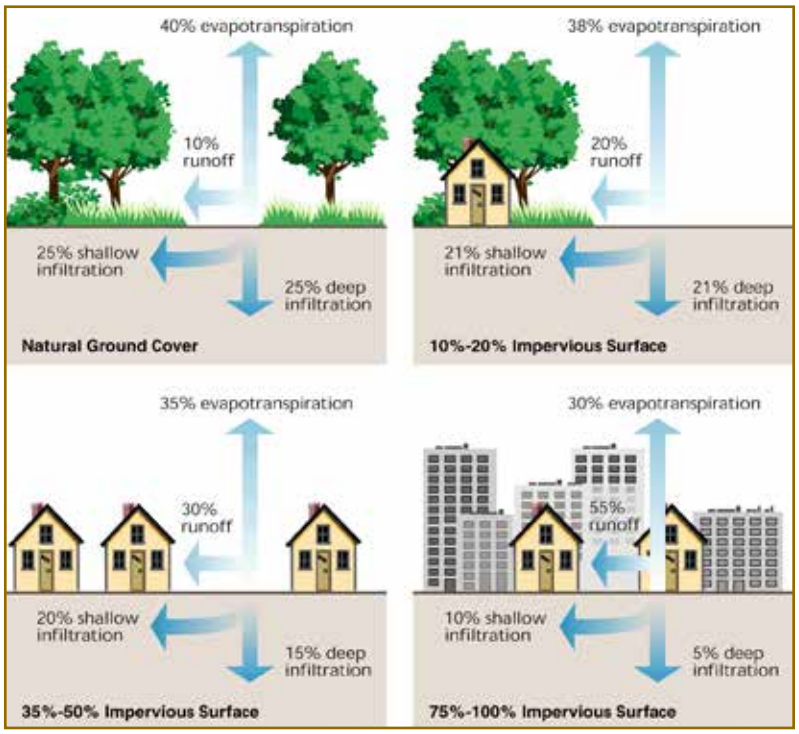
Ongoing threats to the quality and quantity of water represent potential threats to the natural lands in the region. With the advance of technology, humans have the ability to alter the landscape more rapidly and at a broader scale than ever before. The more we clear native vegetation, excavate and compact 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.

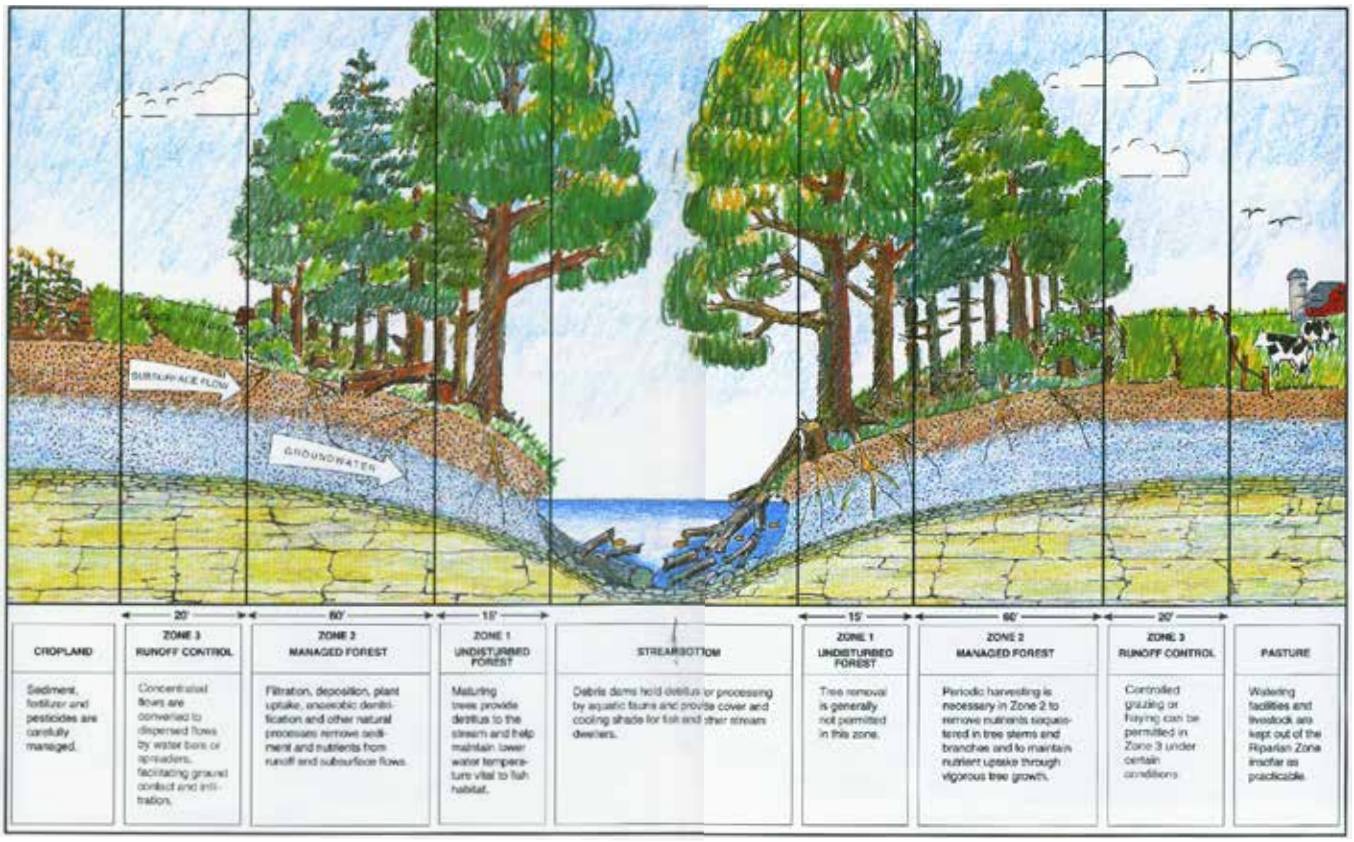
Decades of deforestation, agricultural expansion, and increasing suburban development have drastically reduced the extent of water edge protected by forest in southeastern Pennsylvania. (However, in some watersheds, the combination of less acres in agriculture and better management practices promoted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

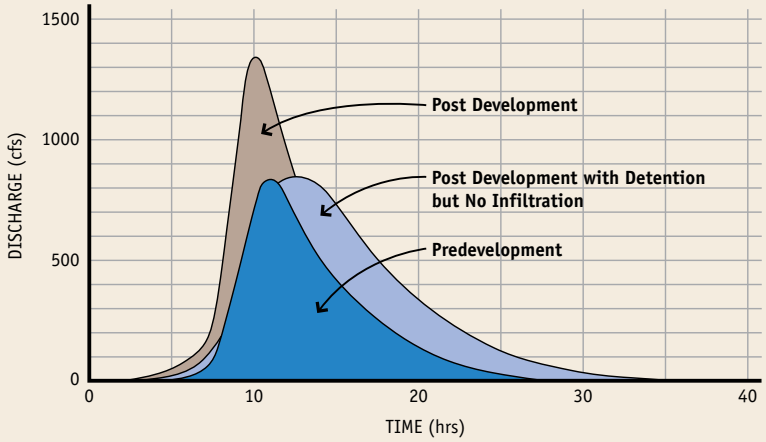
Many of the agricultural areas of the region have been cleared of natural vegetation for centuries. This allows streams to cut deeply into their channels, which reduces their ability to overflow

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*

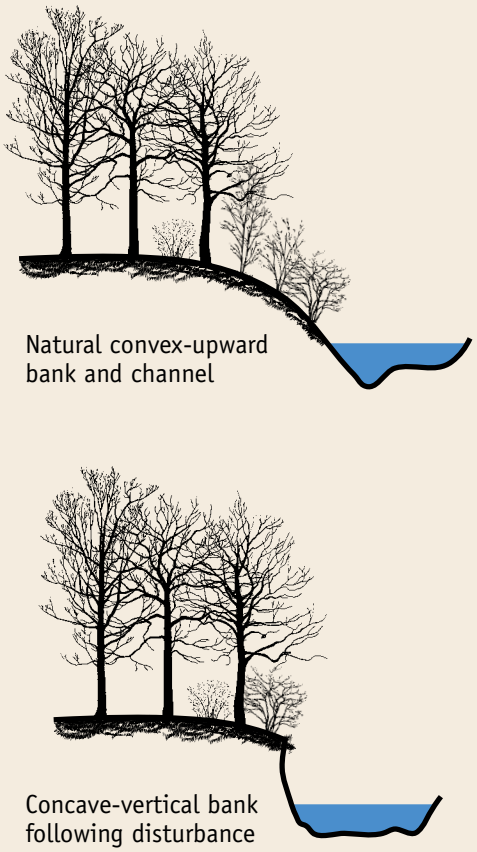
As groundwater supplies diminish, less water reaches the streams that depend on groundwater during dry months. In first and second order streams, decreased

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)*.

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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.