

### ***Chapter 3. A Brief History of Penn's Woods***

Our report starts from the premise that the management of white-tailed deer in large forested areas from an ecosystem perspective will involve attempting, within the constraints of landowner objectives, to restore or maintain ecosystem structures and processes and not just healthy populations of deer. To help define the ecosystem structures and processes that need to be restored or maintained, in this chapter we review the relevant natural history of Pennsylvania and the current state of the forests.

The land that greeted the earliest Europeans to arrive in Pennsylvania was primarily forested, broken only by rivers and lakes, clearings associated with Indian villages and occasional large-scale windstorms, and scattered openings of grassland, shrubland, marsh, and shrub swamp. Early accounts of the landscape of the interior of Pennsylvania contain frequent references like this descriptive passage by Fortescue Cumming while crossing Tuscarora Mountain in 1807, "... view to the westward, though extensive, was cheerless and gloomy, over a broken and mountainous or rather hilly country, covered with forests, chiefly of the dark and sombre pine ...". Another passage referred to extensive grasslands and gallery-type forests in which one could "drive a carriage unhindered," apparently the product of Native Americans' regular use of fire to manage the landscape.<sup>1</sup>

Despite its immensity, however, that forest was a fairly recent product of the geological evolution of Pennsylvania's landscape. Eighteen thousand years ago the northeastern and northwestern corners of the state were covered with ice, and tundra and open, boreal woodlands covered the remainder of the state.<sup>2</sup> As the ice receded, species that had lived only to the south during the most recent ice advance began gradually repopulating the state, a process that is still ongoing.

#### **Influence of Native Americans**

Fossil pollen and charcoal residues preserved in bogs and lake sediments all across the eastern half of North America show the beginnings of wide-scale burning as far back as 2,000 or 3,000 years ago. Native Americans found they could improve the ease of travel, hunting, and defense and promote the growth of animal and plant species prized as food by wielding fire as a powerful land-management tool.<sup>3</sup>

Evidence exists that Native Americans managed vast areas of forest with fire to create open, park-like forests and also to clear fields where they grew corn, beans and other crops. The oak-dominated forests that persist today and native grasslands, most of which disappeared soon after Native Americans were ousted from the land, almost certainly owe their existence to traditions of

large-scale burning among some groups of people for centuries or thousands of years before the arrival of Europeans.<sup>4</sup>

Native American populations were much larger before contact with Europeans introduced smallpox and other diseases, and the extent of land affected by their management was large.<sup>5</sup> When the first European settlers arrived, extensive clearings were described in the Cumberland Valley, Penns Valley in Centre County, the Wyoming Valley, southern York County, and other sites.<sup>6</sup> Later travelers in these same regions described a forested landscape apparently the result of successional growth.<sup>7</sup>

### **Cutting down the trees**

As European settlers claimed the land, taming the wilderness meant cutting down trees and eradicating some forest wildlife, especially large predators, to make room for farms, towns, and villages and assure the safety of settlers and their livestock. Wood not needed for fuel or building material was often burned early in the process of clearing the land — after all, there was a seemingly unlimited supply.

In Pennsylvania, the clearing for farming and cutting trees for commercial uses that began with the first European arrivals had, by 1900, reduced the forest cover from 90 to 95% of the land area to 32%.<sup>8</sup>

#### *Early lumbering*

Tall, straight, and suitable for ships' masts, the eastern white pine was the first large-scale target of waves of loggers in Pennsylvania's forests. Beginning in the 1760s, white pine logs 120 feet long and 4 feet in diameter (or larger) were cut in the hills of northeastern Pennsylvania, fastened together in huge rafts, and floated down the Delaware River to Philadelphia to provide masts for British ships.

A second wave of timber harvesting focused on hemlock bark, which was used in the leather-tanning industry. Hemlock logs were cut and the bark stripped. Charcoal making was another forest industry that thrived before the discovery of coal as a fuel. In areas near early iron furnaces, colliers harvested trees (mainly oaks) and stacked them in conical piles built in the woods. The piles of logs were covered with earth and burned to produce charcoal, which was then hauled by wagon to the iron works. Because small trees as well as large were used for charcoal making, timber could be harvested on a 25-year rotation in most areas. An iron furnace required 20,000 to 35,000 acres of forest to support it on a sustainable basis.<sup>9</sup> Today, it is not unusual to come across level circular areas about 40 feet in diameter scattered in forests where charcoal making occurred.

### *The chemical wood industry and the indiscriminate removal of forests*

The invention of the geared logging locomotive set the stage for the removal of forests between 1890 and 1930 across the entire state. The railroad logging era, as it is known, allowed loggers to reach Pennsylvania's vast interior. Rail beds were constructed up every hollow far into forests unreachable by water transport. Today many of the old railroad beds are the basis for a network of hiking trails.

During the railroad logging era, technology was employed not only to harvest vast areas, but also to utilize everything regardless of species or size. What was not usable as lumber was treated by slow heating and distillation in chemical factories, which produced acetate of lime, wood alcohol, wood tar, charcoal, and gases. Wood products including barrel staves, lath, shingles, boxes, and kindling were produced in hastily built factories located in temporary towns that sprang up throughout the northern tier of Pennsylvania. Old photographs record the boom days at Masten, Golinza, Laquin, and many other sites that today are only names on a map, a few old foundations, or perhaps the site of a hunting camp.<sup>10</sup>

The removals were massive and indiscriminate; fires started by sparks from the logging locomotives frequently followed, burning rapidly and fiercely through the slash. The resulting scenes of devastation generated concern by groups throughout the state and led to the formation of the Pennsylvania Forestry Association. A campaign led by Dr. Joseph Rothrock resulted in the formation of a Division of Forestry within the Pennsylvania Department of Agriculture in 1895 and the appointment of Dr. Rothrock as the first Forestry Commissioner.

Development of a system of forest reserves, now known as state forests, began in 1897 with the acquisition of abandoned cut-over lands that were sold at tax sales. By 1904 the system held about a half million acres; today state forest lands total 2.1 million acres.

### **Impact of pests and diseases**

Pennsylvania's forests have been profoundly affected by pests and diseases introduced from different parts of the world. The chestnut blight fungus, first discovered in New York City in 1904, swept through Pennsylvania in less than one decade, reducing American chestnut, which had previously been the most abundant tree across much of the state, to minor status. The gypsy moth, which spread into the state following its accidental release in eastern Massachusetts in 1869, reduced the abundance of oaks by feeding on them in preference to all other species. Beech bark disease, which appeared in Nova Scotia about 1920, still is spreading across the northern and western half of the state. Typically, the largest, oldest trees are the most susceptible; the full impact of beech bark disease has not yet been realized. Dutch elm disease and dogwood anthracnose have taken their toll. The most recent invader, hemlock woolly adelgid, is killing our state tree, the eastern hemlock, in southern and eastern parts of the state. Mild winters have

### Vertical structure in forests

In forest ecology and forestry, the term understory refers to all of the forest layers beneath the canopy, or topmost layer. We follow the common practice of dividing the forest into four major vertical layers above the surface of the ground. Shrubs and herbaceous plants are generally confined to the two lowest layers but trees (and woody vines) may be present in any or all layers. In forests with low or moderate deer densities, the understory layers typically include seedlings, saplings, and “pole-size” trees of species that are capable of eventually growing into the canopy. Certain tree species, such as flowering dogwood, striped maple, American hornbeam, eastern hophornbeam, and downy serviceberry, never grow large enough to occupy the canopy of a mature forest.

The four layers (including common synonyms for each) are:

- **canopy**, overstory, dominant trees, upper canopy, upper layer, major trees
- **subcanopy**, understory trees, lower canopy, intermediate canopy
- **shrub layer**, understory shrubs
- **herbaceous layer**, herbaceous flora, herbaceous species, ground layer, ground-layer vegetation, forest-floor plants

allowed the adelgid to spread rapidly westward. (Further discussion of these diseases and insects is in Chapter 6.)

Recent outbreaks of native insects such as elm spanworm, forest tent caterpillar, eastern tent caterpillar, and cherry scallop-shell moth have caused extensive tree death in some parts of the state. Research is ongoing to understand the underlying causes of a recent decline of sugar maple in Pennsylvania.<sup>11</sup> Low levels of magnesium combined with

excessive stress, for example from insect defoliation, have been associated with sugar maple decline.<sup>12</sup> On soils with low or intermediate concentrations of base cations, the situation is also worsened by high levels of acidic deposition.<sup>13</sup>

### Major forest types

Pennsylvania contains about 16.7 million acres of forestland.<sup>14</sup> Nearly all current forests are second- and third-generation stands that developed after extensive forest removals between 1890 and 1930, when deer densities were very low.<sup>15</sup> Though generally even-aged, many stands contain scattered residuals from the previous generation and some may contain up to four age classes.

The climate, rainfall, and soils support forest growth throughout most of the state with the exception of scattered areas that are too wet, low in soil nutrients, fire-prone, or dry and rocky. From an ecological perspective, 62 tree-dominated natural community types have been described for Pennsylvania.<sup>16</sup> According to the most recent reconstruction of potential natural vegetation (Figure 4B, page 126),<sup>17</sup> the major forest communities represented in the state are beech-maple forest (parts of Erie, Mercer, Lawrence Counties), mixed mesophytic forest (parts of Greene and Fayette Counties), oak-hickory-pine forest (extreme southeastern Somerset and York, southern

Bedford and Fulton, and southwestern Franklin and Lancaster Counties), northern hardwoods (the high plateaus, Allegheny Mountains, and most of northwestern Pennsylvania) and Appalachian oak forest (the remainder of the state, including portions of the northern tier).

In the following descriptions of the major forest types across the state and throughout this report, common names of plants and other organisms are used. The corresponding scientific nomenclature is indexed in Appendix E.

### *Beech-maple forests, sugar maple-basswood forests*

The common canopy trees of beech-maple and sugar maple-basswood forest communities are sugar maple, red maple, American basswood, American beech, white ash, yellow birch, sweet birch, and yellow-poplar. Understory trees and shrubs include flowering dogwood, pawpaw, eastern hophornbeam, spicebush, witch-hazel, and bladdernut. These forests have a rich and diverse herbaceous flora that includes black snakeroot, blue cohosh, wood geranium, hepatica, wild leek, jack-in-the-pulpit, spring-beauty, yellow trout-lily, bishop's-cap, rattlesnake fern, and many others.

### *Mixed mesophytic forests*

The most species-rich forest type represented in the state is the mixed mesophytic forest, which reaches its greatest development in the Great Smoky Mountains and elsewhere in the southern Appalachians. Canopy dominance is often shared by many species, in Pennsylvania most often including yellow-poplar, sugar maple, American beech, American basswood, northern red oak, cucumbertree, yellow buckeye, Ohio buckeye, white ash, and black cherry. Understory trees and shrubs include flowering dogwood, pawpaw, umbrella magnolia, redbud, witch-hazel, and wild hydrangea. If not severely impacted by deer, this forest, which often occurs on sites with rich, limestone-based soils, has an incredibly diverse herbaceous flora that includes large white trillium, Virginia bluebell, wild blue phlox, dwarf larkspur, blue-eyed-Mary, wood anemone, foamflower, wild-ginger, squirrel-corn, Dutchman's-breeches, toadshade, black snakeroot, and many more.

### *Oak-hickory-pine forests*

Oak-hickory-pine forests are most common on dry ridgetops, rocky sites and south-facing slopes. This community is dominated by chestnut oak, scarlet oak, pignut hickory, blackgum, sweet birch, and Virginia pine in the canopy. Before 1910, American chestnut was a dominant and commercially important component of these forests, but the accidental introduction of the chestnut blight fungus in 1904 reduced chestnut to a minor forest understory component in a few decades. Where deer numbers are low, dry oak forests often have a dense shrub layer of black huckleberry, mountain-laurel, lowbush blueberry, and maple-leaf viburnum. Forest-floor plants

include teaberry, pipsissewa, trailing-arbutus, Pennsylvania sedge, wild sarsaparilla, bracken fern, pink lady's-slipper, and whorled loosestrife.

### *Northern hardwoods*

The northern hardwood forest occupies the northern third of the state and extends south at high elevations along the Allegheny Front. It also occurs farther south on north-facing slopes and ravines. Major canopy tree species are sugar maple, red maple, and American beech; black cherry is also an important component of many stands. Northern hardwood stands where more than 25% of the total basal area<sup>18</sup> of all trees is in black cherry are referred to as black cherry-northern hardwoods<sup>19</sup> (in the wood products industry, this type is known as Allegheny hardwoods). Associated tree species in northern hardwoods include eastern hemlock, eastern white pine, white ash, yellow-poplar, sweet birch, yellow birch, cucumbertree, American basswood, and northern red oak. Understory trees in northern hardwood forests typically include striped maple, mountain maple, American hornbeam, eastern hophornbeam, American mountain-ash, Allegheny serviceberry, and downy serviceberry. Shrubs formerly abundant in the northern hardwood forest included hobblebush, American yew, mountain winterberry, rosebay rhododendron, and witch-hazel; in most of northern Pennsylvania they have been severely reduced or eliminated by deer. Typical herbaceous species include Canada mayflower, starflower, Indian cucumber-root, painted trillium, purple trillium, large round-leaved orchid, shining clubmoss, and marginal wood fern, but these too have been severely impacted by deer in many areas. New York fern and hay-scented fern, formerly minor components of the northern hardwood forest understory, are not favored deer food and have proliferated where deer have eliminated the normal diversity of species.

### *Appalachian oak forests*

Appalachian oak forests (called Appalachian mixed hardwoods or oak-mixed hardwoods in the wood products industry) are the most common community in the southern two-thirds of the state. Common canopy species include northern red, white, black, scarlet, and chestnut oaks in mixture with pignut, mockernut, shagbark, and bitternut hickory, red maple, yellow-poplar, sweet birch, black cherry, cucumbertree, and eastern white pine. In areas with low deer populations, the subcanopy and shrub layers often include mountain-laurel, black huckleberry, lowbush blueberry, flowering dogwood, beaked hazelnut, redbud, eastern hophornbeam, and maple-leaf viburnum. Common forest floor herbaceous species include bellwort, Solomon's-seal, Solomon's-plume, mayapple, blue cohosh, wood ferns, purple trillium, violets, and yellow trout-lily. The dominance of oaks in these forests is partly the result of long-term, recurring fire discouraging competing tree species, most of which are less tolerant of fire than oaks.<sup>20</sup>

## **Additional forest types**

Several other forest types occur in specialized environments. Although they occupy relatively small areas, they add significantly to the overall biological diversity of Pennsylvania.

### *Coastal plain forests*

In the southeastern corner of the state, in the narrow sliver of the Atlantic Coastal Plain physiographic province that parallels the Delaware River, coastal plain forest canopies contain sweetgum, willow oak, southern red oak, and sweetbay magnolia above a shrub layer of sweet pepperbush, swamp dog-hobble, and pinxter-flower azalea. The herbaceous layer features many coastal plain rarities including Maryland meadow-beauty, New York aster, and coast violet.

### *Glacial bog forests*

In the northeastern and northwestern corners of the state, in areas covered by ice during the most recent glaciation, peat deposits support bog forests of a northern character dominated by black spruce and tamarack. Shrubs include Labrador-tea, highbush blueberry, sweetgale, bog-laurel, bog-rosemary, and northern arrowwood. Characteristic herbaceous species include pitcher plant, round-leaved sundew, many sedges, and rare orchids such as dragon's-mouth, yellow fringed orchid, white fringed orchid, rose pogonia, and grass-pink.

### *Barrens*

Serpentinite rock, which occurs in a band of outcrops stretching across southern Delaware, Chester, and Lancaster counties, supports forests of pitch pine or Virginia pine, eastern redcedar, post oak, blackjack oak, sassafras, scrub oak, and dwarf chinkapin oak interspersed with grasslands dominated by little bluestem, Indian grass, big bluestem, prairie dropseed, moss-pink, barren chickweed, and serpentine aster, with a high diversity of other native grass and forb species.

Shale barrens and limestone barrens of the Appalachian Ridge and Valley physiographic province harbor drought-tolerant species including eastern redcedar, Virginia pine, Table Mountain pine, chinkapin oak, post oak, and hackberry. Redbud and fragrant sumac are frequent in the subcanopy and shrub layers. Herbaceous species include side-oats gramma, Indian grass, little bluestem, hoary puccoon, false-gromwell, bird's-foot violet, and shale-barren ragwort.

Pitch pine-scrub oak barrens occur on ridge tops and other fire-prone sites. Ranging from dry to moist, these habitats have a dense shrub layer that includes sheep-laurel, sweet low blueberry, and rhodora; the herbaceous layer includes the globally rare variable sedge, white fringed orchid, dwarf cornel, and climbing fern.

### *Riparian forests*

Riparian areas throughout the state, where periodic flooding is a limiting factor, are characterized by forests of American sycamore, silver maple, boxelder, American elm, slippery elm, black willow, green ash, red maple, and shellbark hickory. River birch occurs along rivers and streams in the eastern part of the state but not in the west. River floodplains are also rich in shrubs, woody vines, and herbaceous species. Those native to Pennsylvania include silky dogwood, frost grape, spicebush, poison-ivy, spotted jewelweed, pale jewelweed, clearweed, wood nettle, great nettle, and jumpseed. Floodplain forests are especially prone to invasion by introduced species, including multiflora rose, Japanese honeysuckle, Morrow's honeysuckle, Tatarian honeysuckle, Japanese stilt grass, Japanese knotweed, giant knotweed, garlic mustard, and lesser celandine.

### *Swamp forests*

Bottomlands and other areas with a year-round high water table are habitats for several swamp forest types. Red maple and blackgum dominate the most common, widespread swamp type. Swamps dominated by pin oak or swamp white oak are mainly in the southern half of the state and those dominated by eastern hemlock, mainly in the northern half. Red maple and black ash-dominated swamps occur mainly where the groundwater is rich in base cations, overlying calcareous (limestone, dolomite) or mafic (diabase) bedrock. Red spruce swamps occur in glaciated northeastern Pennsylvania. Swamp forests along Lake Erie are the only location where pumpkin ash occurs. Other characteristic tree species in swamp forests include yellow birch, eastern white pine, American elm, slippery elm, and bitternut hickory. The shrub layer often includes highbush blueberry, winterberry, spicebush, northern arrowwood, southern arrowwood, smooth alder, speckled alder, or swamp azalea. Common herbaceous species include skunk-cabbage, cinnamon fern, sensitive fern, arrow-leaved tearthumb, halberd-leaved tearthumb, and sedges.

### **The forest today**

Despite dire predictions by Rothrock and others, Pennsylvania's forests did recover in the years following the devastating removals around the turn of the nineteenth century. Trees came back not only on cut-over lands, but also on abandoned farmland; today second growth forests cover 59% of the state's land area. Only a few fragments of the original forest remain. The Allegheny National Forest in northwestern Pennsylvania includes the only sizeable tract of old-growth forest, 4,080 acres in the Tionesta Scenic and Natural Area. Some 30 smaller fragments are fully or partially protected in state forests, state parks, Allegheny National Forest, and lands owned by public utility companies and conservation land trusts.<sup>21</sup> The Snyder-Middleswarth



State Forest Natural Area preserves over 300 acres of old growth and three tracts in Cook Forest State Park total nearly 300 acres. Several protected stands top 100 acres in size, including Woodbourne Forest and Wildlife Sanctuary (The Nature Conservancy), Otter Creek Natural Area (Holtwood Environmental Preserve, PPL Corporation), Detweiler Run, The Hemlocks, and Alan Seegar State Forest Natural Areas (Pennsylvania Department of Conservation and Natural Resources), and Hearts Content Natural Area (U.S. Forest Service).

Pennsylvania's publicly owned forestlands include 2.1 million acres of state forests and 277,000 acres in 116 state parks. State game lands, administered by the Pennsylvania Game Commission, contain another 1.4 million acres in the public domain. Pennsylvania's only national forest, the Allegheny National Forest, contains just over a half million acres. By far the largest proportion (70%) of forested land in the state is privately owned.

The wood products industry remains an important part of Pennsylvania's economy, totaling nearly \$5 billion per year and providing about 100,000 jobs. The most valuable single timber product is black cherry, which is used mainly for veneer by the furniture industry. Oaks and other hardwoods are also important. The resilience of Pennsylvania's forests and their ability to regenerate naturally have long sustained the Pennsylvania wood products industry. But problems resulting from high deer density and fire suppression have affected the abundance of many commercially important species, especially oaks.<sup>22</sup> Extensive burning by Native Americans may have made possible the expansive oak forests found by early Europeans. Fires that followed clearcutting allowed oak forests to become reestablished<sup>23</sup>. But now, oaks are being replaced by red maple in many areas.<sup>24</sup> Research by the Pennsylvania Bureau of Forestry and the U.S. Forest Service suggests that oaks may become reestablished under a regime of deer exclusion followed by fire to reduce competition from faster-growing species such as red maple, sweet birch, black cherry, and pin cherry.<sup>25</sup>

Most forested landscapes in Pennsylvania consist of a mosaic of 70- to 110-year-old stands that originated after catastrophic disturbances, most often heavy logging but also, in some areas, fire and windfall. Stand structure often closely approximates a single cohort (i.e., they are even-aged), although remnant trees from older cohorts are sometimes present. Forest stands typically contain species representing a range in shade tolerance. Stands usually have a stratified canopy (trees occupying both subcanopy and canopy levels) and an irregular diameter distribution.<sup>26</sup> Fast-growing, shade-intolerant species dominate in the larger diameter classes and occupy only the upper layer. In contrast to the situation in most old-growth forests, slower growing, shade-tolerant species are most often concentrated in the smaller diameter classes and understory layers. Woody species composition in second-growth forests can differ from the pre-European-settlement forest composition due to successional status, site conditions, and disturbance history.<sup>27</sup>

The types of disturbances currently affecting second-growth forests differ from those that initiated their development in the nineteenth or early twentieth century. Ordinary windstorms, occasional ice storms and hurricanes, and rare, localized downbursts and tornadoes are still a factor as they have always been,<sup>28</sup> but fire has been drastically reduced. Introduced insects and diseases have altered the successional pathways of some forest types by virtually eliminating certain species, thus creating unprecedented favorable environmental conditions for others.<sup>29</sup> White-tailed deer populations have grown beyond the forest’s ecological carrying capacity in most of the state (see box on page 16 and Chapter 11) and have changed species composition and reduced species diversity, mostly in layers beneath the canopy, through selective browsing.

Despite the presence of a diverse overstory, tree regeneration typically is severely limited in Pennsylvania forests.<sup>30</sup> A statewide survey of the regeneration of commercially important species, part of the U.S. Forest Service’s recent Forest Inventory Analysis (F.I.A.), concluded that “by every measure, the regeneration picture in Pennsylvania is bleak based on findings for the first panel [year] of regeneration measurements”<sup>31</sup> (see Table 3).

Even where regeneration is ample, the tree seedlings present typically represent fewer species than the overstory due to dense deer populations and the deer’s feeding preferences for some species of tree seedlings over others.<sup>32</sup> This is particularly important in stands that may be subject to future canopy thinning or removal by cutting or natural events, because most tree species that grow into the overstory after disturbance must be present as established seedlings before the overstory is removed.<sup>33</sup> Thus, removal of the overstory under present conditions frequently results in regeneration failure or new forests of lower diversity, unless heroic measures are taken. For example, northern hardwood forests frequently regenerate to ferns and grasses, striped maple, or near monocultures of American beech, sweet birch, or black cherry. A

Table 3. Regeneration of trees of value to the wood products industry in Pennsylvania forests.<sup>34</sup>  
The overall trends are assumed to apply to the majority of native tree species (all of Pennsylvania’s indigenous trees are listed in Table 4, with those having significant commercial value marked by an asterisk).

silvicultural region	percent of stands with regeneration of species with high commercial value	percent of stands with regeneration of any species with commercial value
Eastern broadleaf–east	22	50
Plateau	24	45
Central Appalachian	30	44
Eastern broadleaf–west	45	58

monoculture of any species is not a preferred outcome, even if the needs of the wood products industry alone are taken into account, partly because monocultures are much more susceptible to mass mortality from outbreaks of insect herbivores or diseases.

Mixed oaks, in the presence of a high deer density and the absence of occasional fire, frequently regenerate to ferns, mountain-laurel, rosebay rhododendron, flowering dogwood, sassafras, sweet birch, blackgum, red maple, or yellow-poplar. Aside from the commercial losses, a once-magnificent part of Pennsylvania's natural heritage is disappearing as oak forests succumb to a more homogeneous forest dominated by red maple.<sup>35</sup> The vast forests dominated by oaks, American chestnut, and hickories that formerly covered two-thirds of the state sustained a higher total biomass — and in all likelihood a higher diversity — of animal life, with their massive crops of fat-, carbohydrate- and protein-rich nuts and acorns, than the low-diversity woods that are taking their place.

Tree establishment and survival are affected by a variety of factors in addition to deer browsing, including propagule (seed) supply, seedbed conditions, sunlight, competition with other plants, small mammal and insect predation, diseases, non-sustainable forestry, incidence and severity of fire, and soil physical and chemical properties.<sup>36</sup> However, unlike deer overbrowsing, most of these factors rarely limit regeneration of large numbers of species simultaneously over large areas, or for periods of decades or longer. Exceptions may include non-sustainable timber-cutting practices and acidification of soils by atmospheric deposition of pollutants.

In areas such as northwestern Pennsylvania where overbrowsing has been a factor since the 1920s,<sup>37</sup> there may be little in the way of local sources of propagules (seeds, spores, and vegetative reproductive organs such as bulblets) remaining for the shrub and herbaceous species native to the forest understory, which far outnumber tree species in overall diversity. Further exacerbating the situation is the fact that most forest herbs do not have long-distance dispersal mechanisms. The primary means of reproduction for many species is vegetative spread by horizontal roots (rhizomes) or trailing stems (stolons) and the seeds of many others are dispersed by gravity or ants.<sup>38</sup>

Studies of seeds lying dormant in the soil of the region's forests hold out little hope that this "seed bank" will contribute significantly to the recovery of plant species diversity following release from deer overbrowsing.<sup>39</sup> However, there is some hope based on recent work at Hearts Content Natural Area that suppressed individuals of some shrubs and herbaceous species may be present at very low densities even in heavily browsed areas.<sup>40</sup> Some species are still present in local refugia such as large boulders, the tops of which can support small patches of forest floor species,<sup>41</sup> and steep-sided rock outcrops. The prospects for suppressed plant remnants are greater in areas where deer overpopulation is a more recent phenomenon.

Deer threaten the regeneration of all forests throughout the state. Fencing to exclude deer is now a standard practice on state forest lands when timber is harvested. Fencing is necessary to allow new trees to become established and grow beyond the browse line (the height deer can reach, which is about 5 feet). According to the state forester, Dr. James Grace, 20,000 acres of state forest land are fenced at present, but the total could easily be 50,000 if the need were adequately addressed.<sup>42</sup> Optimum timber harvest levels have not been met due to the inability to fence and treat more acres.

### **Findings on the history of Penn's Woods**

- (1) Pennsylvania's forests regrew after the massive cutting that occurred between 1890 and 1930. Trees came back not only on cut-over lands, but also on abandoned farmland; today second-growth forests cover 59% of the state's land area. Only a few fragments remain of the pre-European-settlement forest.
- (2) Today's forests, most of which are in the 70- to 110-year-old category, differ from the forests that greeted the first Europeans in several important ways. Three hundred- to 400-year-old giants are found in only a few remnant old-growth groves. Oaks and eastern white pine are not as abundant as they once were and American chestnut has been relegated to a minor role in the understory due to the impact of the introduced chestnut blight fungus.
- (3) In the areas that have been affected the longest by high deer densities, the diversity of canopy tree species has decreased. Even in some areas that have sustained high deer densities for just a few decades or less, understory tree and shrub layers have been diminished in species diversity, height, and density or completely eliminated, and the formerly diverse ground layer has been reduced to ferns and a few other species that are either not preferred by deer or resilient to repeated browsing.
- (4) Pennsylvania's forests also have been profoundly affected by pests and diseases introduced from other parts of the world.
- (5) Sixty-two tree-dominated natural community types have been described for Pennsylvania by ecologists. To the wood products industry, the major forest categories of interest are the northern hardwood and Appalachian oak-mixed hardwood forests. The northern hardwood forest is the main forest type in the northern one-third of the state and extends southward at high elevations along the Allegheny Front and down the spine of the Appalachians in western Pennsylvania into Maryland and West Virginia. The main forest type in the southern two-thirds of the state is oak-mixed hardwood.
- (6) The U.S. Forest Service's F.I.A. data show that among four tree-harvest regions covering Pennsylvania, desired levels of regeneration were found in only 22 to 45% of the total forest area.

## Endnotes

- <sup>1</sup> Cumming 1810; Maxwell 1910
- <sup>2</sup> Watts 1979; Martin 1958
- <sup>3</sup> Maxwell 1910; Day 1953; Thompson and Smith 1970; Webster 1983; Dent 1985; Denevan 1992; Casselberry and Evans 1994; Black and Abrams 2001
- <sup>4</sup> Marye 1955; Russell 1983; DeSelm 1986; Abrams 1992; Clark and Royall 1996; Clark et al. 1996; Delcourt and Delcourt 1997, 1998
- <sup>5</sup> Dobyns 1966, 1983; Denevan 1992
- <sup>6</sup> Bates and Richard 1887; Losensky 1961; Cook 1887; Schoepf 1788; Marye 1955
- <sup>7</sup> E.g., Maximilian 1834
- <sup>8</sup> deCoster 1995
- <sup>9</sup> Bining 1938
- <sup>10</sup> Kline et al. 1970-1978; Marquis 1975
- <sup>11</sup> Kolb and McCormick 1993; Long et al. 1997; Horsley et al. 2000, 2002
- <sup>12</sup> Bailey et al. 2004; Horsley et al. 2000
- <sup>13</sup> Drohan and Sharpe 1997
- <sup>14</sup> McWilliams et al. 2002
- <sup>15</sup> Marquis 1975, 1992
- <sup>16</sup> Fike 1999
- <sup>17</sup> Küchler 1964
- <sup>18</sup> Basal area is the area occupied by tree trunks in an imaginary plane 1.4 m (4 feet 7 inches) above the ground.
- <sup>19</sup> Fike 1999
- <sup>20</sup> Tome 1854; Abrams and Nowacki 1992; Brose et al. 2001
- <sup>21</sup> Erdman and Wiegman 1974; Bjorkbom and Larson 1977; Pennsylvania Bureau of Forestry 1979; Smith 1989
- <sup>22</sup> Other forest stresses are discussed in Chapters 5 and 6.
- <sup>23</sup> Abrams 1992
- <sup>24</sup> Abrams 1998
- <sup>25</sup> Van Lear et al. 2000
- <sup>26</sup> Oliver and Larson 1996
- <sup>27</sup> For example, in a 1940s forest vegetation assessment of old growth in Kentucky's Cumberland Mountains, Braun (1950) estimated that 84% of the overstory consisted of 10 species, dominated by American beech, sugar maple, American chestnut, and eastern hemlock. In 1988, the U.S. Forest Service reported that 10 different species accounted for 83% of the overstory, which is now dominated by oaks, yellow-poplar, hickories, and red maple (Steinman 1999). Disturbances to the late-successional forests observed by Braun, such as chestnut blight and logging, created growing conditions favorable to the early-successional species that currently dominate.
- <sup>28</sup> Lorimer 1977, 1980; Runkle 1982; Frelich and Lorimer 1991
- <sup>29</sup> E.g., Fajvan and Wood 1996
- <sup>30</sup> Marquis et al. 1992
- <sup>31</sup> McWilliams et al. 2002
- <sup>32</sup> Allegheny National Forest 1995

## Endnotes

<sup>33</sup> Grisez and Peace 1973

<sup>34</sup> Data from McWilliams et al. 2002

<sup>35</sup> Abrams 1992, 1998

<sup>36</sup> Kozłowski 2002

<sup>37</sup> Fronz 1930

<sup>38</sup> Bierzychudek 1982; Sobey and Barkhouse 1977; Beattie and Culver 1981

<sup>39</sup> Leckie et al. 2000; Pickett and McDonnell 1989

<sup>40</sup> Ristau 2001

<sup>41</sup> Rooney 1997

<sup>42</sup> Dr. James R. Grace, State Forester, Bureau of Forestry, Pennsylvania Department of Conservation and Natural Resources, personal communication, 2002