Protecting the Unionville Barrens

Biological, Historical and Value Considerations

By Roger Latham

For the Brandywine Conservancy's Environmental Management Center

Photographs on front cover

Upper left

Serpentine aster (*Symphyotrichum depauperatum*), a globally threatened plant, is endemic to serpentine barrens in Pennsylvania and Maryland. In other words, it is found nowhere else in the world. At Unionville, it lives only in open serpentine grasslands, a habitat that has declined by more than 84% in area in the last 65 years.

Left center

Round-leaved fameflower (*Phemeranthus teretifolius*), threatened in Pennsylvania, is one of 20 species listed as endangered, threatened or rare recorded at the Unionville Barrens. A member of the portulaca family that is succulent like a cactus or aloe, it is well-adapted to the searing summer heat of serpentine grasslands. The Unionville Barrens are one of the northernmost locations for the species, which also lives on granite outcrops in North Carolina and Georgia.

Lower left

The prairie warbler (*Dendroica discolor*) is declining in many areas and has been placed on the global watch list. It lives only in grasslands with scattered conifers such as eastern red-cedar and Virginia pine. It is one of several grassland-dependent birds that are likely to have lived in the Unionville Barrens before fragmentation and shrinkage of the serpentine grasslands reduced the habitable area below the various species' minimum habitat size requirements. With restoration of some of the lost grasslands, the prairie warbler's distinctive song — a series of musical buzzes steadily rising in pitch — may be heard again.

Upper right

The hickory horned-devil and regal moth are the larval and adult forms of the same species (*Citheronia regalis*), a rare and spectacular member of the silk moth family. At the Unionville Barrens it lives on hickory trees in the oak forest stands surrounding the serpentine grasslands. Only one other rare animal species has been recorded at Unionville, the prairie leaf beetle (*Diabrotica cristata*). No systematic inventory of animal species has ever been undertaken, but several animals that are endangered, threatened or rare live at other serpentine barrens in the region and are highly likely to be present.

Lower right

Downy lobelia (*Lobelia puberula*), endangered in Pennsylvania, is one of four endangered, threatened and rare species once found at the Unionville Barrens but not seen there in recent years. They are presumed to have died out due to the sharp and accelerating decline in the area of serpentine grassland habitat at the site. Unless serpentine grassland is restored in at least some of the area it formerly occupied, populations of native species will keep on dwindling and dying out and the exceptional species diversity of the barrens will continue to decline.

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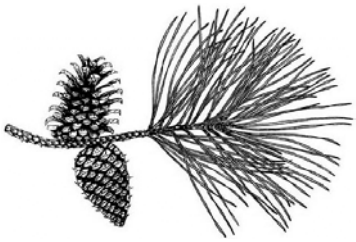
By



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Introduction

The Unionville Barrens are an extraordinary ecosystem with a history extending back into the deep past. They are home to a unique group of plant and animal species including an exceptionally large number of rare, threatened and endangered species relative to the modest area of land involved. There is strong evidence that the barrens have been losing ground for the past several decades, shrinking in area and declining in native species diversity with the waning of the disturbance regime that has sustained them for centuries or thousands of years. With relatively minor effort, this nationally significant piece of our natural heritage could be protected, its decline reversed, and key processes restored to insure its long-term sustainability.

This report summarizes the grounds for why the Unionville Barrens rank among the highest-priority sites for land conservation in the region. Critical issues of biology, history and human values are discussed:

(1) The Unionville Barrens are biologically unique, historically ancient, and nationally significant.

(2) Temperate grasslands such as the Unionville Barrens have been among the least-protected ecosystems and, as a result, now they are critically endangered.

(3) Until the mid-twentieth century the Unionville Barrens were sustained by fire, mining, grazing and natural disturbances, but since then they have been losing area and species at an accelerating rate.

(4) To prevent common invasive plant species from destroying the Unionville Barrens, the critical needs are for land protection, including a buffer zone, and active management of invasives.

The Unionville Barrens are biologically unique, historically ancient, and nationally significant

The Unionville Barrens are biologically unique

The open grasslands and the short-statured woods of eastern red-cedars and stunted oaks at the Unionville Barrens are collectively called serpentine barrens, named after the rare rock formation that lies just beneath the soil. Serpentine grassland is one of the rarest natural communities in eastern North America. Serpentine grassland and the other plant communities that make up serpentine barrens live on thin soils overtop a geologic oddity, a type of rock known as serpentinite. It is a metamorphic, greenish rock formed in deep cracks on the seafloor. Most of the earth's supply of serpentinite lies buried under the seafloor, miles beneath the surface of the world's oceans. It is rare on the continents, present in North America, for example, only in a few isolated locations from Georgia to Newfoundland and in Alaska, Oregon, California and Costa Rica.

The serpentinite underlying the Unionville Barrens formed in a deep ocean a half-billion years ago. Much later, during the slow, titanic collision of North America with Africa, this ocean was squeezed out of existence. Most of the sea-bottom rock was overridden by the drifting continents and pressed downward into the earth's molten interior, but a few pieces broke off, caught on the continent's edges, and were thrust upward. Like cars crashing in slow motion, the two continents' crumpled leading edges compressed horizontally and rose vertically, forming a Himalaya-sized mountain range, much as the Himalayas are still forming today while India, once a huge island, collides with the rest of Asia. The few broken fragments of ocean-bottom rock, including the Unionville serpentinite, lay deep inside the mountains. A hundred million years of erosion by rain and landslides slowly wore the mountains down, depositing most of their bulk as silt and rubble on the continental shelf off the Atlantic coastline and in a shallow sea that once covered the Ohio and Mississippi valleys. The igneous and metamorphic rocks of the present-day Piedmont, including small, scattered areas of serpentinite, are the exposed inner cores of those long-gone mountains.

The soil that forms overtop serpentinite bedrock is different from any other soil in the world. It has unusually high levels of magnesium, nickel and chromium and very low calcium content. Because the plant life of serpentine barrens is stunted, the soil is often assumed to be overly well-drained and sandy like the coastal plain soils of the New Jersey Pine Barrens. This is a misconception. Serpentine soil is actually a moist loam, with a texture and moisture content comparable to a good agricultural soil. It is the soil's peculiar chemical characteristics that make it a challenging medium for plant growth. Most plants need much more calcium than serpentine soil can provide. At the same time magnesium, an essential mineral for plant growth, is present in such high concentrations that it can be toxic. In some places, nickel or chromium also occur in enough abundance to deter the growth of most plant species.

The thinner the soil over serpentinite bedrock, the more pronounced the effects are of not enough calcium and too much magnesium, nickel and chromium. Where the soil is thinnest, the plants that grow best are prairie grasses such as little bluestem, big bluestem, Indian grass, prairie dropseed and side-oats gramma. A variety of other grass species, sedges and wildflowers also inhabit the thinnest soil, including nearly all of the rare species that grow in few or no other habitats in our region besides serpentine grasslands (174 plant species known to live in the Unionville Barrens are listed in Appendix A). Stunted trees, mainly eastern red-cedar, blackjack oak, post oak and black oak, grow sparsely in some areas of serpentine grassland. In ecologists' jargon, the difference between prairie and savanna — two broad categories of grassland — is the presence of scattered trees in savanna.

Relatively few species of plants are equipped to deal with the unusual chemistry of serpentine soil. Even the characteristic plants of serpentine barrens have stunted growth rates on serpentine soil, but unlike ordinary plants, they can "tough it out." They pay a price for this ability, however. The anatomical and biochemical inner workings that enable some plants to tolerate extreme soil conditions are so costly in energy and resources that such plants are incapable of the rapid growth rates needed to compete successfully with common plants on ordinary soil. They grow faster and larger on ordinary soil than on serpentine soil, but not as fast or as large as the plants that lack the ability to endure on serpentine soil. This is the key to why the serpentine barren flora is very different from any other plant community in the region. The characteristic plants of the serpentine barrens are poor competitors in forests and other commonplace habitats surrounding the barrens. Likewise, the plants that are good competitors on ordinary soil lack the ability to thrive on serpentine soil.

The Unionville Barrens are historically ancient

The exceptional diversity of grassland-specialist plants and the large number of rare species are good indicators that grassland has existed at Unionville for a very long time. We have no direct evidence farther back than the earliest botanical records in the mid-1800s, but high grassland diversity and the cluster of rare species are solid clues that the grassland's age is on the order of at least a thousand years. It is likely that its origin dates back to the most recent major episode of global warming, which occurred between 8,000 and 4,500 years ago.[1] With warming came drought, and with drought, an increased incidence of wildfire. But the climate turned cooler and wetter around 4,500 years ago and stayed that way until at least the mid-twentieth century, reducing the incidence of lightning-ignited wildfires to near zero.[2] There is almost no doubt that the practice by Native Americans of regularly burning their woods and fields made it possible for the barrens to persist until European settlement.[3] Indians used fire most likely to improve game habitat, extend visibility to make hunting easier and enhance "homeland security," and encourage the growth of certain fire-enhanced sources of food such as blueberries, huckleberries, blackberries and raspberries.

Despite what most of us were taught in history class, not all of our region was forested when the Europeans first arrived. Evidence is still accumulating from pollen core analysis and other scientific means to verify and amplify what has long been known from the earliest historical records, namely, that grasslands and meadows were far more widespread in prehistoric eastern North America than is generally appreciated.[4] After Native Americans were displaced, nearly all of the grasslands and meadows succeeded into forests or were converted into plowed farm fields. Only where the soils were too poor to grow crops or to support rapid invasion by forest trees (for instance, the thin soil over serpentinite bedrock) were native grasslands sustained after the Indians' departure. Even many of these places were covered over by forest vegetation eventually. Only the few acres that were kept cleared by livestock grazing, accidental wildfires, intentional burning, or mining still have native grassland vegetation today.

Native grasslands in the northeastern United States stir esthetic as well as scientific interest because they are rare and beautiful landscapes and because they are habitats for unusual clusters of rare species. But part of the value and appeal of the serpentine barrens, in particular, also is cultural, historic and anthropological. Despite their wild appearance they are, in a sense, ancient artifacts, a part of our cultural heritage. Any prehistoric Indian-maintained grasslands that still exist in the northeastern United States have been the subjects of active preservation and maintenance, however inadvertently, by Westerners ever since they replaced Native Americans as stewards of the land. It is only recently that conservation agencies and private groups like the Brandywine Conservancy and Natural Lands Trust have made the long-term stewardship of such places intentional.

The Unionville Barrens are nationally significant

The Unionville Barrens have been recommended three times for National Natural Landmark status.[5] Although the National Park Service has not yet acted upon these recommendations, the fact that the Unionville Barrens have been nominated and renominated is a testament to their special value, which has been recognized by botanists since at least as far back as the early 1800s.[6] Two members of Unionville's Seal family contributed botanical specimens from the Unionville Barrens to the herbarium of the Academy of Natural Sciences of Philadelphia from the 1850s through the 1890s. Francis Whittier Pennell, curator of botany at the Academy and the foremost twentieth-century botanical authority on Pennsylvania's serpentine barrens, first visited the site in 1908.

The exceptional diversity of native plant species at the Unionville Barrens includes at least 15 known plant species of special concern (listed as endangered, threatened or rare) in Pennsylvania, including one globally threatened species (see Table 1). This is a phenomenally large cluster of imperiled species for a natural community that is now below 10 acres in size, although less than 70 years ago the serpentine grassland at

Unionville was at least six times larger. Four other plant species of special concern have been recorded from the Unionville Barrens but not seen in recent years (see Table 2).

It is certain that animal species classified as endangered, threatened or rare are also present. However, to date no one has done a systematic animal survey at the Unionville Barrens.[7] There are 45 animal species of special concern known so far at the State Line Barrens, a series of serpentine grasslands and woods along the Mason-Dixon Line in Pennsylvania and Maryland. Scientists expect to find many more kinds of rare animals on serpentine barrens eventually. So far, even at the State Line Barrens relatively little effort has been put into wildlife surveys except to search for butterflies and moths. Searches have been made of the Unionville Barrens specifically targeting three rare insect species, two plant bugs that feed on creeping phlox[8] and one beetle whose larvae feed on the native grasses little bluestem and big bluestem.[9] The rare plant bugs were not found at Unionville but the rare beetle, which lives mainly in the prairies of the Midwest and West, was found there in 1987.

Table 1. Rare plant species recently confirmed at the Unionville Barrens (for information sources, see Appendix)

species	status in Pennsylvania
Bicknell's hoary rockrose (*Helianthemum bicknellii* Fern.)	endangered
Bicknell's sedge (*Carex bicknellii* Britt.)	endangered
prairie dropseed (*Sporobolus heterolepis* [A. Gray] A. Gray)	endangered
Richardson's sedge (*Carex richardsonii* R. Br.)	endangered
serpentine aster (*Symphyiotrichum depauperatum* [Fern.] Nesom)	threatened (in the state and globally)
annual fimbry (*Fimbristylis annua* [All.] Roemer & Schultes)	threatened
round-leaved fameflower (*Phemeranthus teretifolius* Pursh)	threatened
side-oats gramma (*Bouteloua curtipendula* [Michx.] Torr.)	threatened
Appalachian groundsel (*Senecio anonymus* A. Wood)	rare
few-flowered nutrush (*Scleria pauciflora* Muhl. ex. Willd.)	rare
Heller's witch grass (*Panicum oligosanthes* Schultes)	rare
long-haired panic grass (*Panicum villosissimum* Nash)	rare
small white snakeroot (*Eupatorium aromaticum* L.)	rare
tufted hairgrass (*Deschampsia cespitosa* [L.] Beauv.)	rare
water oak (*Quercus nigra* L.)	not previously reported in the wild

Table 2. Rare plant species at the Unionville Barrens vouchered* but not seen in recent years (for information sources, see Appendix)

species	collected	status in Pennsylvania
downy lobelia (*Lobelia puberula* Michx.)	1935	endangered
arrow-feather three-awn (*Aristida purpurascens* Poir.)	1908	threatened
colic-root (*Aletris farinosa* L.)	1929	rare
lion's-foot (*Prenanthes serpentaria* Pursh)	1908	rare

*In this case, "vouchered" means that a specimen was collected from the site, labeled, and deposited at the Herbarium of the Academy of Natural Sciences of Philadelphia.

Many of the rare animal species known to inhabit Pennsylvania serpentine barrens and other grassland ecosystems have specialized diets, feeding mainly or exclusively on certain of the barrens-restricted plants. Examples include eastern regal fritillary (the larvae eat only violets, mainly arrow-leaved violet), red-banded hairstreak and black-waved flannel moth (which feed on the stunted oaks of the barrens), and cobweb skipper (it eats little bluestem and big bluestem).[10] Other animals have behavioral adaptations to certain features of grassland and meadow habitats and depend on them for part or all of their life cycles, for instance, breeding, nesting, hunting for prey, or taking cover from predators. Examples include prairie warbler, eastern meadowlark, northern bobwhite, vesper sparrow and bobolink. There is little doubt that the number of animal species at the Unionville Barrens has declined and is still falling as the area of grassland steadily shrinks. Many birds, for example, have minimum habitat area requirements; in other words, when a patch of habitat dwindles below a threshold size, they die out or leave.

Temperate grasslands such as the Unionville Barrens have been among the least-protected ecosystems and, as a result, now they are critically endangered

Scientists conducting a global study of conservation needs recently tallied the total areas of habitat converted or destroyed and of habitat protected in all of the major ecosystem categories.[11] The picture is upbeat for certain ecosystems — including tundra, boreal forest and taiga, montane grassland and shrubland, and temperate conifer forest — but it is bleak for many others. Of all ecosystem types evaluated, temperate grassland, the category that includes the prairie and savanna at the Unionville Barrens, is in the direst straits (Fig. 1). For temperate grassland, savanna and shrubland together, the ratio of converted to protected land is ten to one, five times higher than even the beleaguered tropical rainforest. Only 4.6% of the land in temperate grassland, savanna and shrubland has been protected to date while 45.8% has already been destroyed. The figures are even more dismal for the eastern United States, where native grasslands

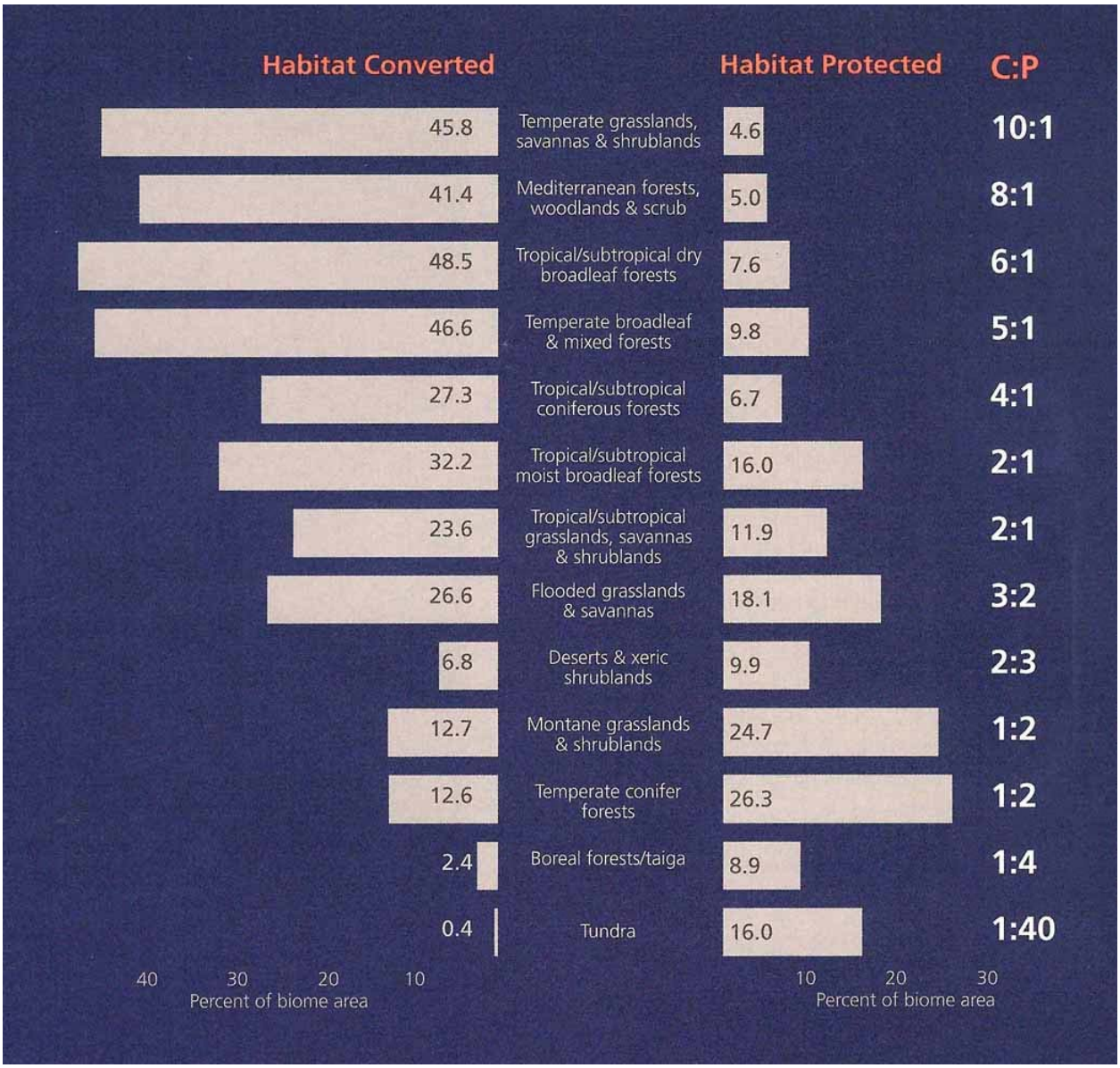

Figure 1. Estimates of the total areas of habitat converted or destroyed and of habitat protected in the world's major biomes (categories of related ecosystems). "C:P" is the ratio of converted area to protected area in each biome.

have been under extreme pressure for more than 300 years and most were converted long ago to agricultural, residential, commercial and other uses.

Historically, meadows and grasslands occurred as breaks in the eastern deciduous forest resulting from disturbances such as fire, periodic flooding, insect infestation and clearing by humans — first by American Indians and later by settlers from the Old World. Most meadows and grasslands in eastern North America are short-lived ecosystems. Without repeated disturbance, trees and other forest plants seed in rapidly and reestablish the forest.

Since the first European settlement, native meadows and grasslands have steadily declined. These plant communities were once composed of hundreds of native plant species that, for millions of years, provided the highest quality food and habitat for native meadow wildlife. The typical meadow today is an abandoned field invaded by a few introduced species — multiflora rose, autumn-olive, Japanese honeysuckle, Amur honeysuckle, Canada thistle, mile-a-minute and Japanese stilt-grass are examples — that crowd out the native plants and degrade the habitat for many native animal species. Native meadows and grasslands are now rare indeed.

Most meadows in southeastern Pennsylvania have an agricultural past (old hayfields or pasture) and are dominated by exotic cool-season grasses[12] such as fescue, ryegrass, bluegrass, orchard grass and timothy.[13] They are called cool-season grasses because they grow best during spring and fall. However, the native meadow grasses that grow most abundantly in our region are warm-season grasses,[14] which are dormant in spring and do most of their growing during the summer months. Common examples of warm-season species include little bluestem, big bluestem, Indian grass, broomsedge and switchgrass.[15] Because they have lived here for millions of years (with interruptions during ice ages), native warm-season grasses are well adapted to the soils and climate. They can thrive on marginal soils and survive periods of low rainfall due to their deep fibrous root systems, which penetrate the soil to a depth of 5 to 15 feet.

Warm-season grasses provide prime habitat for grassland birds because most of them are bunch-grasses, in contrast to the sod-forming growth habit of most cool-season grasses. They grow in dense tufts with space in between. This characteristic provides high-quality nesting sites and can allow grassland birds to move through a meadow more easily and with better protection from predators in their search for food. The space between clumps also provides room for wildflowers to become established.

Grassland animals

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

Populations of grassland nesting birds such as bobolink, eastern meadowlark, grasshopper sparrow, savanna sparrow, upland sandpiper and northern bobwhite have declined drastically in recent years due to the loss of habitat. Most of this loss is from residential and commercial development and from changes in farming practices, such as earlier mowing times and the widespread cultivation of cool-season grasses.

Many butterfly species have also developed close relationships with native wildflowers. As our few remaining undisturbed habitats continue to be lost to development, many native plants are becoming increasingly rare. The implications for butterflies are dire. With the loss of their host plants, some butterfly species are inching closer toward extinction. Unless native wildflowers and butterfly habitats are restored, we can expect to see further declines in overall butterfly populations and continued losses of rare and endangered species.

The grasslands at the Unionville Barrens are exceptionally intact

Of all remaining occurrences of eastern serpentine barrens in temperate North America north of the State Line Barrens (located along the Mason-Dixon Line in Pennsylvania and Maryland), the Unionville Barrens are the largest and most intact, despite major losses in the acreage of native grassland in recent decades (see next section). There used to be 18 separate serpentine barren sites in this northernmost group, in central Chester and Delaware Counties, Pennsylvania, and northern New Castle County, Delaware.[16] Eleven have been completely destroyed and the rest have dwindled in size. Of the seven remnants, the Unionville Barrens comprise more than one-third of the total area and have the highest documented plant species diversity.[17] The Unionville Barrens are one of the two most biologically significant native grassland sites in all of Pennsylvania that do not have legal protected status as natural areas.

Until the mid-twentieth century the Unionville Barrens were sustained by fire, mining, grazing and natural disturbances, but since then they have been losing area and species at an accelerating rate

Across the entire Unionville Barrens site, nearly 85% of the 1937 grassland area has been lost (see Figs. 2, 3 and 4). The rate of loss is accelerating, increasing from nearly three-quarters of an acre per year on average before the 1990s to almost one acre per year in the last decade or so (see Table 3).

Table 3. Documented losses in native grassland acreage at the Unionville Barrens

date of aerial photography	area of serpentine grassland	area lost since previous date	percent loss	average loss rate
1937	58.1 acres*	—	—	—
1992	18.8 acres	39.3 acres	67.6%	0.72 acre/year
2002	8.9 acres	9.9 acres	52.5%	0.99 acre/year

* Included 6.8 acres south of Cannery Road.

This acceleration is expected. As the remnant patches of grassland are squeezed and fragmented by invading common plants, it is a simple fact of plane geometry that their

edge-to-area ratio is increasing. Shrink any two-dimensional shape and its area will decline faster than the total length of its perimeter. In patches of serpentine grassland, the edges are where the invading plants creep in from the protective partial shade of the forest border. The longer the perimeter relative to the interior, the faster a patch of grassland dwindles. Without constant renewal by the types of disturbances that have sustained the grasslands throughout their history, the remaining patches are shrinking at an ever-increasing speed.

Species extirpation

As the area of each patch of grassland declines, the population numbers of all of the native plant and animal species that need grassland habitat also fall off. Wild plants and animals don't have the option of responding to decreasing living space by crowding together. The amount of territory, food and other land-based resources each individual needs is a characteristic of its species. As numbers drop, all species become more and

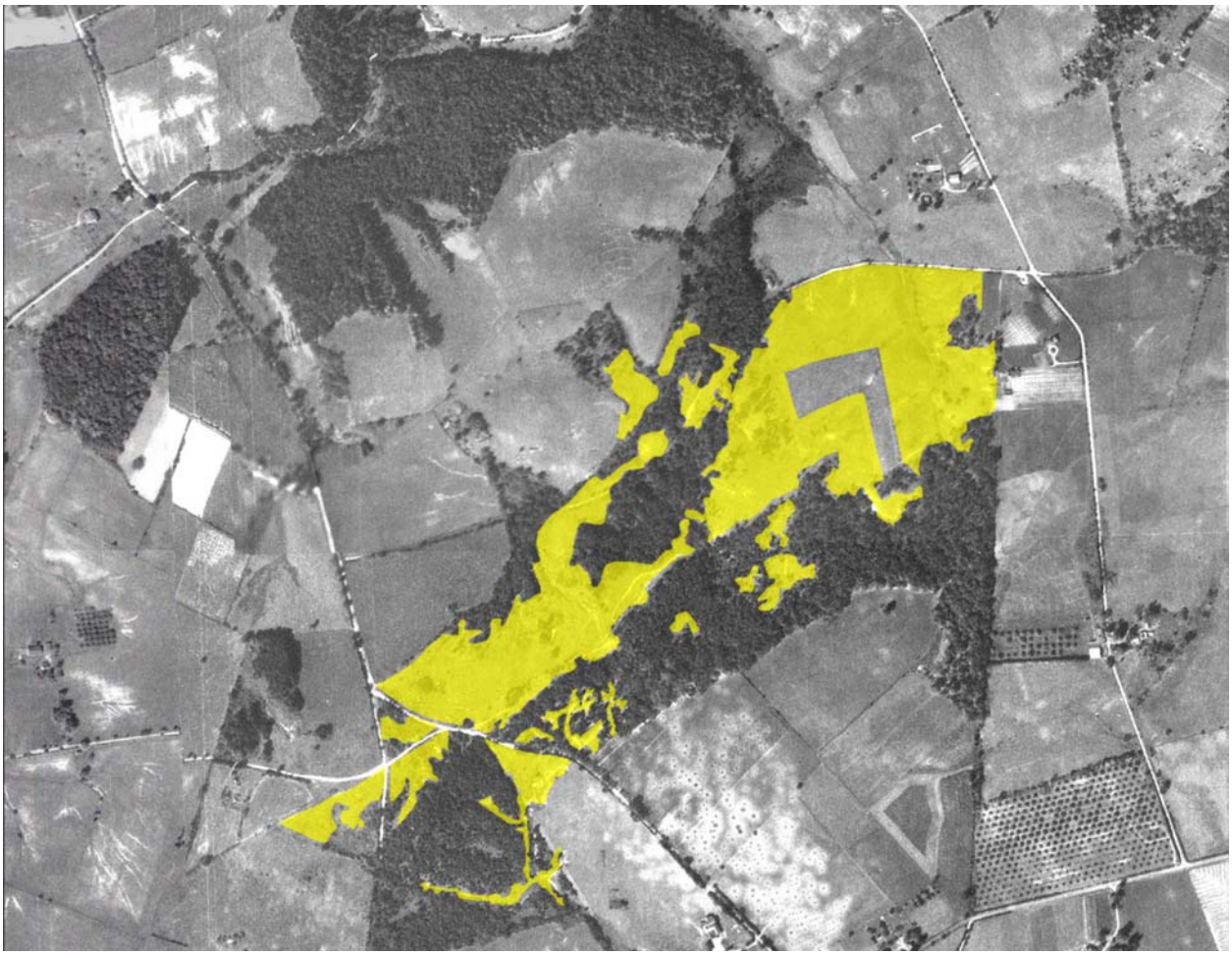

Figure 2. In 1937 serpentine grassland (yellow) at the Unionville Barrens covered approximately 58 acres. (Aerial photograph taken September 1937. North is at the top.)

more vulnerable to local extinction. Wild populations fluctuate as a matter of course with year-to-year differences in weather, predator abundance, disease outbreaks, and other factors. When populations are small, their chances of hitting zero during normal fluctuation greatly increases. There is no recovery from zero population.

Furthermore, small, isolated populations are especially vulnerable to disaster. An example is the heath hen, a wild cousin of the prairie chicken that once lived in Pennsylvania's serpentine barrens.[18] Soon after European settlement of the Northeast the species dwindled catastrophically due to hunting pressure. By the early twentieth century, it survived only on Martha's Vineyard, Massachusetts, where it was protected and considered to be secure. But, ironically, the decision by wildlife managers to protect its habitat from fire probably sealed its fate. The dwindling of grasslands and heathlands on Martha's Vineyard due to an absence of the fires that had sustained them for centuries aggravated the population's decline.[19] When the last individual on Martha's Vineyard died, heath hens became extinct.

Figure 3. In 1992 serpentine grassland (light green) covered approximately 19 acres. The average loss rate over the preceding 55 years was about three-quarters of an acre per year. (Overlain on an aerial photograph taken September 2002.)

Evidently a wild species' local disappearance — termed extirpation — has already happened more than once in recent times at Unionville. Of the 19 plant species classified as endangered, threatened or rare that have been reported since the beginning of the twentieth century at the Unionville Barrens, 4 have not been seen in at least 40 years and are probably gone (see Table 2). It is safe to assume that rare invertebrate species, which have never been comprehensively inventoried at the Unionville Barrens, are declining at even higher rates, because animal populations are generally more sensitive and quicker to respond to habitat loss than plants.

There may be evidence of extirpation even among the patches of grassland within the Unionville Barrens. For instance, the Pennsylvania-endangered Richardson's sedge now occurs only in patches of grassland on the west side of the Unionville Barrens. The Pennsylvania-threatened side-oats gramma and Pennsylvania-endangered prairie

Figure 4. In 2002 serpentine grassland (green) covered approximately 9 acres. The average loss rate over the preceding 10 years was nearly one acre per year. On this map and on Fig. 2, the property lines of the Leisenring, Heckert and Kramkowski families are shown in red. (Aerial photograph taken September 2002.)

dropseed occur only on the eastern side. It is reasonable to assume that those species were more widespread before the grassland was fragmented into small patches.

For thousands of years, when a wild population was extirpated at one of the grasslands in the local group of serpentine barrens, the species had a chance of regaining its lost foothold by chance recolonization from one of the other sites in the group. Ecologists term this the rescue effect. Now that 11 of the 18 serpentine grasslands that once formed the complex of serpentine barrens in central Chester, Delaware and northern New Castle Counties have been eradicated by development, any "rescue" of extirpated species at the Unionville Barrens is highly unlikely. It is more crucial than ever that extirpation be prevented from occurring in the first place.

Rich mining history

Soon after burning by Native Americans was no longer the main force sustaining the serpentine grasslands in the eastern United States, other forms of disturbance took its place. Wildfires and grazing were no doubt important, but the effects on the landscape of mining probably played the most crucial role in keeping the grasslands from disappearing long ago. The Unionville Barrens were a significant early mining site, beginning in 1820s and lasting until around 1900.[20]

Corundum is the mineral that the site is best known for producing. In fact, for many years the Unionville Barrens were known by the name Corundum Hill. Corundum consists of aluminum oxide crystals of nearly diamond-like hardness. Gem-quality corundum crystals are rubies if red and sapphires if blue, purple or any other appealing color, but the output of the Unionville mines was mostly a dull gray or gray-brown. It was crushed and used as an industrial abrasive. The twentieth-century invention of synthetic silicon carbide, of which Carborundum is a well-known brand name, made the mining of corundum obsolete.

The Unionville Barrens achieved lasting fame among mineralogists as the type locality (the place of discovery and source of the first-ever scientifically described specimen) of the rare mineral diaspore,[21] which was originally found there in the 1820s by local banker and amateur mineralogist William W. Jefferis. Diaspore is an aluminum hydroxide crystal resembling topaz, chemically similar to corundum but without its exceptional hardness. Another semiprecious stone found in small quantities at Unionville was tourmaline,[22] bluish or greenish clear crystals, which, if large enough, are used as gemstones.

Other products of the Unionville mines[23] included serpentine building stone, the light green-colored stone that is familiar to many residents of Chester County in a few old houses, barns, churches and public buildings. Another mineral mined in commercial quantities was feldspar, a calcium sodium aluminum silicate used in the making of high-grade ceramics including false teeth, in the enamel finishes of stoves, and in "non-

abrasive" household cleansers, for instance, Bon Ami. A minor product at Unionville but the chief product of mines in the serpentinite outcrops of southern Chester and Lancaster Counties, Pennsylvania and northern Cecil County, Maryland was chromite. Pennsylvania's and Maryland's supply of this mineral was once the world's principal source of chromium, which, in those pre-stainless steel days, was used mainly as a yellow pigment in paints and dyes.

Unique succession

The link between disturbance such as mining, grazing and fire and the maintenance of grasslands in our part of the world has to do with the process ecologists call succession. Succession refers to the gradual replacement of one kind of ecological community by another on the same piece of land. The most familiar example of succession in our part of the world is what happens when a farm field is abandoned. There is a constant rain everywhere of seeds of many plant species, including trees. Abandoned cropland or pasture usually has rich soils, which foster the rapid establishment and growth of seedlings. In early succession, plants of different growth forms, whether they are trees, shrubs, grasses or herbs, are all small in stature. In mid-succession, trees and shrubs have grown taller than their herbaceous neighbors. Still later, the trees outstrip the shrubs in height and the plant community becomes a young woodland or forest.* The maturing of the forest is known as late succession. Any often-observed sequence of this type is called a successional pathway.

Grasslands such as those at the Unionville Barrens have a different successional pathway. With regular disturbance, they cycle from open grassland to savanna and back to open grassland. The unusual soil chemistry together with crowding by the dense grasses make it hard for most of the tree species native to our region to germinate and survive. However, in the absence of disturbance, a transformation occurs along the margins of the grassland patches where grass meets forest. Each year, full-grown forest trees in our region deposit 10 to 20 tons or more of dead leaves per acre.[24] These leaves decompose and enrich the soil, forming a thick layer of humus. The humus layer is so rich in nutrients and available moisture that forest plant species concentrate most of their root growth there. This rich, uppermost soil layer also forms along the grassland margins beneath the overhanging trees of adjacent forests, making the soil there suitable for colonization by trees, shrubs and invasive plants, even those species that are sensitive to the unusual chemistry of serpentine soil. Furthermore, the partial shade at the forest edge suppresses the native prairie plants, which can't tolerate shade, while favoring the growth of tree seedlings and other forest species, which can't tolerate the extreme heat in the middle of a patch of prairie. Disturbances that kill adult trees

* In ecologists' parlance, "woodland" and "forest" are differentiated based on how closely spaced the trees are. In a forest the leafy crowns of the adult trees nearly touch one another and the ground is almost entirely shaded. In a woodland there is space between most trees' crowns, thus small trees, shrubs and herbaceous plants on the forest floor receive a fair amount of direct sunlight each day during the growing season.

(clearing, mining, windstorm, severe fire), or remove tree seedlings (grazing, winter mowing, low-intensity fire), or consume or remove dead leaves and other organic matter (low-intensity fire, runoff erosion) prevent this soil buildup.

Where it is left unimpeded the process of forest soil-building transforms the unique native grassland community, with its high species diversity and many rare species, to common forests of moderate to very low species diversity and abundant introduced invasive species. Examples of introduced invasives that are common at the edges of the Unionville Barrens grasslands are autumn-olive, Oriental bittersweet, Japanese honeysuckle, Amur honeysuckle, multiflora rose and tree-of-heaven. Even some native species can take advantage of the soil-building and heat-shielding opportunities of the forest-grassland edge and begin overrunning the grassland, including red maple, black locust and two species of greenbrier. The result is the shrinkage and disappearance of grassland patches, one by one. The eventual result would be the tragic and irreversible loss of an extraordinary ecosystem that has existed for thousands of years.

To prevent common invasive plant species from destroying the Unionville Barrens, the critical needs are for land protection, including a buffer zone, and active management of invasives

Serpentine grasslands need periodic management if they are to sustain their ecological value in the relatively short term and to persist at all in the long term. Grassland size is a good surrogate measure of ecological value. Regular, low-intensity burning was a very effective tool for grassland maintenance, routine for the people who lived in the area for most of the past several centuries or thousands of years, but nowadays it is out of favor with most current residents.

Restorable areas and buffer zone

One critical need is to protect the land where we have direct evidence of serpentine grassland cover in historic times (Figs. 2, 3 and 4). To a close approximation, this is the area considered as restorable. Nearly as important is the protection of a surrounding buffer zone, ideally 1,000 feet in width but at least 300 feet at the barest minimum. Its main purpose would be to help filter out additional introduced invasive species that could otherwise spread into grasslands from adjacent residential gardens, landscaped areas, pastures and fallow fields — both those that exist now and those that could appear if future development were allowed to take place next to the barrens. The buffer zone also would keep options open for whole-site ecosystem management measures that may be found to be beneficial or even essential to the serpentine grasslands' survival in the future.

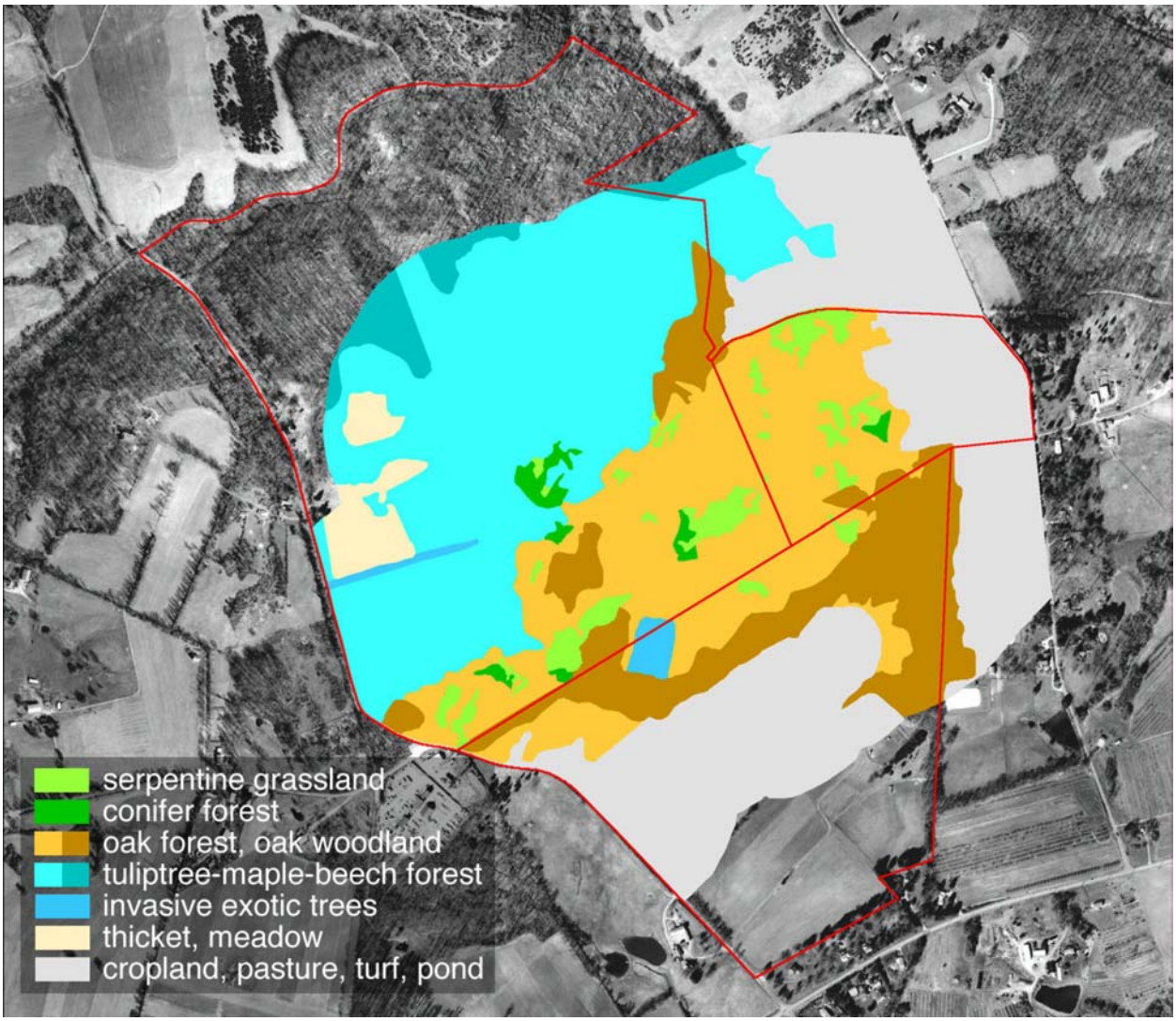

Figure 5. Map of current vegetation at the Unionville Barrens (north is at the top). The two-toned color codes for oak forest, oak woodland and tuliptree-maple-beech forest distinguish immature or short-stature stands (light color) from mature or tall-stature stands (dark color). The limits of the study area are Cannery Road (west and southwest), Glenhall Road (east), and a 1,000-foot buffer zone north and south of the maximum documented historical extent of the serpentine grasslands (see Figs. 2 and 3). The property lines of the Leisenring, Heckert and Kramkowski families are shown in red.

Management needs

The other major need is to begin a program of invasive-plant management. Annual or alternate-year mowing around the prairie edges, performed in winter to minimize disruption of wildlife, would keep greenbriers and other invasive woody plants from reducing the size of the remnant grassland patches still further. Basal-bark herbicide treatment would limit the further spread of autumn-olive, ailanthus, black locust, red

maple and other invasive trees. If spot-application of herbicide is performed correctly and at the right time of year, "collateral damage" to rare plants can be minimized.

The grasslands at the Unionville Barrens have already declined to a critically small total size. Further losses of rare plant and animal species are assured unless the decline is not just halted but substantially reversed. A key goal of an invasive-plant management program is to begin restoring the 40 to 45 acres of the Unionville Barrens north of Cannery Road that are known to have supported grassland within the last 70 years.

Opportunities for restoration

The areas with the best potential for successful restoration to serpentine savanna or prairie are where some of the native grassland species are still present. Such areas in the Unionville Barrens are of two types. One is conifer forests or woodlands, which presently cover 2.9 acres at Unionville (see Fig. 5). The dominant tree species is eastern red-cedar, a common species in intact serpentine savanna. The ground layer still includes some of the serpentine grasses and other native herbaceous species. The other type is oak-dominated forests that are immature or short in stature, which currently cover 61 acres (see Fig. 5). They are dominated by post oak, blackjack oak and black oak, which also are important components of intact serpentine savanna.

One additional vegetation type, which covers about 1.7 acres in a single contiguous patch, is well suited for conversion to native grassland. This is an area of immature forest dominated by introduced species, mainly tree-of-heaven, Japanese honeysuckle, multiflora rose and Japanese stilt-grass (see Fig. 5). As long as it is allowed to persist, this vegetation threatens the integrity of nearby intact grasslands by serving as a prolific seed source for several of the most invasive plant species.

To be truly effective, a program of invasive plant management and grassland restoration must include a well-planned and rigorously executed monitoring program. Its purpose is to gauge the degree of success or failure of management measures by tracking trends in the populations of rare species and in the extent of rare plant communities over the long term. Monitoring would provide an early warning of any deterioration so action can be taken while the effort required for a successful remedy is still modest and practical. It would document the comparative successes of various measures employed for invasive plant management, providing the information necessary to determine what adjustments may be needed to maximize the efficiency and effectiveness of the program.

The Unionville Barrens are a world-class natural resource, with a unique combination of geological and biological assets. The site has a rich history, including the remarkable story of how the serpentine barren ecosystem and its exceptional diversity of native species have been sustained even in the face of changing cultural practices. Despite the decline of grassland area in the last 70 years from 58 to only 9 acres, the Unionville

Barrens still include some of the best serpentine grasslands remaining. However, the remnants are critically endangered by accelerating forest encroachment. Several rare, barrens-restricted species are known to have died out already. Management of the remaining grasslands would arrest their acreage decline but rare species are expected to keep vanishing as the effects of the recent drastic loss in habitat area continue to unfold. Extending management into known areas of former grassland would restore the capacity of the Unionville Barrens to sustain their extraordinary species diversity and even to reinstate lost species, if they can be transferred from other sites in the region and reintroduced.

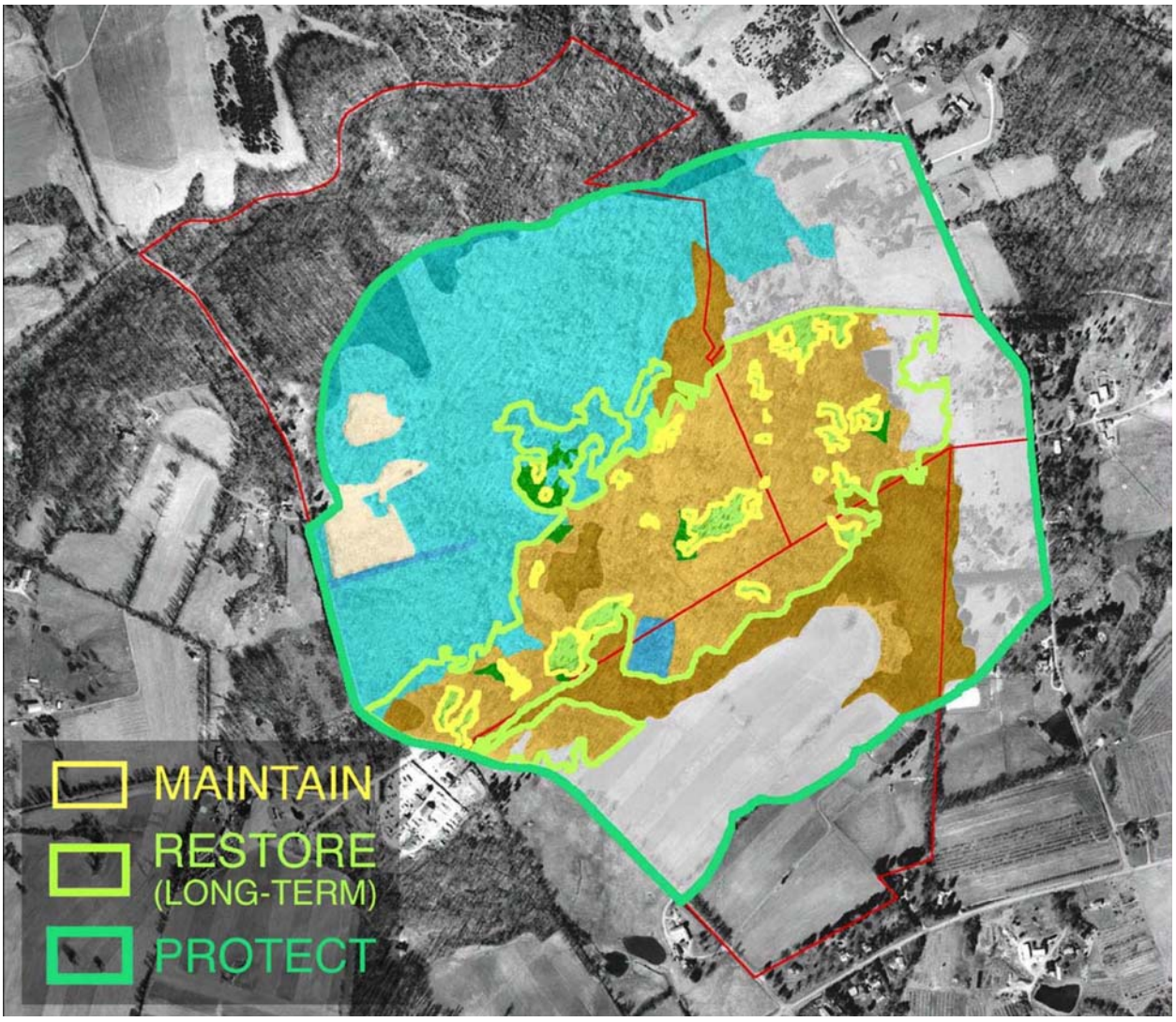

Figure 6. Recommended stewardship zones at the Unionville Barrens. Remnant serpentine grasslands (outlined in yellow) should be maintained by managing invasive plants. Areas documented as having supported serpentine grassland in recent decades (outlined in yellow-green) have the best potential for gradual, piecemeal restoration, perhaps over a period of 20 years or more. A buffer zone (outlined in green) should remain undeveloped as a barrier to dispersal of exotic plant seeds and other detrimental influences of surrounding land uses.

Endnotes

[1] Deevey and Flint 1957; Overpeck et al. 1992; Haas and McAndrews 2000; Williams et al. 2000

[2] Loope and Anderton 1998

[3] Maxwell 1910; Day 1953; Thompson and Smith 1970; Webster 1983; Dent 1985; Denevan 1992; Casselberry and Evans 1994; Black and Abrams 2001

[4] Patterson and Sassaman 1988; Denevan 1992; Clark and Royall 1996; Delcourt and Delcourt 1997, 1998

[5] Radford and Martin 1975; Erdman 1977; Latham 1984

[6] Darlington 1926, 1937

[7] Northeimer (1955) listed 44 species of grasshoppers, locusts, crickets, katydids and their close relatives that he had found on Chester County serpentine barrens from 1940 to 1955, but did not indicate at which sites each species was found.

[8] In the same study that failed to turn up the rare plant bugs on creeping phlox (*Phlox subulata*) at the Unionville Barrens, Wheeler (1995) did find two species of relatively common plant bugs, *Lopidea heidemanni* Knight and *L. minor* Knight.

[9] Wheeler (1988) found the rare beetle species, *Diabrotica cristata* (Harris), whose larvae are thought to feed on the native prairie grasses big bluestem (*Andropogon gerardii*) and little bluestem (*Schizachyrium scoparium*).

[10] Eastern regal fritillary (*Speyeria idalia idalia* Drury), red-banded hairstreak (*Calycopis cecrops* [Fabricius]), black-waved flannel moth (*Lagoa crispata* Packard), cobweb skipper (*Hesperia metea* Scudder)

[11] Hoekstra et al. 2004

[12] Cool-season grasses possess the most common photosynthetic pathway, known as C3 photosynthesis; new leaves emerge in late winter or early spring and they generally flower and set fruit in spring or early summer.

[13] Fescues (*Festuca arundinacea, F. elatior, F. longifolia, F. ovina, F. pratensis, F. rubra*), ryegrasses (*Lolium multiflorum, L. perenne*), bluegrasses (*Poa annua, P. pratensis, P. trivialis*), orchard grass (*Dactylis glomerata*), timothy (*Phleum pratense*)

[14] Warm-season grasses possess modified leaf anatomy and an unusual photosynthetic pathway, C4 photosynthesis; their emergence is often delayed until late spring or early summer and they generally flower and set fruit in late summer or fall.

[15] The native warm-season grasses present at the Unionville Barrens are little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardiiI*), Indian grass (*Sorghastrum nutans*) tall gramma (*Bouteloua curtipendula*), purpletop (*Tridens flavus*), prairie dropseed (*Sporobolus heterolepis*), tumble-grass (*Eragrostis spectabilis*), satin grass (*Muhlenbergia mexicana*), three-awn poverty grass (*Aristida dichotoma*), Philadelphia panic-grass (*Panicum philadelphicum*) and dropseed poverty grass (*Sporobolus vaginiflorus*),

[16] Pennell 1910, 1912

[17] R. E. Latham, unpublished data

[18] Poole 1949

[19] Hamerstrom 1982

[20] Gordon 1922; Pearre and Heyl 1960; Dague 1999

[21] Curran 1988

[22] Gordon 1922

[23] Pearre and Heyl 1960

[24] J.-L. Machado, Swarthmore College, personal communication, 2004; Shipley and Vu 2002

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Appendix A: Vascular plant species of the Unionville Barrens*

The list includes species recorded in 2002-2003 in surveys by Janet Ebert, with additions from fieldwork in 2003 by Roger Latham and historical records from the Pennsylvania Flora Project database (Rhoads and Block 2005). Species found in the woods, fields and roadsides adjacent to the barrens but not in the barrens themselves are excluded. Botanical nomenclature follows Rhoads and Block (2005).

common name	botanical name	state status	growth form
red maple	*Acer rubrum* L.	occasional	deciduous tree
yarrow	*Achillea millefolium* L.	introduced	perennial herb
agrimony	*Agrimonia pubescens* Wallr.	frequent	perennial herb
upland bent-grass	*Agrostis perennans* (Walt.) Tuckerman	common	perennial cool-season grass
tree-of-heaven	*Ailanthus altissima* (P.Mill.) Swingle	introduced & highly invasive	deciduous tree
field garlic	*Allium vineale* L.	introduced	perennial herb
common ragweed	*Ambrosia artemisiifolia* L.	common	annual herb
shadbush	*Amelanchier arborea* (Michx.f.) Fern.	common	deciduous tree
big bluestem	*Andropogon gerardii* Vitman	frequent	perennial warm-season grass
field pussy-toes	*Antennaria neglecta* Greene	frequent	perennial herb
plantain-leaved pussy-toes	*Antennaria plantaginifolia* (L.) Richardson	occasional	perennial herb
sweet vernal grass	*Anthoxanthum odoratum* L.	introduced	perennial cool-season grass
lyre-leaved rock cress	*Arabis lyrata* L.	frequent	biennial herb
wild sarsaparilla	*Aralia nudicaulis* L.	common	perennial herb
common burdock	*Arctium minus* (Hill) Bernh.	introduced	biennial herb
three-awn poverty grass	*Aristida dichotoma* Michx.	frequent	annual warm-season grass
Virginia snakeroot	*Aristolochia serpentaria* L.	occasional	perennial herb
whorled milkweed	*Asclepias verticillata* L.	occasional	perennial herb
green milkweed	*Asclepias viridiflora* Raf.	occasional	perennial herb

*Vascular plants are those with fluid-conducting "circulatory" systems, a category that includes all trees, shrubs, vines, wildflowers, grasses, sedges, ferns, clubmosses, and similar plants. It does not include mosses, liverworts, algae, or non-plants such as fungi, lichens, bacteria, and other microbes.

common name	botanical name	state status	growth form
ebony spleenwort	*Asplenium platyneuron* (L.) BSP	common	perennial herb
Japanese barberry	*Berberis thunbergii* DC.	introduced	deciduous shrub
side-oats gramma	*Bouteloua curtipendula* (Michx.) Torr.	threatened	perennial warm-season grass
upright bindweed	*Calystegia spithamaea* (L.) Pursh	occasional	perennial vine
nodding thistle	*Carduus nutans* L.	introduced	biennial herb
a sedge	*Carex albicans* Willd. ex Sprengel	occasional	perennial herb
a sedge	*Carex amphibola* Steud.	common	perennial herb
Bicknell's sedge	*Carex bicknellii* Britt.	endangered	perennial herb
a sedge	*Carex blanda* Dewey	frequent	perennial herb
a sedge	*Carex digitalis* Willd.	frequent	perennial herb
glaucous sedge	*Carex glaucodea* Tuckerman	frequent	perennial herb
a sedge	*Carex hirsutella* Mackenzie	common	perennial herb
a sedge	*Carex pensylvanica* Lam.	common	perennial herb
Richardson's sedge	*Carex richardsonii* R. Br.	endangered	perennial herb
a sedge	*Carex swanii* (Fern.) Mackenzie	common	perennial herb
a sedge	*Carex umbellata* Schkuhr ex Willd.	occasional	perennial herb
pignut hickory	*Carya glabra* (P.Mill.) Sweet	common	deciduous tree
American chestnut	*Castanea dentata* (Marshall) Borkh.	frequent	deciduous tree
New Jersey-tea	*Ceanothus americanus* L.	frequent	deciduous shrub
Oriental bittersweet	*Celastrus orbiculatus* Thunb.	introduced & highly invasive	woody vine
barrens chickweed	*Cerastium velutinum* Raf.	rare?	perennial herb
lamb's-quarters	*Chenopodium album* L.	frequent	annual herb
spotted wintergreen	*Chimaphila maculata* (L.) Pursh	common	perennial herb
swamp thistle	*Cirsium muticum* Michx.	occasional	biennial herb
wild oat-grass	*Danthonia spicata* (L.) Beauv. ex Roemer & Schultes	common	perennial herb
Queen Anne's-lace (wild carrot)	*Daucus carota* L.	introduced	biennial herb
hay-scented fern	*Dennstaedtia punctilobula* (Michx.) T.Moore	common	perennial herb
tufted hairgrass	*Deschampsia cespitosa* (L.) Beauv.	rare?	perennial cool-season grass

common name	botanical name	state status	growth form
small-leaved tick-trefoil	*Desmodium ciliare* (Muhl. ex Willd.) DC.	occasional	perennial herb
smooth small-leaved tick-trefoil	*Desmodium marilandicum* (L.) DC.	occasional	perennial herb
Deptford-pink	*Dianthus armeria* L.	introduced	biennial herb
autumn-olive	*Elaeagnus umbellata* Thunb.	introduced & highly invasive	deciduous shrub
slender spike-rush	*Eleocharis tenuis* (Willd.) Schultes	endangered	perennial herb
beechdrops	*Epifagus virginiana* (L.) Bart.	common	annual herb
trailing arbutus	*Epigaea repens* L.	frequent	evergreen shrub
tumble-grass	*Eragrostis spectabilis* (Pursh) Steud.	occasional	perennial warm-season grass
small white snakeroot	*Eupatorium aromaticum* L.	rare	perennial herb
white wood aster	*Eurybia divaricata* (L.) Nesom	common	perennial herb
American beech	*Fagus grandifolia* Ehrh.	common	deciduous tree
meadow fescue	*Festuca elatior* L.	introduced	perennial cool-season grass
annual fimbry	*Fimbristylis annua* (All.) Roemer & Schultes	threatened	annual herb
black huckleberry	*Gaylussacia baccata* (Wang.) K.Koch	common	deciduous shrub
witch-hazel	*Hamamelis virginiana* L.	frequent	deciduous shrub
hoary rockrose	*Helianthemum bicknellii* Fern.	endangered	perennial herb
tall sunflower	*Helianthus giganteus* L.	occasional	perennial herb
alumroot	*Heuchera americana* L.	frequent	perennial herb
rattlesnake-weed	*Hieracium venosum* L.	frequent	perennial herb
bluets	*Houstonia caerulea* L.	common	perennial herb
American holly	*Ilex opaca* Ait.	threatened	evergreen tree
one-sided rush	*Juncus secundus* Beauv. ex Poir.	occasional	perennial herb
path rush	*Juncus tenuis* Willd.	common	perennial herb
eastern red-cedar	*Juniperus virginiana* L.	common	evergreen tree
mountain-laurel	*Kalmia latifolia* L.	common	evergreen shrub
yellow smooth wild lettuce	*Lactuca canadensis* L.	occasional	annual herb

common name	botanical name	state status	growth form
prickly lettuce	*Lactuca serriola* L.	introduced	annual herb
cow-cress	*Lepidium campestre* (L.) R.Br.	introduced	annual herb
narrow-leaved bush-clover	*Lespedeza virginica* (L.) Britt.	occasional	perennial herb
spiked lobelia	*Lobelia spicata* Lam.	frequent	perennial herb
Japanese honeysuckle	*Lonicera japonica* Thunb.	introduced & highly invasive	woody vine
Amur honeysuckle	*Lonicera maackii* (Rupr.) Maxim.	introduced & highly invasive	deciduous shrub
wood rush	*Luzula multiflora* (Ehrh.) Lej.	common	perennial herb
bugleweed	*Lycopus virginicus* L.	frequent	perennial herb
whorled loosestrife	*Lysimachia quadrifolia* L.	common	perennial herb
Japanese stilt-grass	*Microstegium vimineum* (Trin.) A.Camus.	introduced & highly invasive	annual warm-season grass
rock sandwort	*Minuartia michauxii* (Fern.) Farw.	occasional	annual herb
partridge-berry	*Mitchella repens* L.	common	perennial herb
Indian-pipe	*Monotropa uniflora* L.	common	perennial herb
satin grass	*Muhlenbergia mexicana* (L.) Trin.	occasional	perennial warm-season grass
bayberry	*Myrica pensylvanica* Loisel.	occasional	deciduous shrub
blackgum	*Nyssa sylvatica* Marshall	common	deciduous tree
sundrops	*Oenothera fruticosa* L.	occasional	perennial herb
yellow wood-sorrel	*Oxalis dillenii* Jacq.	common	perennial herb
pointed-leaved panic-grass	*Panicum acuminatum* Swartz	common	perennial cool-season grass
deer-tongue grass	*Panicum clandestinum* L.	common	perennial cool-season grass
poverty panic-grass	*Panicum depauperatum* Muhl.	occasional	perennial cool-season grass
forked panic-grass	*Panicum dichotomum* L.	common	perennial cool-season grass
Heller's witch-grass	*Panicum oligosanthes* Schultes	rare?	perennial cool-season grass

common name	botanical name	state status	growth form
Philadelphia panic-grass	*Panicum philadelphicum* Bernh. ex Trin.	frequent	annual warm-season grass
globe-fruited panic-grass	*Panicum sphaerocarpon* Ell.	occasional	perennial cool-season grass
long-haired panic-grass	*Panicum villosissimum* Nash	rare?	perennial cool-season grass
Virginia-creeper	*Parthenocissus quinquefolia* (L.) Planch.	common	woody vine
fame-flower	*Phemeranthus teretifolius* Pursh	threatened	perennial herb
creeping phlox	*Phlox subulata* L.	occasional	perennial herb
shortleaf pine	*Pinus echinata* P.Mill.	rare?	evergreen tree
ragged fringed orchis	*Platanthera lacera* (Michx.) G.Don	occasional	perennial herb
Canada bluegrass	*Poa compressa* L.	introduced	perennial cool-season grass
Kentucky bluegrass	*Poa pratensis* L.	introduced	perennial cool-season grass
whorled milkwort	*Polygala verticillata* L.	frequent	annual herb
long-bristled smartweed	*Polygonum caespitosum* Blume	introduced	annual herb
slender knotweed	*Polygonum tenue* Michx.	frequent	annual herb
polypody	*Polypodium virginianum* L.	common	perennial herb
Christmas fern	*Polystichum acrostichoides* (Michx.) Schott	common	perennial herb
bigtooth aspen	*Populus grandidentata* Michx.	common	deciduous tree
dwarf cinquefoil	*Potentilla canadensis* L.	common	perennial herb
tall white wild lettuce	*Prenanthes altissima* L.	common	perennial herb
heal-all	*Prunella vulgaris* L.	common	perennial herb
black cherry	*Prunus serotina* Ehrh.	very common	deciduous tree
bracken	*Pteridium aquilinum* (L.) Kuhn	common	perennial herb
narrow-leaved mountain-mint	*Pycnanthemum tenuifolium* Schrad.	common	perennial herb
Virginia mountain-mint	*Pycnanthemum virginianum* (L.) Durand & Jackson ex B.L.Robins. & Fern.	occasional	perennial herb
white oak	*Quercus alba* L.	common	deciduous tree

common name	botanical name	state status	growth form
scarlet oak	*Quercus coccinea* Muenchh.	common	deciduous tree
blackjack oak	*Quercus marilandica* Muenchh.	occasional	deciduous tree
chestnut oak	*Quercus montana* Willd.	common	deciduous tree
water oak	*Quercus nigra* L.	endangered	deciduous tree
dwarf chestnut oak	*Quercus prinoides* Willd.	occasional	deciduous shrub
northern red oak	*Quercus rubra* L.	common	deciduous tree
post oak	*Quercus stellata* Wang.	occasional	deciduous tree
black oak	*Quercus velutina* Lam.	common	deciduous tree
pinxter-flower	*Rhododendron periclymenoides* (Michx.) Shinners	common	deciduous shrub
shining sumac	*Rhus copallina* L.	frequent	deciduous shrub
black locust	*Robinia pseudoacacia* L.	common	deciduous tree
pasture rose	*Rosa carolina* L.	frequent	deciduous shrub
multiflora rose	*Rosa multiflora* Thunb. ex Murr.	introduced & highly invasive	deciduous shrub
blackberry	*Rubus allegheniensis* Porter	common	deciduous shrub
dewberry	*Rubus flagellaris* Willd. sensu lato	frequent	woody vine
thimbleberry	*Rubus occidentalis* L.	common	deciduous shrub
wineberry	*Rubus phoenicolasius* Maxim.	introduced	deciduous shrub
sheep-sorrel	*Rumex acetosella* L.	introduced	perennial herb
sassafras	*Sassafras albidum* (Nutt.) Nees	common	deciduous tree
early saxifrage	*Saxifraga virginiensis* Michx.	common	perennial herb
little bluestem	*Schizachyrium scoparium* (Michx.) Nash	common	perennial warm-season grass
few-flowered nutrush	*Scleria pauciflora* Muhl. ex Willd.	threatened	perennial herb
hyssop skullcap	*Scutellaria integrifolia* L.	occasional	perennial herb
Appalachian groundsel	*Senecio anonymus* A.Wood	rare	perennial herb
common groundsel	*Senecio vulgaris* L.	introduced	annual herb
yellow foxtail	*Setaria pumila* (Poir.) Schultes	introduced	annual warm-season grass
starry campion	*Silene stellata* (L.) Ait.f.	occasional	perennial herb
glaucous greenbrier	*Smilax glauca* Walt.	common	woody vine

common name	botanical name	state status	growth form
round-leaved greenbrier	*Smilax rotundifolia* L.	common	woody vine
Canada goldenrod	*Solidago canadensis* L.	very rare	perennial herb
early goldenrod	*Solidago juncea* Ait.	common	perennial herb
gray goldenrod	*Solidago nemoralis* Ait.	common	perennial herb
rough-stemmed goldenrod	*Solidago rugosa* Ait.	occasional	perennial herb
Indian grass	*Sorghastrum nutans* (L.) Nash	frequent	perennial warm-season grass
Prairie wedge-grass	*Sphenopholis obtusata* (Michx.) Scribn.	rare	perennial cool-season grass
prairie dropseed	*Sporobolus heterolepis* (A.Gray) A.Gray	endangered	perennial warm-season grass
dropseed poverty grass	*Sporobolus vaginiflorus* (Torr. ex A.Gray) A.Wood	frequent	annual warm-season grass
serpentine aster	*Symphyotrichum depauperatum* (Fern.) Nesom	threatened	perennial herb
calico aster	*Symphyotrichum lateriflorum* (L.) A.&D.Love	common	perennial herb
heath aster	*Symphyotrichum pilosum* (Willd.) Nesom	very rare	perennial herb
dandelion	*Taraxacum officinale* Weber	introduced	perennial herb
marsh fern	*Thelypteris palustris* Schott	common	perennial herb
poison-ivy	*Toxicodendron radicans* (L.) Kuntze	common	woody vine
bluecurls	*Trichostema dichotomum* L.	frequent	annual herb
purpletop	*Tridens flavus* (L.) A.S.Hitchc.	common	perennial warm-season grass
lowbush blueberry	*Vaccinium pallidum* Ait.	common	deciduous shrub
deerberry	*Vaccinium stamineum* L.	frequent	deciduous shrub
moth-mullein	*Verbascum blattaria* L.	introduced	biennial herb
maple-leaved viburnum	*Viburnum acerifolium* L.	common	deciduous shrub
southern arrowwood	*Viburnum dentatum* L.	common	deciduous shrub
arrow-leaved violet	*Viola sagittata* Ait.	frequent	perennial herb
common blue violet	*Viola sororia* Willd.	common	perennial herb
frost grape	*Vitis vulpina* L.	frequent	woody vine

Appendix B: Author's profile

Dr. Latham's career as an ecologist, conservation biologist, and environmental planner spans 32 years. His basic research is on plant diversity patterns, from micro- to global scales. He does applied research and planning as a consultant for The Nature Conservancy, Natural Lands Trust, National Park Service, and other organizations and agencies involved in wildland management.

Since earning his B.A. in biology at Swarthmore College and his Ph.D. in biology at the University of Pennsylvania, he has also served as Director of Science and Stewardship and Stewardship Ecologist for The Nature Conservancy in Pennsylvania; post-doctoral researcher in fire ecology and forest biogeochemistry at the Department of Geology, University of Pennsylvania; and Assistant Professor in the Department of Biology at Swarthmore College.

Dr. Latham's work has been published in top ecological journals, including *Ecology*, *American Naturalist*, *Oikos*, *Quarterly Review of Biology*, *Biodiversity and Conservation, Landscape Ecology, Forest Ecology and Management*, and *Canadian Journal of Forest Research*. His scientific publications also include chapters in peer-reviewed books and proceedings: *Species Diversity in Ecological Communities: Historical and Geographical Perspectives* (R. E. Ricklefs and D. Schluter, 1993, U. of Chicago Press); *Global Biodiversity Assessment* (V. H. Heywood, 1995, Cambridge U. Press/U.N. Environmental Programme); and *Shrublands and Early-successional Forests: Critical Habitats Dependent on Disturbance in the Northeastern United States* (J. A. Litvaitis et al., 2003, Elsevier).

Recently, Dr. Latham was the editor and a contributing author of the peer-reviewed book *Managing White-tailed Deer in Forest Habitat from an Ecosystem Perspective* (2005, Audubon Pennsylvania). He has served since 1999 as Editor of *Bartonia*, the journal of the Philadelphia Botanical Club, and is currently working on a book about the vegetation of Pennsylvania and how earth history, geology, climate, hydrology, soil processes, fire, and human influences have shaped it.