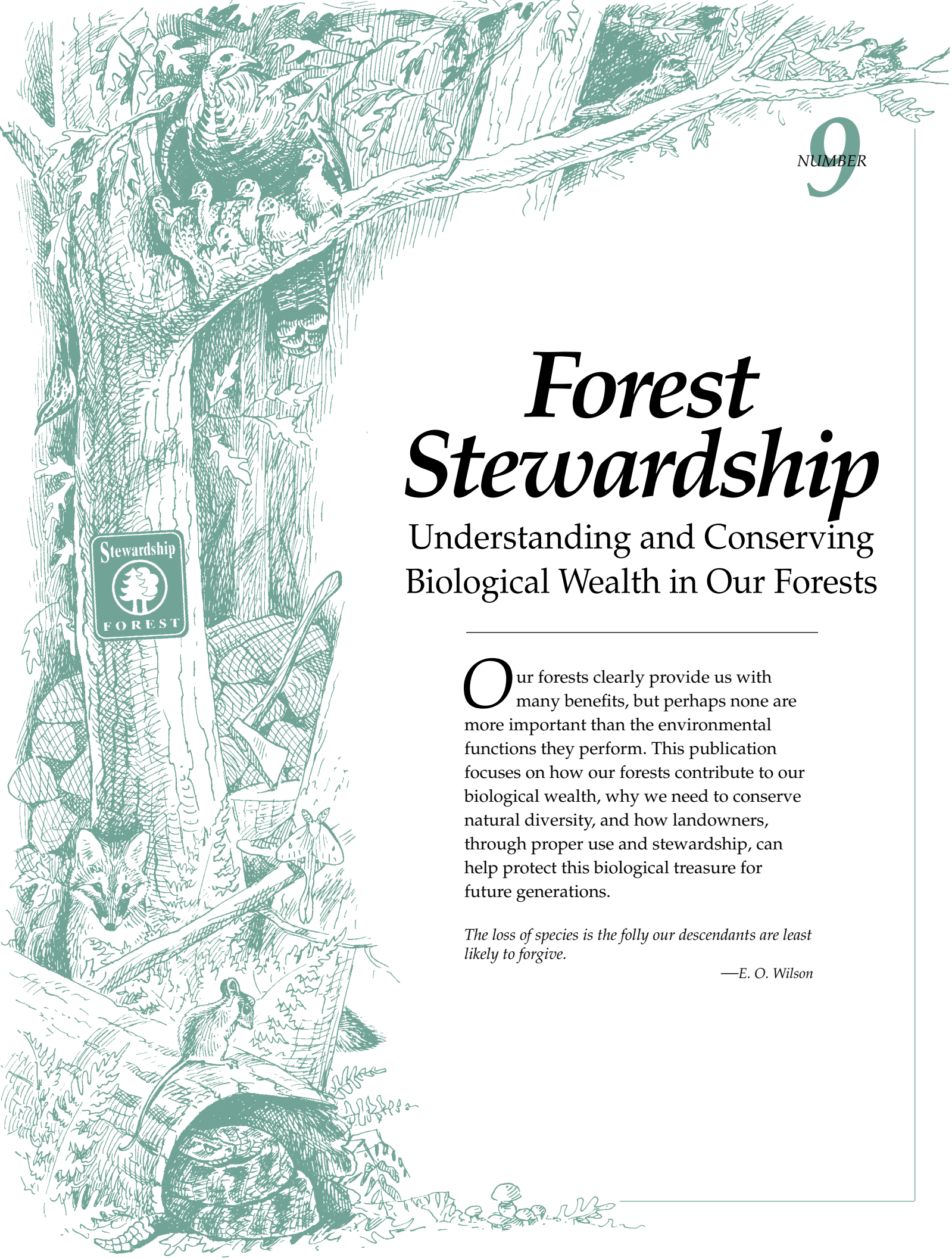


NUMBER 9

Forest Stewardship

Understanding and Conserving Biological Wealth in Our Forests

Our forests clearly provide us with many benefits, but perhaps none are more important than the environmental functions they perform. This publication focuses on how our forests contribute to our biological wealth, why we need to conserve natural diversity, and how landowners, through proper use and stewardship, can help protect this biological treasure for future generations.

The loss of species is the folly our descendants are least likely to forgive.

—*E. O. Wilson*

Understanding biological wealth in our forests

No series about the value of forests would be complete without addressing the issue of biodiversity. *Biodiversity,* a term used interchangeably with *biological diversity*, is often confusing and sometimes controversial. In general, biodiversity refers to the richness or variety of animal, plant, and other life in a given area, from the tiniest snail or moss to the largest predator. More comprehensively, biodiversity encompasses not only the species themselves, but the complex interactions between species and the natural communities and ecosystems that they form. These interacting plant and animal species are like strands of a spider web, each adding to the delicate balance that fosters environmental stability. This rich and complex composite of life is our biological wealth, for it forms the living part of the natural resource base upon which humans depend and of which humans are an integral part. As new technology allows us to exert more and more control over our environments to suit our needs, it is important to keep this connection in mind. (See box at right.)

On a global level, the way we manage our biological diversity may, in the long run, determine our biological destiny. It is not likely that the actions of any one individual will cause a large-scale environmental catastrophe. But it is possible that the collective actions of people across the world will effect a gradual erosion of environmental stability and hence create an environment in which humans, among other species, would be unable to survive. To some, this view may seem alarmist, but it is important to see how individual actions contribute to the whole. The management section of this publication focuses on the need for individuals to make environmentally responsible decisions in the area in which they live or own land. It also provides suggestions on how biodiversity may be incorporated into long-range management planning.

UNDERSTANDING BIODIVERSITY

Because individual life forms do not exist in a vacuum, we need to expand our concept of diversity to include more than just numbers of particular species. By examining the interactions between species at various levels, we can learn more about how natural communities function. In turn, we can learn how to influence these processes so that we can meet our growing needs in sustainable ways. Because the idea of biodiversity is so complex, it is useful to ask ourselves about this variety of animal and plant life, and why we are managing for it. The variety of biological diversity includes genetic diversity, species diversity, and ecosystem diversity. (See Figure 1 on page 3.)

GENETIC DIVERSITY

This is the level of biodiversity most people have difficulty understanding. Each individual organism is a unique chemical and genetic factory unlike any other of its species. No two humans are alike, for example. This reservoir of information has taken centuries to develop; it cannot be duplicated or retrieved once it has been lost. A diverse or varied gene pool provides a hedge against an unknown future. It allows a species to adapt to constantly changing environmental conditions.

SPECIES DIVERSITY

This is the level of biodiversity that usually receives the most attention. It is the many different kinds or varieties of plants, fungi, fish, amphibians, reptiles, mammals, birds, and other organisms that make up the living world around us. Pennsylvania has more than 108 native tree species, over 250 shrub species, approximately 62 native mammal species, 250 native birds (with 177 nesting), 73 native species of amphibians and reptiles, and more than 150 kinds of fish. An important part of species diversity comes with understanding how species change from place to place, and how they change over time in the same place.

ECOSYSTEM DIVERSITY

This kind of diversity involves the various species living in an area, the ecological processes that link them together, and the soil, air, and water that support the living organisms comprising the ecosystem. Many different kinds of ecosystems occur in different physical settings, and within each ecosystem many tiers exist which support additional diversity. We know ecosystems as a hardwood forest, a wetland, a prairie, a cave, or a stream, to name just a few. The multiple layers of plant growth in a hardwood forest, from herbaceous to shrub to the forest canopy, are an example of the tiers within an ecosystem.

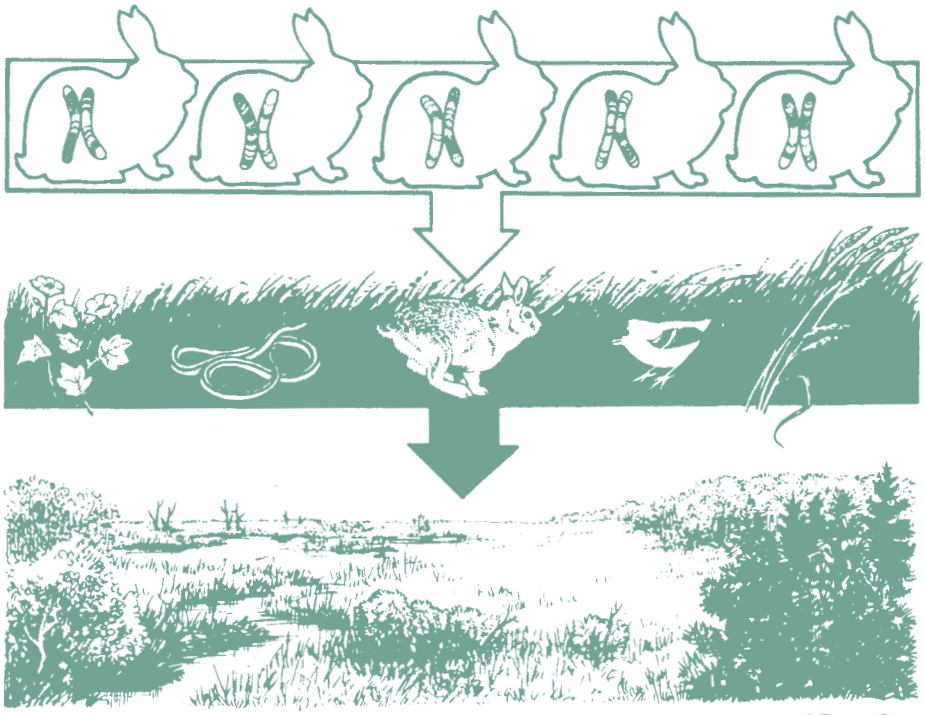
All these components of biodiversity—genetic, species, and ecosystem diversity—are interconnected. As we begin to better understand the complex processes that occur at these different levels, we need to consider how our management decisions affect each of these biodiversity components. Since ecosystems rarely, if ever, follow management boundaries or property lines, the issue of scale becomes very important in this process.

Figure 1. Levels of biodiversity.

Genetic Diversity
The variation in genetic composition of individuals within and among species (e.g., variation within a population of rabbits).

Species Diversity
The variety of different species found in an area (e.g., the variety of species found in a prairie).

Ecosystem Diversity
The variety of physical environments and biotic communities over a landscape (e.g., the variety of forests, grasslands, wetlands, and aquatic systems over a region).



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INVESTMENT IN THE FUTURE

The many ways that we benefit from biodiversity are not readily apparent, but they are very important. These values can be categorized into four general areas: economics, environmental benefits, personal values, and enjoyment.

Economics

While many may think that biodiversity has little relevance to our daily lives, it does in fact contribute to many products we use each day—including food, fiber, medicine, paper, and plastics. Yet all the plant and animal products that fill our homes are just a minute representation of the world's biodiversity. Are you aware, for example, that the world's agricultural base today relies on only a few wild plant species, while almost half of our nation's prescription medicines comes from a few plant and animal species? Although some of nature's chemical compounds can be replicated in the lab, there is no replacement for the many tangible products, both known and unknown, that each species contributes to the overall system.

Although humans have benefited a great deal from a few cultivated species, a wealth of information is awaiting discovery. For instance, snails and other mollusks might seem to be expendable. However, scientists recently discovered that certain mollusks do not get cancer. Now scientists are searching for the chemicals that produce this natural immunity. Many overlooked species, in their own way, contribute a good deal to our lives and to the lives of other species. (See Table 1.)

Environmental benefits

As mentioned earlier, biodiversity is also the source of many ecological benefits. All species depend on our natural environment for survival. Biodiversity is the basis for life-sustaining ecological services such as nutrient cycling, photosynthesis,

Table 1. Examples of benefits derived from other species.

SPECIES OR GROUP	TYPE	USE BY PEOPLE
Bacillus thuringiensis	bacteria	gypsy moth control
Penicillium	mold	medicine (penicillin)
Foxglove	plant	heart medicine (digitalis)
Snails/mollusks	invertebrates	cancer research
Brown bat	mammal	transplant research
Wheat	plant	food
Rhesus monkey	mammal	medical research
Loblolly pine	plant	paper
Rosy periwinkle	plant	antileukemia medicine
Acinetobacteria	bacteria	oil spill cleanup
Freshwater mussel	invertebrate	indicator of water quality
White ash	plant	furniture products
Atlantic squid	invertebrate	nervous system research

decomposition, soil creation, climate regulation, removal of pollutants, and insect control. All these processes contribute to the stability of the earth's environment, on which we rely for the air we breathe, the water we drink, and the food we eat. Mollusks, in addition to their possible benefit to medicine, are also very sensitive indicators of changes in environmental quality. Because many species are sensitive to pollution, declining populations of freshwater mussels can indicate degraded water quality conditions. Currently, more than half of the freshwater mussels native to the United States are threatened or endangered.

Personal values

Many people support biodiversity because it satisfies some personal value. These personal values are as varied as the people who hold them. Conservationists today vary in their approaches to the ethical dimensions of resource management. However, most people agree that we have a responsibility to ensure that future generations have all the pieces needed to sustain life on earth. As Aldo Leopold once said, "The first rule of intelligent tinkering is to save all the cogs and wheels."

Enjoyment

Biodiversity contributes to our enjoyment of natural beauty, outdoor recreation, and peace of mind. Some people are drawn to nature to escape the hurried pace of city life. Others may rarely see natural places in their day-to-day lives, but find comfort knowing that natural places exist. Even though some people will never see a bog or an Indiana bat, just knowing that they exist is important to them. Will your children and grandchildren have the chance to know and enjoy the environment that you now enjoy? That, in part, depends on the collective decisions we make today.

THE EXTINCTION DISTINCTION

Now that we've covered how we benefit from biodiversity, let's examine some of the issues that make managing for biodiversity so controversial. One frequently cited argument against preserving biodiversity is that extinction is a natural process and that trying to prevent the loss of species is futile. The total number of species is unknown, but reports show only one-tenth of the estimated total number of species has been identified. Some scientists estimate that 90 percent of all species that ever existed are now extinct, but does that make the loss of species natural? Well, yes and no. Losing species that can no longer adapt to an area is a natural process. But losing them at the rate we are today is not. What has caused scientists concern in recent years is not that extinction is occurring, but how quickly it's occurring. The rate of species loss is higher than in the past, including times of mass extinction. This tremendous difference in the rate of species facing extinction is what is meant by the *extinction distinction.*

An example is the passenger pigeon. At one time the most abundant bird in the world, passenger pigeons were so numerous in Pennsylvania that a flock of 300 million could fly overhead in one hour. Some nesting colonies occupied more than 40 square miles. But due to a combination of overhunting and habitat loss, the last one died in 1912. When a species goes from abundance to extinction in such a short time, it draws attention to the possibility that humans may be affecting the environment in ways we do not understand. Because we have a lot to learn about how the web works and what species are the "cornerstones" of our environmental system, we should assume that each species plays an important role in the natural world and work to maintain as much of the biodiversity around us as we can.

Another argument against saving endangered species (species in danger of extinction), is the enormous economic costs usually involved. Some people believe that protecting biodiversity means putting plants and animals before people. However, the cost of saving species would be greatly reduced if some basic environmental management principles were applied proactively, that is, before environmental degradation is severe enough to cause the rapid decline of species. To effectively preserve biodiversity, we must expand our approach to managing natural systems to encompass long-term and long-range perspectives. This will entail leaving behind a reactive management approach that narrowly focuses on only those species already threatened or endangered. By attempting to understand the interactions of plants, animals, microorganisms, and fungi in their natural communities and managing with an ecosystem perspective over large areas, we will be better prepared to respond to both anticipated and unanticipated changes in the surrounding environment. Currently, partnerships are developing among private citizens, government agencies, industry, and conservation organizations to develop and implement ecosystem management plans across ownership boundaries.

WHY ARE WE LOSING BIODIVERSITY?

Why are we losing species at such an accelerated rate? A number of factors contribute to the decline and loss of species. Historically, humans directly caused the loss of many species through overexploitation for food or profit, or habitat destruction such as in the case of the passenger pigeon. Today, however, the reasons for species decline are more indirect and involve complex ecological interactions that are not always easy to determine. Some of these more indirect causes include habitat loss and fragmentation, introduced species and disease, overpopulation of certain species, pollution, and poor management practices. (See box on page 5.) The appendix on page 13 provides more information on federal and state definitions.

Habitat loss occurs when the habitats of animals and plants are changed or significantly reduced. An extreme example of habitat loss is when a forest is converted into a parking lot or housing development. A related problem is habitat fragmentation, which occurs when a large habitat is broken into a number of smaller habitat patches, or fragments. Patches isolated from each other by areas that are very different from the

HOW FOREST LANDOWNERS FIT IN

If you are a forest landowner, you play a vital part in conserving our state's biological wealth, simply because private landowners own most of Pennsylvania's forestland. Like pieces of a puzzle, what you and other landowners choose to do with your land will affect the management efforts already underway by state agencies such as the Game Commission, the Fish and Boat Commission, and the Bureau of Forestry, as well as conservation organizations and the timber industry.

No one is suggesting that you should lock up your land as a biodiversity preserve. Quite the contrary. This publication, as part of the Forest Stewardship series, is intended to provide you with the background necessary to make informed judgments. We encourage you to become more knowledgeable about the values your land has to offer, and to actively manage it to meet as many of your objectives as possible. The background information presented here is provided to help you better understand and implement the management steps suggested in the second part of this publication.

original habitat restrict species movement and interactions. Three groups of species are adversely affected by habitat fragmentation.

- *Species with large home ranges,* such as bears and large carnivores, which require extensive areas of habitat to survive
- *Species unable to disperse easily,* such as many amphibian and reptile species, which do not move over large areas (Fragmentation of their preferred habitat isolates small populations and disrupts their breeding patterns.)
- *Habitat interior species,* such as many of our forest songbirds, which breed most successfully in extensive areas of the forest but raise few young in small forest patches

In Pennsylvania, fragmented forests often benefit generalists, such as deer and raccoon, which do not have exacting habitat requirements. But fragmented forests negatively affect populations of species such as wood thrush and other types of songbirds that require the protected interior of forests. Forest fragmentation is considered a major threat to the biodiversity of forested habitats in this state.

Another threat to biodiversity is competition from introduced species (animal or plant species that have been brought into areas where they never existed before), such as the gypsy moth. Introduced species may outcompete native species and have negative effects on a forest ecosystem. Examples of exotic invasive plant species include Japanese honeysuckle and multiflora rose, which are both prolific and tenacious competitors. Yet another threat to our forests' ecological stability is pollution. Air pollution and acid rain can have detrimental effects on the productivity of a forest ecosystem and may make certain species more susceptible to damage from insects or disease.

When a species, even a native species, explodes to the point of overpopulation, other species in the natural community are adversely affected. High populations of white-tailed deer across the state are diminishing plant diversity on a dramatic scale. The resulting change in plant communities is consequently affecting other organisms that rely on our forests for nesting and food. Perhaps of greatest concern to the forest landowner is that high deer densities across the state have created regeneration problems in hardwood stands and have the potential to lower the quality of the future timber resources. (See box on page 6.)

The final threat we'll discuss is poor management practices. For instance, improper timber harvesting can cause adverse environmental effects, such as soil erosion and stream sedimentation, damage to residual stands, long-term regeneration problems, and low species diversity. All of these negative impacts combine to reduce biodiversity in our forest ecosystems. As our human population continues to grow and more land is developed or converted for human use, it is essential that we each embrace a stewardship ethic as we manage the natural resources in our care.

WHAT MAKES CERTAIN SPECIES PRONE TO EXTINCTION?

Habitat disturbances do not affect all species equally. Some plants and animals are very sensitive to changes in the areas where they breed or find food and shelter. These species generally fall into one or more of the following categories.

Specialized species

These species have evolved highly specialized habitat requirements. They may have adapted to a particular habitat to avoid competition from other species. Often such species have developed characteristics that serve them well when they are living in one area, such as eating a certain kind of food, but if they are forced outside that area or if that area changes significantly, these species may begin to decline. A specific example in Pennsylvania is the decline in wetland-dependent species, such as migratory water-fowl, and many rare plants and invertebrates that need these wet, productive areas to survive. (See box on page 7.) Also, many amphibians, such as the

spotted salamander, are dependent on seasonal ponds, and have difficulty successfully reproducing if the pond is altered or their dispersal routes are modified.

Species sought by people

Certain species are declining because they either interfere with human activities or have commercial value. "Pest" species are vulnerable to extinction because they are frequently poisoned, shot, or harmed in some other way. Some Pennsylvanians, for example, consider predators to be pests, while some anglers dislike certain birds, such as herons and kingfishers, that consume large quantities of fish. Other species are sought for their valuable fur, skin, meat, or other special quality. In addition, species such as the timber rattlesnake, perceived as posing a danger to humans, are sometimes destroyed indiscriminately regardless of their actual threat. Although the timber rattlesnake is not listed as endangered, it is thought to be declining throughout its central Pennsylvania range and currently is a candidate species for state protection. Over the years, development has fragmented more of its habitat, contributing to the problem. Researchers who work closely with timber rattlesnakes have found that rattlesnakes have remarkable homing abilities, although the mechanisms remain a mystery. They also have learned rattlesnakes pose very little threat to humans. Rattlesnakes prefer to leave people alone and almost always do. Unfortunately, many people consider rattlesnakes a nuisance to be removed, and they are hunted for sport in many areas of Pennsylvania. Recognition of the rattlers' value in the web of life may elicit a change in people's attitudes.

Rare species

Another factor contributing to certain species' decline is the fact that they are naturally rare. A rare species has a small number of individuals and/or a limited range. In both cases, these species are often vulnerable to habitat modification or other changes in their environment, such as the introduction of competing species. Sometimes the fact that a species is rare makes it more vulnerable to other pressures, such as collecting. This is true in the case of many plants, such as Pennsylvania's only native cactus, the prickly pear. One-third of all cacti in the United States are now endangered.

Species dependent on "partner" species

Sometimes species have "partners" or other species they depend on to help fill one or more of their ecological needs. When human actions affect one species, they indirectly affect its partner as well. An example of paired species in the United States is the black-footed ferret and the prairie dog. The ferret's main source of food is the prairie dog, which is considered a pest by Western ranchers and is frequently hunted and poisoned. The ferret is endangered in large part due to declining numbers of prairie dogs, its main prey, and the frequent ingestion of poisoned meat. Pennsylvania may have dependent species relationships of which we are unaware. Scientists have studied only a small percentage of the world's plant and animal species, and very little is known about how species ultimately depend on each other.

POPULATION LEVELS DETERMINE WHETHER DEER ARE FOREST FRIENDS OR FOES

Some foresters, and perhaps some frustrated forest landowners, too, refer to deer as "mountain maggots" because of their relentless appetite for spring wildflowers, agricultural crops, hardwood seedlings, suburban landscaping, and other browse. Deer consume a variety of plant material ranging from broadleaf plants to lichens. One study found that deer consume close to 100 different plant species. Deer change foods with the seasons, as their nutritional needs change and as browse availability varies. In winter deer are forced to eat less nutritious woody browse, such as hemlock or pine boughs. By eating the buds, stems, and leaves of shrubs and young trees, deer greatly influence the types and abundance of trees, shrubs, and herbaceous plants that grow in our forests. The change in forest plant communities that this creates in turn affects wildlife species that depend on this vegetation for shelter and food.

So how many deer can our forests sustain without adversely affecting a number of plant and animal species? According to the Pennsylvania Game Commission, the deer density in Pennsylvania varies depending on habitat availability, food sources, and hunting pressure. The USDA Forest Service recently completed a 10-year study of the impact of deer density on forest resources in the Allegheny National Forest. The study compared higher levels of deer density (38 and 64 deer per square mile) to control areas that had 10 deer per square mile. In the experimental areas valuable wildlife food species such as aspen, sugar maple, and cucumber tree were lost; the ground cover was reduced by 27 percent; and the wildflowers jack-in-the-pulpit and goldenrod were completely removed. Songbird abundance declined by 12 percent, and the least flycatcher, wood pewee, phoebe, cerulean warbler, and black-billed cuckoo were eliminated. In summation, density levels greater than 20 deer per square mile negatively affected the diversity of woody vegetation, wildflowers, and songbirds in the study areas. Researchers believe that maintaining the diversity of plant and animal species will require reducing the state's deer herd to more sustainable levels.

FRAGILE WETLANDS IN PENNSYLVANIA

All life has its roots in the meeting of earth and water. —T. H. Watkins

Wetlands are among Pennsylvania's most undervalued natural resources. Covering less than 2 percent of the state, they provide benefits that far exceed their limited distribution. Over the past 200 years, agricultural expansion and urban development have destroyed or degraded 56 percent of our state's original wetlands. What are wetlands and why do we need to protect them? Wetlands are areas of land saturated by water for varying periods of time during the growing season. They include marshes, swamps, wet meadows, sloughs, floodplains, bogs, fens, mud flats, and shallow ponds. Wetlands act as a vital link between dry land and open water and provide us with a number of invaluable environmental benefits.

Most people think of wetlands as swampy areas that support grasses, sedges, rushes, and other plants. In reality, two-thirds of Pennsylvania wetlands are either brush-shrub or forested wetlands. Forested wetlands are dominated by large trees (over 20 feet in height) such as silver maple, river birch, red maple, elm, spruce, blackgum, green ash, tamarack, and hemlock. Almost one-half of Pennsylvania's wetlands are located in the northern part of the state and close to 45 percent (221,000 acres) are forested. Other wetland types associated with forests include temporary (vernal or autumnal) ponds, spring seeps, and streamside wetlands.

Why all the concern about wetlands? Today there is a growing awareness that Pennsylvania's wetlands are more than wastelands or sinks for agricultural runoff, refuse, or industrial wastes. Wetlands check the destructive power of storms and floods, and act as filters to purify polluted waters. They stabilize shorelines from erosion, recharge groundwater, and provide critical habitat for fish, wildlife, and migratory birds. Marshes, swamps, and forested wetlands are diverse ecosystems that provide habitat for countless species including many of Pennsylvania's threatened, rare, and endangered species. In fact, approximately one-third of all plants and animals that are endangered or threatened in North America make their homes in wetlands. But wetlands also have more visible values. Each year they attract hundreds of hunters, anglers, bird watchers, and other enthusiasts for the recreational opportunities they provide.

One type of wetland especially important to forest landowners is the streamside or "riparian" forest. Streamside forests are highly productive and diverse systems that act as valuable filters for trapping and absorbing nutrients, waterborne pollutants, and runoff. Sycamore, alder, silver maple, and river birch are some of the more common streamside tree species. Their roots help stabilize streambanks, and the woody debris they deposit create pools and eddies used by fish and other aquatic organisms. A tree-lined bank may help keep water temperatures cool enough for species such as trout. Careful management of riparian forest zones is essential during farming and timber harvesting activities. If you have crop, pasture, or fallow land next to a stream, you can help improve water quality and habitat by planting a 50-foot-wide buffer strip alongside the stream. Streambank fencing is another important technique you can use to protect or establish streamside vegetation and improve water quality.

Following guidelines for controlling erosion and sedimentation pollution can help you protect wetlands during logging and road building activities. A Bureau of Forestry service forester, conservation district representative, or private resource professional can help you better understand what regulations apply to your particular situation. Cost-share assistance is sometimes available to help you properly manage your forested wetlands.

Species at the top of the food chain

Certain species are vital to the functions of their ecosystems. Among these are large predators, which require expansive home ranges to meet their biological needs. As human populations continue to grow, more wild areas that provide habitat for plants and animals are converted to suburbs and cities. When this happens, predators like cougars, wolves, and bobcats are some of the first species to disappear from an area. Did you know that wolverine and lynx once inhabited Pennsylvania? Species at the top of the food chain are also more vulnerable to pollutant bioaccumulation (the gradual buildup of contaminants within the body). A well-known example involves the DDT effect on birds of prey. DDT, a powerful and long-lasting pesticide, was used on crops for many years in the United States before being banned in 1972. This chemical entered the food chain through small mammals and fish. Birds like ospreys, eagles, and pelicans were attracted to the dying animals because they were easy to kill. Due to their large size, few of these birds were killed outright. However, the buildup of DDT in the birds' tissues disrupted reproductive behavior and led to improperly formed eggs, reducing the birds' ability to successfully reproduce. Banning DDT and implementing ecosystem-wide recovery efforts successfully halted the rapid population decline of the osprey and the eagle. However, DDT is still used in developing countries, so its potential to affect biodiversity on a global level remains high.

Species with low reproduction rates

These species are vulnerable to extinction because, compared with other species, they can't reproduce as quickly. Have you ever noticed how quickly insects can multiply? Animals like elephants and bats, on the other hand, give birth to only one or two young every year or two. When animals like these decline in number, it takes substantially more time for their populations to recover. Pennsylvania's endangered Indiana bat is particularly vulnerable during hibernation; a mother may abort her

young if disturbed, which further contributes to its low reproductive rate. An additional factor is that sometimes it takes many years for species to reach reproductive maturity. If the environment changes rapidly or if these species are heavily pursued by humans, individuals sometimes die without leaving any offspring at all. Because they can't reproduce fast enough to replace the individuals that die, these species are vulnerable to extinction.

Table 2. Species diversity in Pennsylvania (2007).

SPECIES OR GROUP	NATIVE SPECIES	ENDANGERED OR THREATENED	EXTINCT OR EXTIRPATED	NATIVE SPECIES LOST OR IN JEOPARDY (%)
Mammals	62	8	8	26
Birds	183	18	6	13
Amphibians	37	5	1	16
Reptiles	36	5	2	19
Fish	176	43	19	35
Invertebrates	10,000+/-	214	32	2+/-
Mussels (unionids)	65	2	20	34
Vascular plants	2,050	375	106	23
Bryophytes and lichen	916+/-	?	3	?
Protists and fungi	7,380	2 +	0	0

Adapted from information provided by the Pennsylvania Biological Survey and the U.S. Fish and Wildlife Service.

PUTTING THE PIECES TOGETHER: CUMULATIVE EFFECTS

When you combine mounting pressures such as habitat loss and fragmentation with characteristics that make certain species prone to extinction, you can see why we are losing so many species globally. The issues are complex and the solutions uncertain. Balancing human needs with natural concerns almost always involves trade-offs, and management actions sometime have unforeseen effects. Take, for example, the white-tailed deer. Past policies limiting large predators in Pennsylvania no doubt have contributed to the deer overpopulation problem now affecting our woodlands. Although hunting and vehicular accidents certainly play a role in reducing deer numbers, the population remains very high in many areas of the state. Solving multifaceted resource dilemmas like these involves research, planning, and compromise. We still have much to learn about interactions among species and even more to learn about developing long-term management strategies that will maintain, rather than offset, the balance found in natural communities.

WHAT SPECIES HAVE WE LOST IN PENNSYLVANIA?

As you read earlier, the passenger pigeon is one example of a species that went from abundance to extinction in a relatively short time. Table 2 provides a quick review of species diversity in Pennsylvania. Some of the species that once inhabited Pennsylvania include:

- *Mammals:* gray wolf, timber wolf, eastern cougar, moose, bison, lynx, wolverine, mountain lion, pine marten, eastern elk, Delmarva Peninsula fox squirrel
- *Birds:* Bachman's sparrow, lark sparrow
- *Fishes:* mud sunfish, longjaw cisco, lake whitefish, skipjack herring
- *Mollusks:* butterfly mussel
- *Insects:* American burying beetle, precious underwing moth, Karner blue butterfly, northeastern beach tiger beetle
- *Plants:* flame azalea, Carolina petunia, American barberry, small white lady's slipper, eastern prairie fringed orchid, Virginia spiraea, crested yellow orchid
- *Reptiles:* eastern mud turtle, midland smooth softshell turtle
- *Amphibians:* eastern tiger salamander

Overall, the statistics for plants are not encouraging. Of the 2,139 kinds of native higher plants known to inhabit Pennsylvania, well over 400 are already gone or are in jeopardy. More than 1,200 invading exotic plants now inhabit the state, and more are likely to be introduced. Purple loosestrife, a beautiful showy wetland invader, has squeezed out many native plant species. Another problem exotic is reed grass, or *Phragmites*, which spreads quickly in wet areas. Partly because of these two invasive plants, the nearly 40 species of rare wetland plants that existed near Philadelphia's Tinicum National Wildlife Refuge have been reduced to only four today. One federally threatened wildflower found in Pennsylvania is the small-whorled pogonia, which is known to exist in only 15 sites in the United States. In our state, it is found in one county, where it is primarily threatened by shifts in land use, but also by collectors who have intentionally dug up two of the remaining specimens in the county.

WHAT SPECIES ARE RECOVERING FROM RAPID POPULATION DECLINE?

Not all species that experience population decline become extinct. In Pennsylvania several species have made a noticeable recovery in recent years. These include the great blue heron, osprey, bald eagle, river otter, bobcat, and wild turkey. A few plant species have also made some progress. These success stories are a result of conservation strategies that focused not only on the species but also on restoring or cleaning the ecosystems on which they depend.

Helping species recover takes a combined effort of government and private initiatives, which may include the following:

- *protective government regulations* such as banning the pesticide DDT in the case of the osprey and bald eagle
- *agency actions that maintain or restore certain ecosystems,* such as the Game Commission program to promote streambank fencing, and the Fish and Boat Commission program to install in-stream habitat improvement structures
- *public support,* such as voluntary tax donations to the Wild Resource Conservation Fund, and contributions to conservation agencies
- *management efforts of landowners* including government, industry, and private individuals

The second part of this publication will help you take steps to conserve biodiversity while implementing management plans.

Conserving biological wealth in our forests

You may feel overwhelmed by the complexity of biodiversity and its implications for management. In this section we discuss some practical steps that landowners can take to help conserve biodiversity while meeting their primary objectives for owning land. Managing for biodiversity is not incompatible with managing for economic return. Forest managers who practice sustainable forestry already incorporate many of the same management principles. Any management activity affects the ecosystem in which it is implemented. Certain plant and animal species will benefit from the changed environment, while others may suffer temporary or long-term setbacks. Management decisions almost always involve trade-offs. Thus, our goal in managing for biodiversity is to choose the trade-offs that maintain, minimize the loss of, or improve the habitat and ecosystems of native species, especially those whose populations are declining.

FOUR BASIC STEPS FOR LANDOWNERS JUST GETTING STARTED

The following is an outline of four steps to help you incorporate biodiversity objectives into your management decisions.

STEP ONE: Get to know your land.
You may have owned your forestland for years, or perhaps you acquired it recently. In either case, it's a good idea to walk your land periodically to see the changes that take place over time. Become familiar with the plant, animal, and other species that live there and how they interrelate. Look for any unique or special areas that you may have previously overlooked, such as a seasonal pond. As you more fully appreciate the richness of your small parcel, take a moment to think how your land relates to your neighbors' land and to the region as a whole. Is your land bordered by hundreds of acres of a similar forest type? Is it fragmented by development or agricultural lands? The answers to these questions will help you formulate reasonable long-term management objectives.

STEP TWO: Reevaluate your reasons for owning land.
Have your primary reasons for owning land changed over the years you've owned it? What are the things you and your family value most about the land? Are you uncertain about the potential economic, recreational, and ecological benefits your forestland holds? A professional forest manager can help you better understand your options and assist you in developing a long-term plan for your property.

STEP THREE: Engage a professional and develop a stewardship plan.
Whether your primary interest is to preserve species or generate income, qualified stewardship resource professionals can help you meet your goals. Contacting your Bureau of Forestry service forester is a good way to start. A forest stewardship plan provides you with an overview of your land's ecological makeup, describes various land-use potentials, and highlights any rare or unique features. This information empowers you to make informed management decisions with the help of the professional resource manager developing your plan. For more information on developing a Forest Stewardship Plan, see *Forest Stewardship* 1, *Pennsylvania Forest Stewardship: Our link to the past, our legacy for the future,* and *Forest Stewardship* 6, *Planning Your Forest's Future.* Also contact the Bureau of Forestry service forester for your county. When your plan is complete, review it and see that it is in keeping with your interests and plans for the land. A plan is effective only when it's followed! Forest stewardship plans are flexible, and your resource professional can help you modify the plan if your needs and objectives change.

STEP FOUR: Incorporate biodiversity objectives into your management practices.
As we discussed earlier, trade-offs are an inevitable part of management. As you plan your management activities with your resource professional, keep the following rules of thumb in mind.

RULES OF THUMB FOR BIODIVERSITY MANAGEMENT

Think of your land as one piece of a much larger whole.
Forest management activities alter forest composition and structure, changing the composition, abundance, and diversity of wildlife communities. For example, if you choose to clearcut a large tract connecting two other forested areas, you will reduce the habitat available for species that need large areas of uninterrupted forestland, such as large predators and forest interior birds. If the site regenerates to forest, forest habitat loss will be temporary, but the area will be changed for at least 25 to 30 years. A preferable solution is to consider with your resource professional ways that harvesting could have less impact on regional biodiversity. If, on the other hand, your surrounding region has very little habitat for early successional species like woodcock, clearcutting might be a preferable management option. An ideal approach to the maintenance of

biodiversity would consider all types of species, such as interior, edge, and wide-ranging species. Again, your resource professional will be able to suggest various alternatives that meet your management objectives.

Manage with the future in mind.
Habitat components can be affected by forest management, but the magnitude and direction of the effects depend on the type and intensity of the activities. Management practices, such as shaping harvesting units to reduce the amount of edge, retaining snags, developing buffer strips, and connecting wooded corridors, may ameliorate potential negative impacts on wildlife, while enhancing potential benefits. Any forest disruption, such as timber harvesting, will likely reduce habitat suitability for one or more species but improve suitability for others. These will change with time as the plant community grows and changes. For example, the availability of certain food sources (e.g., acorns) and canopy layers may be reduced following harvest, while downed woody cover increases. As the downed material rots, habitat for beetles, grubs, and other sources of protein-rich food increases. As the forest plant community changes in age and composition, components of wildlife habitat, such as food, cover, and activity areas (e.g., decaying logs, canopy layers) also change.

Balance trade-offs to favor species and habitats of special concern.
When managing forests, primary consideration should be given to habitats or species that are rare, threatened, or endangered. Very often, managing for these species can be done in conjunction with other objectives. For example, suppose one of your management objectives is to place a recreational trail through your woodlot, and one of the proposed routes goes close to a seasonal pond. Choosing to run the trail near the pond without disturbing it might take additional planning, but benefits include providing a pond for reproduction of species such as salamanders and fairy shrimp and encouraging observation and enjoyment for trail users. In general, special areas to protect include wetlands, barrens, riparian areas, old-growth stands, extensive areas of contiguous forest, and rare habitats such as a heron rookery or a bald eagle nesting site.

Manage for regional biodiversity, not local species diversity.
Many people assume that managing for biodiversity means managing to maximize diversity on a very local scale—that is, trying to get as many species on your property as you can. This is generally done by creating a patchwork of successional stages and trying to maximize edge—the transitional zone between two vegetation types. Because many of our game species frequent the edges, management practices that maximize edge are promoted. Management that maximizes species richness locally often favors generalist species over habitat specialists. Generalists usually are least vulnerable to extinction. Adding generalists at the local level is unlikely to add new species to regional diversity because these generalists are often abundant throughout the region. In contrast, many of the habitat specialists are rare regionally, and their loss on a local level has a negative impact on regional biodiversity. As a result, if all managers strive for local diversity, they may collectively impoverish regional diversity.

Don't assume that no management is best for biodiversity.
With problems such as deer overpopulation and invading exotic plants and insects, not doing anything to your forestland may still lead to the decline of native species, simply because they are buckling under the weight of these growing pressures. Regardless of how pristine an individual parcel of land may seem, there is no escaping human influence on the natural world. Active management may be necessary to adjust certain imbalances that occurred in the past. Making the choice to let nature take its course is in itself a management decision, and on some sites this may be the course of action that best meets a landowner's needs at a given time. By far, poor management practices have a much greater negative impact on forest health than a hands-off management approach, but landowners should still consider how different species and habitats may be affected over time, in both active and passive management approaches.

Manage for uncommon species or features rather than common ones.
Again, any habitat manipulation involves a balance between species that benefit from the change and those that don't. If the species that are harmed by a given management action are rare or more imperiled than the ones that benefit, or if the manipulation eliminates one of the few regional occurrences of a species, community, or process, then biological diversity is reduced. If your management actions eliminate an element that is common elsewhere in the landscape and provide an opportunity for an uncommon element in the landscape to increase, then biological diversity is more secure. In a region where conifers are uncommon, harvesting a hardwood stand while leaving the understory hemlock to grow is an example of a balance that could benefit biodiversity. Remember, it is always important to consider the scale of the impact in time and space when assessing an action's effect on biodiversity.

Manage for vertical structure diversity.
The vertical arrangement of vegetation in a forest is as important to many species as the size of the forest itself. Introduced wildlife species depend on different vegetative layers in the forest—subterranean, understory, midstory, and canopy layers (Figure 2). Each layer offers a unique set of habitat features. Fallen logs, snags, and cavity trees also add to vertical structure and enhance biodiversity. Leaving standing snags and cavity trees after a timber harvest is a good way to benefit different species. It is generally estimated that snags and fallen trees directly support up to 20 percent of the vertebrate species in a typical temperate forest. Woodpeckers use snags to scavenge for insects, and hawks use them as perches while hunting prey. Leaving the tops of the fallen trees on-site rather than "cleaning" them will also add cover for smaller mammals and birds and add to the site's diversity. In addition, retaining conifers in areas where

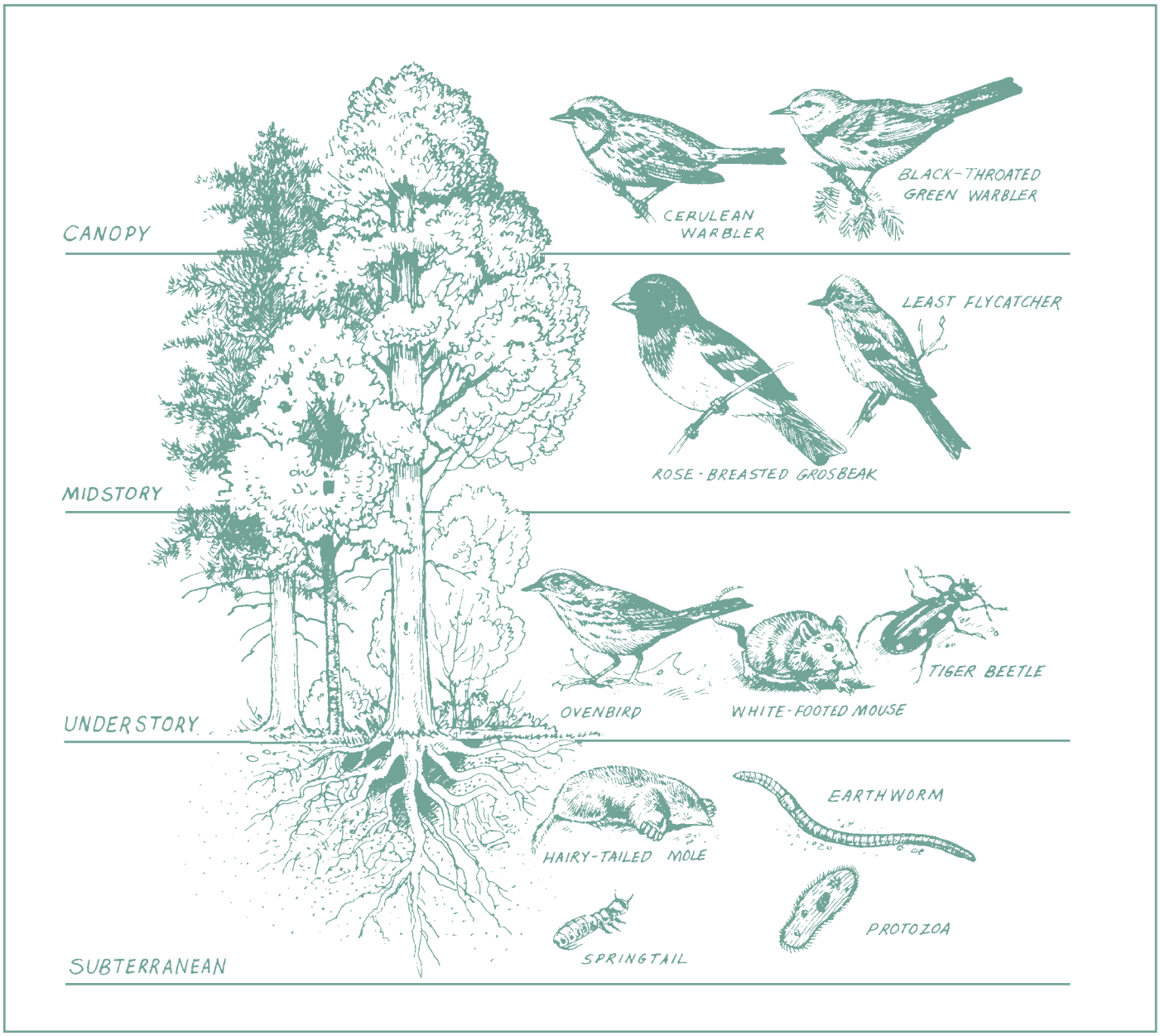
they are uncommon also enhances structural diversity.
Note: Standing dead trees, such as snags, pose serious hazards during timber harvesting. Make sure that your decision to leave snags recognizes the hazard and allow the logger flexibility to avoid it.

Maintain corridors between habitats. Last, when reviewing your management options, consider how your actions may influence the migration pathways and travel corridors of certain species, such as migratory waterfowl and large predators. When at all possible, maintain connections between forest patches to serve as corridors linking similar habitat types together. Because so many large habitats have been broken into smaller, discontinuous parcels, individual efforts to keep habitats connected will play increasingly important roles in regional biodiversity management efforts.

To review, keep in mind the following guidelines as you develop a long-term management plan for your property.

- Think of your land as one piece of a much larger whole.
- Manage with the future in mind.
- Balance trade-offs to favor species and habitats of special concern.
- Manage for regional biodiversity, not local species diversity.
- Don't assume that no management is best for biodiversity.
- Manage for uncommon species or features rather than common ones.
- Maintain or enhance vertical structure.
- Maintain connections or corridors between habitats.
- Protect wetlands and riparian areas.
- Identify and protect threatened, rare, and endangered species.

Figure 2. Vertical stratification.



WHAT OTHER PROGRAMS ASSIST WITH BIODIVERSITY MANAGEMENT IN PENNSYLVANIA?

The Forest Stewardship program is not the only program helping landowners better understand and manage for biodiversity. A key program is the Pennsylvania Natural Heritage Program (PNHP), which is funded in part by the Wild Resource Conservation Fund. The program is a cooperative effort of the Department of Conservation and Natural Resources (DCNR), the Pennsylvania Fish and Boat Commission, the Pennsylvania Game Commission, and the Western Pennsylvania Conservancy. Biologists locate and identify threatened and endangered flora and fauna and unique natural communities throughout the Commonwealth. This information is maintained in the Pennsylvania Natural Diversity Inventory (PNDI) database, which stores location, biological, historical, and ecological data on computer, map, and manual files. PNHP uses historical specimen information and secondary sources to target where threatened and endangered species may exist today. Field surveys are conducted to verify the species' current status. The site-specific and dynamic nature of the PNDI database offers an efficient starter tool for use by environmental planners, resource managers, and conservation groups to protect Pennsylvania's remaining natural heritage.

County-Based Natural Heritage/ Natural Areas Inventories, funded in part by the Pennsylvania Department of Community Affairs, provide additional information to supplement PNHP. These inventories, which identify significant natural areas and ecological sites at the county level, serve as planning tools for local governments. The inventories are conducted following the nationwide Natural Heritage Network protocols. The Department of Conservation and Natural Resources, county residents, and conservation groups provide input into this process. Check with your county planning commission to find out if a Natural Heritage Inventory Report and inventory maps are available for your area.

If you are interested in learning more about biodiversity or natural history in your area, a good way to start is to visit conservation organizations, environmental centers, libraries, and natural history museums. For additional information, consult the organizations listed in the appendix.

HOW DO WE MANAGE FOR BIODIVERSITY BEYOND OUR BOUNDARIES?

The very fact that biodiversity extends past our human-erected boundaries poses a complex forest stewardship challenge. How do we get government agencies, professional resource managers, industry representatives, conservation organizations, timber harvesters, scientists, and private landowners to all work together? Specific solutions to this complex issue will most likely evolve over time as groups develop more effective communication systems to plan and implement cooperative resource management efforts. Already some cooperative projects, such as the American Tree Farm System and the Forest Stewardship Program, are fostering better understanding. Although we tend to focus more on the differences than the similarities, all the forestland-use players, whether public or private, large or small, can benefit by managing for biodiversity.

Cooperative efforts that meet human needs while promoting sustainability may become more widespread as our tools for measuring biodiversity on its many levels become more sophisticated. Educating resource managers about biodiversity concerns is an essential part of the process. With better tools and a clearer sense of cooperation, the task of managing resources at ecosystem and regional levels appears less daunting.

Even landowners who have relatively small properties can play an active part in ecosystem level management by staying on top of the emerging data. Landowners can share information through woodland associations, which are becoming increasingly popular across the state. These associations provide landowners with the opportunity to work together with their neighbors and resource professionals, designing regional plans to minimize negative effects at the landscape level.

Conclusion

The way we manage biological diversity in our own backyards and woodlots will not significantly affect global biodiversity, but it will largely determine our quality of life and the quality of life that we pass on to our descendants. As caretakers of our forest resources, landowners have the responsibility to learn the effects of management on forest health and to make their management decisions wisely.

Appendix

FEDERALLY LISTED, PROPOSED AND CANDIDATE SPECIES IN PENNSYLVANIA

COMMON NAME	SCIENTIFIC NAME	STATUS[1]	DISTRIBUTION (COUNTIES AND/OR WATERSHEDS)
Mammals			
Indiana bat	*Myotis sodalis*	E	Hibernacula: Armstrong, Beaver, Blair, Centre, Fayette, Huntingdon, Lawrence, Luzerne, Mifflin, and Somerset Counties Maternity sites: Bedford, Berks, and Blair Counties Potential winter habitat: statewide in caves or abandoned mines Potential summer habitat: statewide in forests or wooded areas
Birds			
Piping plover	*Charadrius melodus*	E	Designated critical habitat on Presque Isle (Erie County) Migratory No nesting in PA since 1950s, but recent colonization attempts at Presque Isle
Reptiles			
Bog turtle	*Clemmys (Glypternys) muhlenbergii*	T	Current: Adams, Berks, Bucks, Chester, Cumberland, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Schuylkill, and York Counties Historic: Crawford, Mercer, and Philadelphia, Counties
Eastern massasauga rattlesnake	*Sistrurus catenatus catenatus*	C	Current: Butler, Crawford, Mercer, and Venango Counties Historic: Allegheny and Lawrence Counties
Mussels			
Clubshell	*Pleurobema clava*	E	Current: French Creek and Allegheny River (Armstrong, Clarion, Crawford, Erie, Forest, Mercer, Venango, and Warren Counties); Shenango River (Mercer and Crawford Counties) Historic: Streams in Butler, Beaver, Fayette, Greene, Indiana, Lawrence, and Westmoreland Counties
Dwarf wedgemussel	*Alasmidonta heterodon*	E	Current: Delaware River (Pike and Wayne Counties) Historic: Delaware River (Bucks, Carbon, Chester, and Philadelphia Counties) and Susquehanna River (Lancaster County)
Northern riffleshell	*Epioblasma torulosa rangiana*	E	Current: French Creek and Allegheny River (Armstrong, Clarion, Crawford, Erie, Forest, Mercer, Venango, and Warren Counties) Historic: Shenango River (Lawrence County) and Conewango Creek (Warren County)
Rayed bean	*Villosa fabalis*	C	Current: French Creek and Allegheny River (Armstrong, Clarion, Crawford, Erie, Forest, Mercer, Venango, Warren Counties) and Cussewago Creek (Crawford Counties) Historic: Streams in Armstrong, Lawrence, Mercer, and Warren Counties
Sheepnose	*Plethobasus cyphyus*	C	Current: Allegheny River (Forest and Venango Counties) Historic: Allegheny River (Armstrong County); Beaver River (Lawrence County); Ohio River (Allegheny and Beaver Counties); and Monongahela River (Washington County)

(Appendix continued on next page.)

Appendix (continued)

COMMON NAME	SCIENTIFIC NAME	STATUS[1]	DISTRIBUTION (COUNTIES AND/OR WATERSHEDS)
Fish			
Shortnose sturgeon[2]	*Acipenser brevirostrum*	E	Delaware River and other Atlantic coastal waters
Plants			
Northeastern bulrush	*Scirpus ancistrochaetus*	E	Current: Adams, Bedford, Blair, Cambria, Carbon, Centre, Clinton, Columbia, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Lackawanna, Lehigh, Lycoming, Mifflin, Monroe, Perry, Snyder, Tioga, and Union Counties Historic: Northampton County
Small-whorled pogonia	*Isotria medeoloides*	T	Current: Centre, Chester, and Venango Counties. Historic: Berks, Greene, Monroe, Montgomery, and Philadelphia Counties

1. E = Endangered; T = Threatened; P = Proposed for listing; C = Candidate
2. Shortnose sturgeon is under the jurisdiction of the National Marine Fisheries Service.

Revised 3/26/08

Information provided by the U.S. Fish and Wildlife Service, 315 S. Allen St., Suite 322, State College, PA 16801.

DEFINITIONS

Biological diversity	the variety of life and its processes; includes the number of species and populations in an area and the communities that they make
Carrying capacity	the number of animals an area can support; usually determined by the amount of available food and cover
Community	all the populations occurring in a particular area; for example, the plant and animal populations in a city park, backyard, or woodlot
Ecosystem	the system formed by a community of organisms and their interactions with one another and their physical environment
Endangered species	any species or subspecies in immediate danger of becoming extinct throughout all or a significant portion of its range
Extinction	the death of the last individual of a species
Extirpated species	species no longer surviving in regions that were once part of their range
Habitat	the physical area where an animal lives and finds nutrients, water, shelter, and living space; each species has a unique set of requirements for life
Poaching	illegal hunting or trapping
Population	an interbreeding group of animals or plants of the same species that live in a certain area at a certain time
Rare species	species with small populations
Species	a population or many populations of an organism with characteristics in common that make them different from individuals of other species populations; members of a species share a common and unique inheritance and interbreed with one another but not with members of other species
Species richness	the number of species present in a community or an area
Sustainable ways	manner or method of making each forest the source of sustained and uniform flow of benefits
Threatened species	a species or subspecies whose numbers are so low or are declining so fast that it is likely to become endangered in the foreseeable future throughout all or a significant portion of its range

ORGANIZATIONS

U.S. Fish and Wildlife Service

Organized under the Department of the Interior, this is the lead federal agency in the conservation of the nation's migratory birds, endangered species, certain mammals, and sport fishes. The Ecological Services branch provides technical assistance for restoring or creating wetlands and enhancing fish and wildlife habitat. Financial assistance for certain practices, such as wetlands restoration, is available to qualifying landowners. The service also issues certain environmental permits and disseminates wildlife management information. For more information, contact the Fish and Wildlife Service, Ecological Services, 315 South Allen St., Suite 322, State College, PA 16801; phone: 814-234-4090; Web site: **www.fws.gov**

Pennsylvania Bureau of Forestry

Organized within the Department of Conservation and Natural Resources (DCNR), this bureau offers a range of information and technical assistance to woodland owners. Service foresters, on request and as schedules allow, will examine woodlands and make management recommendations. They will assist landowners in obtaining Forest Stewardship Plans and will provide technical assistance in implementing the plans. They will also authorize cost-share assistance for some management activities. The bureau provides advice on erosion and sedimentation control, wildlife and native plant habitat improvement, insect and disease control, forest recreation, and urban and community forestry. The bureau also offers guidance in conserving biological diversity in the Commonwealth through the Pennsylvania Natural Heritage Program (PNHP). For more information about PNHP, contact PNHP Director, Pennsylvania Bureau of Forestry, Department of Conservation and Natural Resources, PO Box 8552, Harrisburg, PA 17105-8552; phone: 717-787-3444; Web site: **www.dcnr.state.pa.us/forestry**

Pennsylvania Game Commission

This commission is responsible for protecting and managing birds and mammals in Pennsylvania. For more information, contact the wildlife conservation officer listed in the local telephone directory under "Government Services, Game Commission," or contact the Pennsylvania Game Commission, 2001 Elmerton Avenue, Harrisburg, PA 17110-9797; phone: 717-787-4250; Web site: **www.pgc.state.pa.us**

Pennsylvania Fish and Boat Commission

Responsible for protecting and managing fishes, reptiles, amphibians, and all aquatic organisms inhabiting Pennsylvania's waters, the commission enforces Fish and Boat Code regulations dealing with the pollution and alteration of stream channels and the subsequent impact on aquatic life. You can contact the waterways conservation officer in your locality or the Pennsylvania Fish and Boat Commission, 1601 Elmerton Ave., Harrisburg, PA 17105; phone: 717-705-7800; Web site: **www.fish.state.pa.us**

Pennsylvania Biological Survey

This nonprofit scientific organization consists of professional and dedicated amateur biologists who volunteer their expertise and energies to increase the knowledge of and foster the perpetuation of the natural biological diversity of Pennsylvania.

LAND CONSERVANCIES

Land conservancies work to conserve and preserve the plants, animals, and natural communities that represent the diversity of life on Earth. Many tools to protect land and water are available through conservancies, including outright purchase of land, conservation easements, professional assistance, and funding. There are well over 300 land conservancies and land trusts in Pennsylvania. To find a land trust or land conservancy in your region, check the yellow pages of your local telephone directory or contact the Pennsylvania Land Trust Association, an umbrella organization and clearinghouse for land conservancy and land trust information: Pennsylvania Land Trust Association, 105 Locust Street, Suite 300, Harrisburg, PA 17101; phone: 717-230-8560; Web site: **conserveland.org**

PENNSYLVANIA NATURAL DIVERSITY INVENTORY SPECIES LISTS

The statutory authority for Pennsylvania's animals and plants resides with three separate agencies. The Pennsylvania Department of Conservation and Natural Resources is responsible for managing the Commonwealth's native wild plants. The Pennsylvania Fish and Boat Commission is responsible for management of fish, reptiles, amphibians, and aquatic organisms within the Commonwealth. The Pennsylvania Game Commission is responsible for managing the state's wild birds and mammals.

For information on current species status, please consult the appropriate agency.

Plants and PNHP, General

Plant Program Manager
Pennsylvania Department of Conservation and Natural Resources
Bureau of Forestry
Pnhp
PO Box 8552
Harrisburg PA 17105-8552
Phone: 717-787-3444

Fish, Reptiles, Amphibians, Aquatic Organisms

Endangered Species and Herpetology Coordinator
Pennsylvania Fish and Boat Commission
Bureau of Fisheries
450 Robinson Lane
Bellefonte PA 16823
Phone: 814-359-5100

Birds and Mammals

Pennsylvania Game Commission
Bureau of Wildlife Management
2001 Elmerton Avenue
Harrisburg PA 17110-9797
Phone: 717-787-4250

For information on species listed under the federal Endangered Species Act of 1973 occurring in Pennsylvania, contact:

Endangered Species Biologist
U.S. Fish And Wildlife Service
315 South Allen Street, Suite 322
State College PA 16801
Phone: 814-234-4090

PENNSYLVANIA NATURAL DIVERSITY INVENTORY SPECIES LISTS

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For information on current species status, please consult the appropriate agency.

Plants and PNDI, general — **Plant Program Manager**

PENNSYLVANIA DEPARTMENT OF
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BUREAU OF FORESTRY
PNDI
P.O. BOX 8552
HARRISBURG PA 17105-8552
Phone: 717-787-3444

Fish, Reptiles, Amphibians, Aquatic Organisms — **Endangered Species and Herpetology Coordinator**

PENNSYLVANIA FISH AND BOAT COMMISSION
BUREAU OF FISHERIES AND ENGINEERING
450 ROBINSON LANE
BELLEFONTE PA 16823
Phone: 814-359-5154

Birds and Mammals — **Pennsylvania Game Commission**

BUREAU OF WILDLIFE MANAGEMENT
2001 ELMERTON AVENUE
HARRISBURG PA 17110-9797
Phone: 717-787-5529

For information on species listed under the federal Endangered Species Act of 1973 occurring in Pennsylvania, contact:

ENDANGERED SPECIES BIOLOGIST
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315 SOUTH ALLEN STREET, SUITE 322
STATE COLLEGE PA 16801
Phone: 814-234-4090

NOTES

PENNSTATE

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Agricultural Research and
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Pennsylvania Forest Stewardship Program

Forests for Life

The Forest Stewardship Program is administered nationally by the USDA Forest Service and is directed in Pennsylvania by the DER Bureau of Forestry with assistance from a statewide steering committee. The Forest Stewardship Program assists forest landowners in better managing their forestlands by providing information, education, and technical assistance. For more information about program services, contact the Pennsylvania Forest Stewardship Program, DCNR Bureau of Forestry, PO Box 8552, Harrisburg, PA 17105-8552; phone: 814-364-5157. For more information about publications, contact the Pennsylvania Forest Stewardship Program, Penn State School of Forest Resources, 320 Forest Resources Building, University Park, PA 16802-4705; phone: 800-235-9473.

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