Pennsylvania
Statewide Forest Resource Assessment

June 2010

Pennsylvania Department of Conservation and Natural Resources
Bureau of Forestry
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* Not included in this PDF document - please see the separate PDF files for these appendices.

Chapter 1

Introduction

Background
Forests cover 60 percent of Pennsylvania and provide citizens with an array of values including clean water, clean air, recreation opportunities, wood products, and habitats for thousands of plants and animals. Sustaining these values for future generations requires a shared vision and coordination among many stakeholders including agencies, landowners, forest industry, natural resource professionals, conservation organizations, and community leaders and policy makers. The purpose of this Forest Assessment is to document the condition of Pennsylvania's forests across all ownerships and establish a framework for developing strategies to achieve long-term forest sustainability.

The Bureau of Forestry receives funding from the US Forest Service for Forest Stewardship, Urban and Community Forestry, Forest Health, and Wildland Fire programs. Completing this five-year Assessment, along with the associated Strategy, is a requirement of the 2008 Farm Bill, thus ensuring continued funding for these programs. In addition to meeting the Federal requirements, the bureau is utilizing this process as an opportunity to undertake a holistic, long-term evaluation and strategic planning effort for Pennsylvania's forests. The completion of the Farm Bill requirements by June 18, 2010 is the first step of this longer-term, continuous endeavor, including updating the bureau's strategic plan: *Penn's Woods*, which was developed and adopted in 1995.

Overview
The Assessment contains four main components:

- Existing and Emerging Benefits
- Forest Conditions and Trends
- Issues, Threats, and Opportunities
- Priority Landscape Areas

Part two of the overall effort, the Strategy, proposes long-term strategies for each of the issues, threats, and opportunities. Below is brief description of each of the four main components of the Assessment.

<u>Existing and Emerging Benefits</u>
Pennsylvanians value their forests for many different reasons. Understanding and documenting the benefits and services our forests provide is an important step in developing long-term strategies to ensure their sustainability. Including the range of

landscapes from rural to urban, benefits and services of Pennsylvania's trees and forests are described in five broad categories:

1. Quality of Life: Recreation, Aesthetics, and Sense of Place
2. Water
3. Wildlife and Biodiversity
4. Air Quality and Climate Change Mitigation
5. Wood, Energy, and Other Economic Values

Forest Conditions and Trends

Understanding and documenting forest conditions and trends is a critical part of developing long-term strategies for sustainability. Using the *Montreal Process Criteria and Indicators* for sustainable forestry, this chapter documents current conditions and future trends, and provides an assessment of sustainability for each of eighteen Indicators. The intent of the chapter is to present in a concise format, relevant data and our interpretation of the data related to sustainability.

At the conclusion of each indicator, a "Sustainability Meter," similar to the one pictured below, is presented as a visual interpretation of the indicator. The image below reflects our overall assessment of Pennsylvania's forests. Our forests face many challenges and threats including land use change and development, forest health concerns, ownership demographics, poor management decisions, and uncertainties of Marcellus shale development. The evaluation of many indicators resulted in sustainable conclusions, but with many causes for concern. Overall, the Bureau of Forestry is concerned about the future sustainability of Pennsylvania's forests.

Sustainability Meter
Overall Assessment

Issues, Threats, and Opportunities

Considering the sustainability analysis (Chapter 3), existing programs and future directions, and stakeholder input, the Bureau of Forestry identified eight priority issues for Pennsylvania's forests:

1. Land Use
2. Forest Health
3. Forest Management
4. Clim ate Change
5. Communicating Natural Resource Values
6. Energy Development
7. Wildfire and Public Safety
8. Plant and Animal Habitats

For each issue, the situation is described, available data are presented and discussed, and a foundation is set for developing long-term strategies which are presented in the Strategy part of the overall project.

Priority Landscape Areas

Pennsylvania's forests occur in diverse landscapes ranging from urban park and street trees to scattered woodlots in highly developed areas to the heavily-forested PA Wilds. These landscapes are influenced by many factors including geology, the spatial arrangement and sizes of forested tracts, and local communities and development patterns. Understanding geography and landscape variability helps policy makers and program leaders tailor programs to meet local, specific needs while working within a broader statewide context.

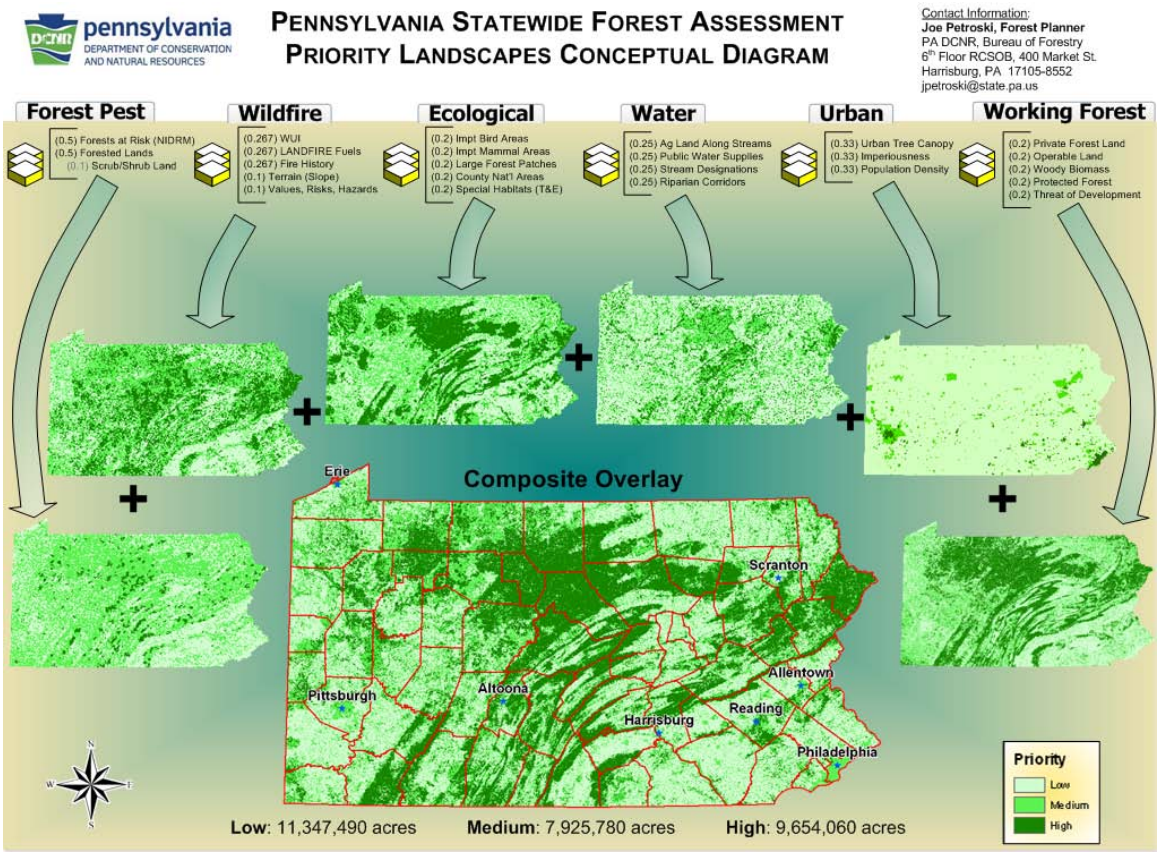
Developing regional or landscape-level programs is not a new concept in Pennsylvania. Several models and programs already occur, though implementation among the state's 2,562 separate municipalities poses a significant challenge. The intent of this section of the Assessment is to acknowledge and build upon existing landscape-level approaches while identifying additional areas for future consideration. These landscape areas will be utilized as a basis for implementing the Strategies developed for the Priority Issues identified in Chapter 4.

Seven categories of Priority Landscape Areas have been identified for Pennsylvania:

1. GIS-derived Landscape Areas
2. DCNR Conservation Landscape Initiatives
3. Bureau of Forestry Private Lands Regions
4. Major Watersheds
5. Marcellus Shale Region
6. PA Forest Legacy Areas

7. Northeast Area Multi-state Areas

Overview diagrams on the following two pages illustrate the general location of these areas across Pennsylvania. Overall, there are more than 40 priority landscapes for Pennsylvania, including potential Multi-state efforts that cross state boundaries.

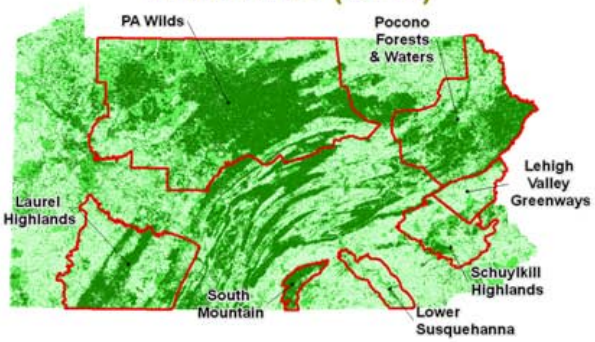


PRIORITY LANDSCAPES

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

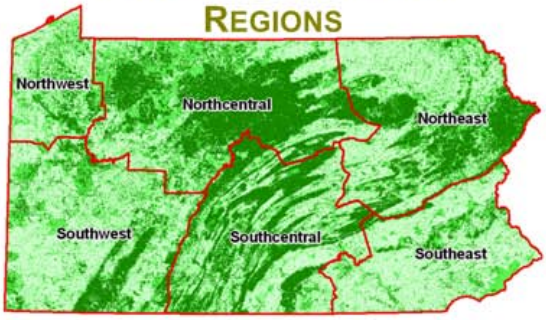
MULTI-STATE PRIORITY AREAS

CONSERVATION LANDSCAPE INITIATIVES (CLIs)

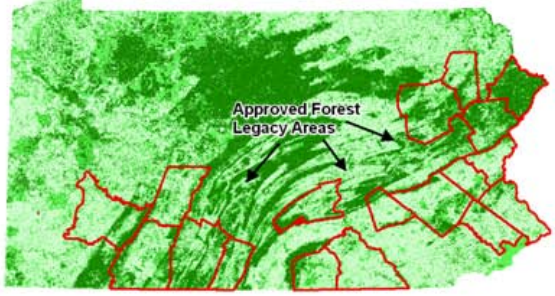


NEW PRIORITY LANDSCAPES

PRIVATE FORESTLAND REGIONS

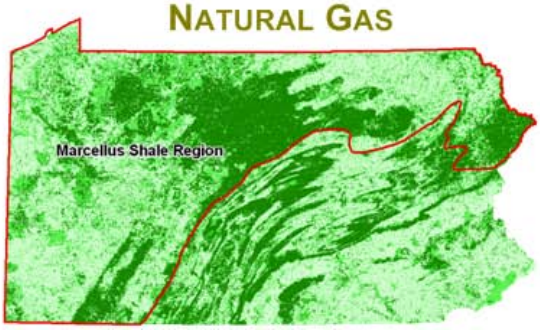


FOREST LEGACY AREAS



WATERSHEDS & RIVER BASINS

NATURAL GAS



Connecting to National Priorities and Funding Opportunities
As part of the State and Private Forestry nationwide planning effort, the US Forest Service identified a set of national priorities and objectives for guiding investments in forest resources across the Nation. Pennsylvania's priority issues and landscapes clearly connect to the national priorities:

1. **Conserve and Manage Working Forest Landscapes for Multiple Values and Uses**

   1.1. Identify and conserve high priority forest ecosystems and landscapes.

   1.2. Actively and sustainably manage forests.

2. **Protect Forests from Threats**

   2.1. Restore fire-adapted lands and/or reduce risk of wildfire impacts.

   2.2. Identify, manage and reduce threats to forest and ecosystem health.

3. **Enhance Public Benefits from Trees and Forests**

   3.1 Protect and enhance water quality and quantity.

   3.2. Improve air quality and conserve energy.

   3.3. Assist communities in planning for and reducing forest health risks.

   3.4. Maintain and enhance the economic benefits and values of trees and forests.

   3.5. Protect, conserve, and enhance wildlife and fish habitat.

   3.6. Connect people to trees and forests, and engage them in environmental stewardship activities.

   3.7. Manage trees and forests to mitigate and adapt to global climate change.

Once completed, the bureau will utilize the Assessment and Strategy for determining priorities for staff, justifying funding for projects, and identifying opportunities for engaging partners and stakeholders. The strategies developed for each of the priority issues will provide direction for how the bureau utilizes US Forest Service funding for Forest Stewardship, Urban & Community Forestry, Forest Health, and Fire. The bureau will submit work plans and grant proposals to the US Forest Service annually. In addition, the bureau will look to the Assessment and Strategy while allocating state funding and other resources to the priority issues and landscapes as appropriate.

Chapter 2

Benefits and Services

Introduction
The Pennsylvania State Constitution, Section 27, states "The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."

The obligation to conserve and maintain these resources for all people is foundational to DCNR. The mission of DCNR's Bureau of Forestry is to ensure the long-term health, viability, and productivity of the Commonwealth's forests by managing state forests under sound ecosystem management, to retain their wild character and maintain biological diversity while providing pure water, opportunities for low-density recreation, habitats for forest plants and animals, sustained yields of quality timber, and environmentally sound utilization of mineral resources.

The forests of Pennsylvania provide many benefits and services to citizens of, visitors to, and to the businesses and industry of the Commonwealth. Pennsylvania forests offer wood products, watershed values, recreation opportunities, plant and wildlife habitat, and are valuable sources of renewable energy. Under the forest floor are reserves of fossil fuels like coal, oil and natural gas, many tapped but more being discovered each day.

Pennsylvania's forests serve different people in different ways. The variety of recreational opportunities provided is vast. Many of these pursuits require clean water for good fishing, proper habitat for healthy numbers of deer to hunt, or perhaps the perfect setting from which to view or photograph rarely seen birds or Pennsylvania's elk herd. Some may be best served by the serenity of the forest and the benefits afforded to their mental health.

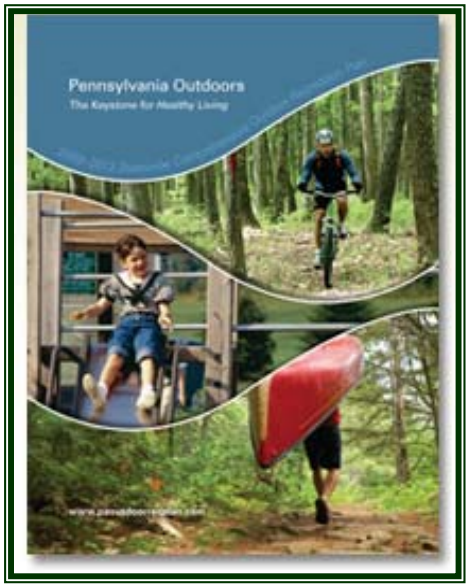
With proper management and sound conservation leadership, the Commonwealth's forests have and will continue to sustain these benefits and more over time, and the forests benefit the entire environment reciprocally. Improved air and water quality, along with greater biodiversity and the possibility for climate change mitigation are benefits of forests to the overall environment of the Commonwealth and beyond.

Quality of Life: Recreation, Aesthetics, Sense of Place

The Conservation and Natural Resource Act of 1995, P.L. 89, No.18 authorizes the establishment and provides for the use and control of state forest lands. This law states that one of the purposes for which the state forest system was created is "... to furnish opportunities for healthful recreation to the public."

Pennsylvania is a time-honored outdoor destination. Visitors to and citizens of the Commonwealth have enjoyed traditional outdoor pursuits like fishing, hunting, camping and boating across generations, and Pennsylvania's whitewater rivers, notably the Lehigh and Youghiogheny, have lured thrill-seekers from around the world. The Allegheny and Clarion Rivers are both part of the National Wild and Scenic River System, as designated by Congress, and they provide unique recreation opportunities. Forests spanning the Allegheny and Appalachian Mountains cover two-thirds of the state and provide endless opportunities for outdoor experiences, recreation and solitude.

Pennsylvanians today benefit from a long proud history of natural resource conservation. Public ownership protects over two million acres of state forest land, one-and-a-half million acres of game and wildlife lands, the half-million acre Allegheny National Forest and 117 state parks. Many private forest landowners also allow recreational pursuits such as hunting and hiking on their properties and many have purchased properties specifically for recreational pursuits, such as hunting clubs. Research consistently shows that Pennsylvanians place a high value on outdoor places and activities from the standpoint of personal benefit, viewing these resources as an important component of maintaining quality of life. Forestlands serve as incubators for stewardship and facilitate meaningful outdoor experiences for all who appreciate the history, science and natural beauty within.



Today Pennsylvania faces many challenges as it continues to conserve lands and waters while working to meet the outdoor recreational needs of a changing population. The Commonwealth's people are more diverse and their life experience is more urban than a generation ago. Simultaneously, Pennsylvania's population is aging. Over a quarter of its citizens (3.4 million) are considered "Baby Boomers," born between 1946 and 1964. These societal shifts, in combination with development pressure on rural landscapes and open space everywhere, global climate change and economic recession, make it imperative to plan carefully for the future if

Pennsylvania is to meet the outdoor recreation needs of its people and conserve its natural heritage. An important tool to help guide recreation planning and related land management across all of Pennsylvania is produced every five years. The 2009-2013 Statewide Comprehensive Outdoor Recreation Plan can be found at this link: http://www.paoutdoorrecplan.com/downloads.htm.

Recreation may begin as soon as one walks out the door and enters the community. Street trees and urban forests are often forgotten about in discussions regarding benefits of forests, but these urban forests are sometimes the only outdoor setting people experience. "Trees create more pleasant walking environments, bringing about increased walking, talking, pride, care of place, association and therefore actual ownership and surveillance of homes, blocks, neighborhoods, plazas, businesses and other civic spaces." (Burden, Dan. 22 Benefits of Urban Street Trees. May 2006.)

Because of the size of the land base, state forests provide a unique opportunity for dispersed outdoor recreation. Long-standing, traditional recreation pursuits such as hunting and fishing have shaped the outdoor heritage of the state forest visitor. Recreational opportunities on state forest land are aimed at those forms of dispersed forest recreation that are not being provided by other land uses or ownerships and that are compatible with the forest ecosystem.

Today there are many forest users who have views and activities that sometimes conflict. Some people seek the peace and solitude that forests provide in order to promote mental and physical fitness. Others enjoy more physical activities to achieve the same outcome. There are those who prefer traditional forms of recreation such as sight-seeing, hiking, hunting, fishing, horse-back riding, cross-country skiing and others who find state forests ideal places to hang glide or geocache or to ride ATVs, snowmobiles, mountain bikes and dog sleds.

With almost all Pennsylvania state forest land open to hunting, along with State Game Lands, private forestlands, and much of the Allegheny National Forest, there is an abundance of land and wildlife available for hunters and trappers to enjoy. Specially designated areas of state forest are also open to disabled hunters with special permissions to aid in their hunting experience. This includes allowances like use of all-terrain type vehicles for transport and access to areas otherwise closed to the general public. Pennsylvania's forests also have an abundance of streams, ponds and lakes that supply opportunities for cold-water and warm-water fishing. State forests have some of the most pristine waters in the Commonwealth and they support abundant fish life, including the 207 miles classified as wilderness trout streams by the Pennsylvania Fish and Boat Commission.

There are also many other great opportunities for water activities in Pennsylvania including canoeing and kayaking rivers and streams, motorized boating and use of personal watercraft in lakes and rivers. For non-motorized boaters, there is an extensive system of water with guides available from partner groups (responsible for establishment of water trail) to make users aware of important things such as water access points and hazards.

DCNR's Bureau of Forestry has management responsibilities of all rivers islands in Pennsylvania that remain unwarranted and not under patent. These islands offer some excellent recreational opportunities. Today, DCNR partners with several volunteer groups that design, develop and maintain river islands trails throughout the Commonwealth. These volunteers also serve as trail stewards for maintenance, monitoring resource impacts and tracking public use, and many of these river island groups produce maps and brochures describing the trail, explaining access and camping opportunities.

Pennsylvania state forests also provide the necessary and beloved backdrop for passive activities like wildlife watching and nature observation. The Audubon Society has designated certain areas of state forest land with unique or unusual bird species as Important Bird Areas. These areas have particularly large and unique habitats for unusual bird species. State Forest Natural Areas and Wild Areas are exemplary places for passive recreation. These specially designated areas are managed with the objective of preserving the natural resources within in as natural and untouched a state as possible, but the entire state forest system is maintained in a largely natural system. Nature photographers and artists also find an abundance of subjects in the natural settings of the Commonwealth's forests.

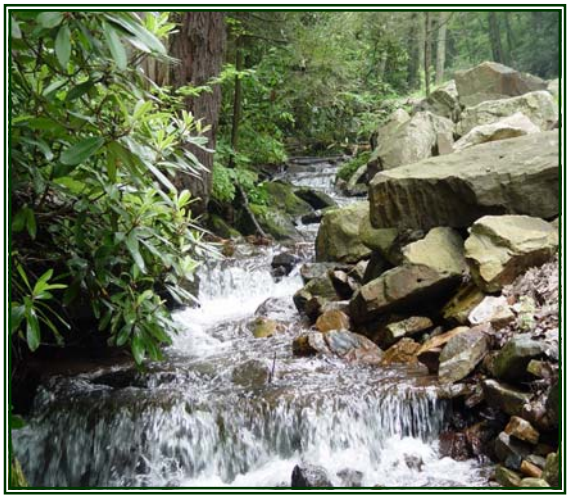
There is an almost endless list of personal recreational pursuits enjoyed by citizens of and visitors to Pennsylvania's forestland. These forests provide the necessary resources for rock climbing and rappelling; they provide the perfect setting for geocaching expeditions and for vast numbers of campers; and they offer the perfect winter setting for downhill skiing, tubing and snowboarding. The forests of Pennsylvania also house thousands of miles of trails for hiking, biking, horseback riding, cross-country skiing, snowmobiling and riding all-terrain vehicles. Number one in the nation in rail trail projects, boasting 24 National Recreation Trails, and housing the longest multi-use trail in the nation with the Great Allegheny Passage - Pennsylvania is a national leader when it comes to trails, and its forests are certainly instrumental to outdoor recreation.

Water

Forests provide water, protect water sources, and protect communities from high costs of treating contaminated water and stormwater overload. "Many forests are created or maintained for the primary purpose of watershed protection and management. Forests are the chief sources of water for vast metropolitan areas and agricultural irrigation." (The Practice of Silviculture: Applied Forest Ecology. Pg 449.)

Approximately two-thirds of the water that fills streams and replenishes groundwater flows from forested lands. Forests normally provide higher quality water than from other land uses. They provide a more steady supply of water, gradually filtering and continually releasing clean water; and forest vegetation not only intercepts some precipitation to help manage storm runoff, but vegetation on the ground protects soils from eroding with the flow of water. "Trees absorb the first 30% of most precipitation through their leaf system, allowing evaporation back into the atmosphere. This moisture never hits the ground. Another percentage (up to 30%) of precipitation is absorbed back into the ground and taken in and held onto by the root structure, then absorbed and then transpired back to the air. Some of this water also naturally percolates into the ground water and aquifer. Storm water runoff and flooding potential to urban properties is therefore reduced." (Burden, Dan. 22 Benefits of Urban Street Trees. May 2006.)

"Forest vegetation protects soil and water by shedding the leaves and other organic matter that feeds soil organisms… Litter also protects the mineral soil from the impact of falling raindrops and of the even larger drops of water that fall from the leafy canopy. Water that filters into the soil does not run over the surface picking up solid materials in the process of surface erosion. Erosion harms twice – first by removing soil and second by depositing it on better soils or as mud in streams. Much of the water that sinks into the soil emerges later in springs as clear, filtered water." (The Practice of Silviculture: Applied Forest Ecology. Pg 449-450.)



Riparian buffers (vegetation along banks of waterways) further protect streams and waterways by acting as a filtering system. As water flows toward drainage areas, soil particles and other contaminants are filtered through this vegetative buffer before entering the waterway. Eroding solid otherwise left to be deposited in streams and rivers as sediment is trapped in the roots and matter of streamside vegetation, and thus kept out of waterways. This keeps the water quality high for public drinking supply purposes and also for aquatic life dependent on clean, flowing waters.

Forests are also a large part of Pennsylvania's water management infrastructure. A recent survey of water suppliers conducted by the Trust for Public Land and the American Water Works Association showed that treatment costs for drinking water increase when the amount of forestland is decreased. The differences in water treatment costs across the country depend heavily on whether or not the sources of drinking water are in forested areas. (Conserving Forests to Protect Water. American Water Works Association. Opflow Report Vol 30. May 2004.)

Pennsylvania has over 300 surface water supply systems that provide drinking water to 7.5 million people. Northcentral and northeast Pennsylvania boast forestland with great ability to produce clean drinking water. The northeast region contains four of the top 15 watersheds in the northeastern United States in terms of importance of watersheds and private forests for drinking water supply.

In addition to providing clean drinking water and lowering water treatment costs, forests protect Pennsylvania communities from flooding and other problems due to excessive stormwater flows. Municipal stormwater systems face overloading problems after large storm events which can cause flooding and contaminated water supplies, among other problems. A forested ecosystem decreases storm runoff by the interception of precipitation by trees and vegetation, and by the slowing and filtering of water through the organic matter on the surface of the ground.

Watershed health begins to decline as forest cover drops below 65-75%. Currently, more than half of Pennsylvania's small watersheds meet the threshold of 65% forest cover. Water quality decreases as forests are converted to other uses, and so the importance of forest cover is evident. The United States Forest Service recommends planting trees in urban watersheds to recharge groundwater, reduce soil erosion and sediment in streams, and to improve water quality.

Wildlife and Biodiversity

William Penn first established the tradition of protecting the natural diversity of the Commonwealth in the mid-1600s. In keeping with this stewardship ethic, Pennsylvania adopted Article 1, Section 27 as part of the Pennsylvania Constitution in 1972. The ecological rights described encompass the resources we know as Pennsylvania's state forests, the intricacy of which being that very natural diversity William Penn recognized as important centuries ago.

Biodiversity refers to the complex interactions among all living organisms and the natural ecosystems they form in a given area. The complexity of these systems also defines their fragility. For the system to continue to work properly, all parts must remain in order. Basically, if one part of the larger system is removed, no matter how minute, the entire system (ecosystem) may break down. "The diversity of life is a key measure of the health of our environment. Urbanization and fragmentation of landscapes, the introduction of exotic species and air and water pollution all degrade natural habitats and pose the greatest threats to Pennsylvania's remaining natural diversity. (Report of the Pennsylvania 21st Century Environment Commission, September 1998. pg. 34.)

Forest biodiversity is important for many reasons. It is "the basis for life-sustaining ecological services such as nutrient cycling, photosynthesis, decomposition, soil creation, climate regulation, removal of pollutants, and insect control. These processes contribute to the stability of the Earth's ecosystems and contribute to higher quality air, water, and food." (Forest Biodiversity: Understanding Biological Health in Our Forests. PSU College of Agricultural Sciences. Ag. Research and Coop. Extension publication 2006.)

Forest biodiversity can be preserved by the provision and protection of various habitat types. The greater the diversity of habitat types in the forest, the greater the diversity of plant and animal life that will coexist in the forest. Reducing forest fragmentation will help to protect important habitat for many species that are unable to spread without continuous forestland. DCNR uses and supports sustainable timber harvesting practices that mimic natural occurrences and conserve natural resources, and that protect sites from pollutants by use of best management practices, and that also promote desired tree growth and composition of tree species in the forest. Proper planning and site management help to maintain the level of biodiversity, and sometimes even increase biodiversity in Pennsylvania's forest ecosystems.

Other strategies used to promote the natural biodiversity of forests are to control the establishment, growth and spread of invasive species and to reduce pollutants. Invasive species are any organisms thriving in an area to which they are not native. They may be brought into that area on vehicles or equipment, or may have spread from nursery stock imported from other areas. These non-native or introduced species have the potential to out-compete native species for food or habitat, and can thus have detrimental impacts on the forest system. "Pollution has negative effects on forest ecosystem productivity and may make certain species more prone to damage from insects and disease." (Forest Biodiversity: Understanding Biological Health in Our Forests. The Pennsylvania State University College of Agricultural Sciences. Ag. Research and Coop. Extension publication 2006.)

The biodiversity of the forest attracts many visitors, such as hunters, fisherman, bird watchers, wildlife photographers and naturalists. Pennsylvania forest land has an abundance of streams, ponds and lakes that supply opportunities for cold-water and warm-water fishing. State forests have some of the most pristine waters in the Commonwealth and they support abundant fish life. The Department of Environmental Protection classifies 2,970 miles of waterways as high quality and 626 miles of waterways are classified as exceptional value. In addition the Fish and Boat Commission classifies 207 miles as wilderness trout streams.

Hunting is a recreational activity that in many cases also plays a key role in sustainable forest management. Forests can only be sustainably managed if balanced populations of wildlife are maintained. Nearly all of Pennsylvania's state forest land is open to public hunting and trapping. There are over 5,100 miles of trails for foot travel open that allow hunters and trappers access to this large public landholding. Hunters also play a key role in species management on State Game Lands, and much of the Allegheny National Forest and private forestland across Pennsylvania.

Biodiversity is also a benefit to forest visitors as it adds to the natural beauty and changing scenery enjoyed by so many outdoor recreation enthusiasts. Citizens and visitors alike appreciate the aesthetic benefits of a diverse forest system. Even on a small scale, urban forests offer refuge and solitude to people while also creating small, but complete ecosystems of many living parts. Looking deeper into the benefits to humans, many species of plants and fungi are gathered and sold for economic value and require proper habitat to thrive. Many plants also have medicinal properties that humans benefit from, not to mention the potential of our plant and animal kingdom to hold the secrets to yet undiscovered medical breakthroughs.

Air Quality and Climate Change Mitigation

"Air is inseparable from all other resources. It is the key component linking virtually all living and non-living components of the earth…Poor air quality decreases visibility, acidifies or disrupts the natural balance in lakes and streams, injures plant and animal communities and harms human health." (http://www.fs.fed.us/air/)

Air pollution in the United States has increased historically as industry and populations grew. The burning of non renewable fossil fuels such as coal, oil and natural gas introduces pollutants into the earth's atmosphere, most notably the greenhouse gas, carbon dioxide. Carbon dioxide emissions from fossil fuel combustion occur directly from residential, industrial/commercial, or transportation sources.

Large forest systems, as well as smaller urban forests, have the ability to sequester carbon dioxide and other pollutants from the atmosphere through absorption in the soil, trees and other vegetation. "Trees in street proximity absorb 9 times more pollutants than more distant trees, converting harmful gasses back into oxygen and other useful and natural gasses." (Burden, Dan. 22 Benefits of Urban Street Trees. May 2006.)

To residents and visitors of Pennsylvania's cities and suburbs, not only do trees improve air quality, but they also affect air temperature and help reduce energy costs by shading nearby homes and businesses. "Asphalt and concrete streets and parking lots are known to increase urban temperatures 3-7 degrees. These temperature increases significantly impact energy costs to homeowners and consumers. A properly shaded neighborhood, mostly from urban street trees, can reduce energy bills for a household from 15-35%." (Burden, Dan. 22 Benefits of Urban Street Trees. May 2006.)

Recent and current rising energy costs have magnified the importance of reduced energy consumption in Pennsylvania and across the United States. This tightening demand for new and renewable sources of energy like forest biomass, coupled with the current carbon-constrained economy has made many realize the importance and potential of

forest lands for climate change mitigation. This will only happen through proper and innovative management of Pennsylvania's state forest system and the natural resources within.

Climate change mitigation includes any actions taken to reduce greenhouse gases, blamed for steady increases in the earth's temperature and subtle changes in weather patterns. Mitigating activities on state forest lands can be management strategies adopted with the purpose of increasing the forests' natural ability and capacity to store carbon. Because soils, trees, and all plants and biomass have this capability to sequester carbon, making it unavailable for release into the atmosphere, forests are referred to as carbon sinks. *Sinks* basically absorb the carbon produced by greenhouse gas *sources*, thus reducing environmental or climatic impacts.

Forest systems are among the most beneficial carbon holding sinks and may be the only ones that human activity can directly influence. With proper management, the capacity of these sinks can be increased without compromising other intended and necessary uses of Pennsylvania's forests. Pennsylvania forest lands currently hold 1.5 billion tons of carbon and will remain most beneficial if they remain forested. Preventing forest land conversion to other uses is an important first step to maintain capacity to store carbon. Tree plantings or other techniques to revegetate sites disturbed by harvesting practices, industrial use/growth or natural disasters will increase the sinks carbon-holding capacity by increasing vegetative cover, biomass and soil productivity.

Adapting management strategies that will reduce *sources* and amounts of greenhouse gases, and that will increase *sinks* that store carbon is not only necessary for climate change mitigation, but is also necessary for participation in a carbon credit trading program. Tracts of forest land may be able to enter into a carbon trading program under registry with one of ten different groups or partnerships now offering carbon emissions or offset registries.

The recent emphasis placed on climate change and reduction of greenhouse gas emissions is paradoxically relative to the desire to reduce energy consumption from non renewable sources. Basically, the desire for renewable energy sources focuses some attention on

forest biomass as a viable part of the solution. But forest biomass is an integral part of the carbon sink and removal of such would decrease the amount of carbon sequestered by the forest.

In answer to the attention placed on Pennsylvania state forests recently as possible sources of renewable energy resources such as biomass, DCNR produced the *Guidance on Harvesting Woody Biomass for Energy in Pennsylvania* in June 2008. This document provides best management practices and advice based on sound science to land managers, landowners and others interested in learning more about the potential of biomass harvesting and its effects on forest systems.

GUIDANCE ON HARVESTING WOODY BIOMASS FOR ENERGY IN PENNSYLVANIA

Pennsylvania Department of Conservation and Natural Resources

The guidelines and pilot projects entered into by DCNR work strongly toward its mission to ensure the long-term health, viability, and productivity of the Commonwealth's forests. The mission further calls for promoting forestry and the knowledge of forestry by advising and assisting other government agencies, communities, landowners, forest industry, and the general public in the wise stewardship and utilization of forest resources. The biomass guidelines have been well-received by other government agencies and interested individuals in Pennsylvania and across the country, as the document has been praised as being one of the first of its kind in the nation. The pilot carbon projects will provide the necessary research and answer the questions about carbon offset and emissions reductions projects, and what DCNR learns from this will certainly be passed along to all others interested in learning more or entering into new projects themselves.

Wood, Energy and Other Economic Values

The many objectives encompassed by the mission of DCNR's Bureau of Forestry include ensuring sound ecosystem management while providing sustained yields of quality timber and environmentally sound utilization of mineral resources. The major benefits and services from Pennsylvania's forests are these intrinsic economic values that forests provide to the Commonwealth.

Community trees that make up urban forests can provide economic values as an added benefit to the environmental advantages noted. Energy savings from strategically placed trees can reduce residential heating and cooling costs by 8 to 12%. Properties with trees adjacent to them have been shown to sell for 3.5 to 6% more than those without trees. Business districts too benefit from added street trees. Consumers have been shown to prefer shopping in tree lined business districts and to spend more time there. Studies of social and psychological benefits of trees indicate that trees have a calming effect, reducing stress, reducing road rage, and even slowing the movement of vehicular traffic. As an additional benefit, the fruits, berries and nuts produced by some trees can be a

valuable food source. These products could also potentially be sold for income where permitted, and can also be planted as part of urban tree planting programs.

Trees that fall or must be removed can be recycled by utilizing the wood for anything from fuelwood to pulpwood for paper products to low-cost construction material. Similarly, fallen or removed branches as well as leaves can be chopped and used as composting material, mulch or collected as biomass. Street trees and urban forests also significantly cut energy costs in homes and buildings. "Trees properly placed around buildings can reduce air conditioning needs by 30 percent and can save 20 - 50 percent in energy used for heating." (USDA Forest Service)

Take these values and apply them to a larger scale forest and the value of timber to Pennsylvania becomes evident. "More than half of Pennsylvania—12 million acres—is covered in forest… Economically, Pennsylvania's hardwood forests are some of the most valuable and productive in North America. Each year, our wood industry processes 1.2 billion board feet of lumber, employs nearly 100,000 people, and produces annual shipments valued at more than $5 billion." (PSU, College of Agricultural Sciences. http://paimpact.cas.psu.edu/agr14.html.)

Pennsylvania forests are dominated by hardwood forests that include oaks, maples, hickories, cherries and birch trees, among many others. All vary in their specific value, but almost all tree species growing in Pennsylvania have some inherent timber value, whether for top quality furniture and cabinets or to be pulped for paper products. Among the top timber products are the exported amounts of some of the best black cherry wood in the world. But in today's market, even sawdust, a simple by-product of timbering, is growing in value as it has recently gained popularity as a source of woody biomass material to mold into pellets for burning in heaters.

The Pennsylvania Fuels for Schools and Beyond program is a shining example of the value of Pennsylvania's forest products to its citizens. In an effort to reduce dependence on fossil fuels and find renewable energy sources for Pennsylvania schools and businesses, this initiative promotes the use of local wood and biomass resources. A collaborative partnership between over 50 organizations and groups, Pennsylvania Fuels for Schools and Beyond provides education, financial analysis support, and technical assistance to Commonwealth business and schools. The program has already seen measured success with systems installed at Clearfield Middle School and Elk Regional Health Center, among others. "Wood fired systems are currently a viable alternative when installed in schools, offices, prisons or greenhouses. Such projects save substantial

money on fuel, when compared to the price of fossil fuel. Combined heat and power systems generate electricity to offset power costs and can power air conditioning systems during the summer." For more information or to read success stories, visit the program website at this link: http://www.pafuelsforschools.psu.edu/default.asp.

Much of the wealth of Pennsylvania has been provided by its forests, from the trees that provided and continue to provide economic benefit to the citizens and communities of the Commonwealth, to the mineral resources under the surface. Along with timber production, Pennsylvania remains one of the top producers of anthracite and bituminous coal, used to generate half of the Commonwealth's electricity, as well as heating private homes and businesses. And though emerging interest in the natural gas from Marcellus Shale is fairly new, oil and gas production from sources under Pennsylvania forests has been in play since the mid-1800s.

More than 350,000 oil and gas wells have been drilled in Pennsylvania since the first commercial well was developed in 1859. Since 1947, DCNR has sustainably leased state forest lands for natural gas extraction, serving its mission to provide environmentally sound utilization of the mineral resources within Pennsylvania's state forest system. At the close of 2009, approximately 750 gas wells were in production on about 660,000 acres of DCNR land. Since 1955, state forest lease sale and royalty proceeds have been used to help fund conservation, recreation and flood control projects. More recently, these funds have been used to help balance the state government budget.

With resources as significant as timber, oil, and natural gas within the forests of Pennsylvania, it is easy to forget about the vast amount of less significant, but still valuable products. These products all have some worth to people, whether as heat/energy sources, food products, herbal remedies or sources of income (if sale of products is permitted). Using state forests as the example, it is possible to obtain nursery stock as permitted, and gathering permits are available for fuelwood and for certain plants used for food or medicinal purposes, like certain fungi and ginseng.

Spending on the recreational pursuits available in the forests of the Commonwealth generates money to state and local economies. Many individuals and businesses provide land for activities like hunting or hiking, or offer goods and services like guided trips or recreation equipment rentals and sales.

Conclusion

The value of the forests of Pennsylvania for some may be found in the timber, or in the natural gas reserves. Others may find value in the opportunities the forests create to engage in traditional or modern recreational pursuits. Environmental values of natural biodiversity and the provision of clean air and water keep ecosystems and communities vibrant and healthy. Sensory benefits arise from the peace and serenity found within the Commonwealth's forests, given credit for benefiting mental health. Physical health improves with outdoor activities for which forests are the desired setting as well.

Renewable energy sources may be the biggest future value of the Commonwealth's forests as fossil fuels continue to diminish in supply as well as in reputation for environmental and climatic degradation. Wildlife must continue to thrive in Pennsylvania to ensure not just sporting opportunities, but more importantly the biodiversity and ecosystem functions of all species.

Proper management with objectives for sustainable product yields and conservation of the natural resources within the forests is the best means by which the Commonwealth can ensure the productivity of the forests for future generations and so the usability by people and industry. Proper and careful management, based on sound-science, research and experience will secure the health and vitality of the forests of Pennsylvania now and into the future, allowing for continuity of services and benefits for generations to come; and who knows what other valuable secrets the forests hold that have yet to be discovered by those future generations.

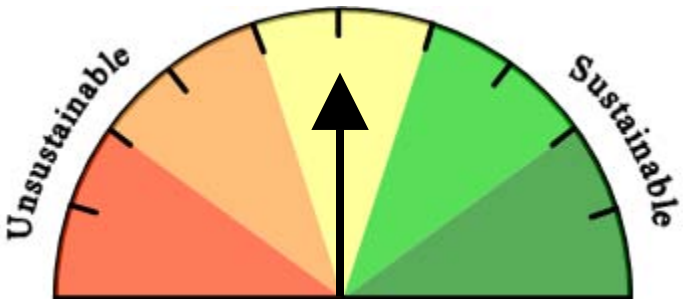
Chapter 3

Forest Conditions and Trends

Introduction

The concept of sustainability refers to the forest's ability to produce the full suite of ecological, economic, and social benefits and services for both current and future generations. The interconnectedness of plant and animal habitats, ecosystem health, and meeting human needs and desires is a central theme of forest sustainability. In an effort to measure and track global progress toward achieving forest sustainability, an international seminar held in 1993 Montreal, Quebec resulted in the *Montreal Process Criteria and Indicators* for sustainable forestry. The *Montreal Process* includes a set of seven criteria and sixty-seven indicators for assessing sustainability. To help make the process relevant on a smaller scale, the USFS Northeastern Area, in cooperation with the Northeastern Area Association of State Foresters, developed a set of seven criteria and eighteen indicators for the Northeastern U.S.

What follows is an analysis of Pennsylvania's forests relative to the eighteen indicators of sustainable forestry. For each indicator we've briefly described what the indicator means, presented and discussed relevant data, and provided a conclusion regarding sustainability. Additionally each indicator includes a visual interpretation of sustainability in the form of a scale like the one pictured below.



Sustainability Meter

The color codes for the meter can be roughly interpreted as:

- **Red** = Situation is unsustainable.
- **Orange** = Situation is trending toward unsustainable and/or will be unsustainable if certain conditions are not addressed.
- **Yellow** = Situation is cautionary and merits close monitoring.
- **Light Green** = Situation is sustainable with a few minor concerns.
- **Green** = Sustainable.

This analysis represents an initial, snapshot view of Pennsylvania's forests. Much more work is required to adequately assess forest conditions and establish consistent, measurable metrics for each indicator. A major objective of this analysis is to present an initial assessment and stimulate dialogue on the current condition and future sustainability of Pennsylvania's forests.

Definitions

Criterion: categories that provide a large-scale reflection of public values

Indicator: a specific measure within each criterion

List of Criteria and Indicators

Criterion 1: Conservation of Biological Diversity

Indicator 1. Area of total land, forest land, and reserved forest land Metrics

Indicator 2. Forest type, size class, age class, and successional stage

Indicator 3. Extent of forest land conversion, fragmentation, and parcelization

Indicator 4. Status of forest/woodland communities and associated species of concern

Criterion 2: Maintenance of Productive Capacity of Forest Ecosystems

Indicator 5. Area of timberland

Indicator 6. Annual removal of merchantable wood volume compared with net growth

Criterion 3: Maintenance of Forest Ecosystem Health and Vitality

Indicator 7. Area of forest land affected by potentially damaging agents

Criterion 4: Conservation and Maintenance of Soil and Water Resources

Indicator 8. Soil quality on forest land

Indicator 9. Area of forest land adjacent to surface water, and forest land by watershed

Indicator 10. Water quality in forested areas

Criterion 5: Maintenance of Forest Contribution to Global Carbon Cycles

Indicator 11. Forest ecosystem biomass and forest carbon pools

Criterion 6: Maintenance and Enhancement of Long-Term Multiple Socioeconomic Benefits to Meet the Needs of Societies

Indicator 12. Wood and wood products production, consumption, and trade

Indicator 13. Outdoor recreational participation and facilities

Indicator 14. Investments in forest health, management, research, and wood processing

Indicator 15. Forest ownership, land use, and specially designated areas

Indicator 16. Employment and wages in forest-related sectors

Criterion 7: Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management

Indicator 17. Forest management standards/guidelines

Indicator 18. Forest-related planning, assessment, policy, and law

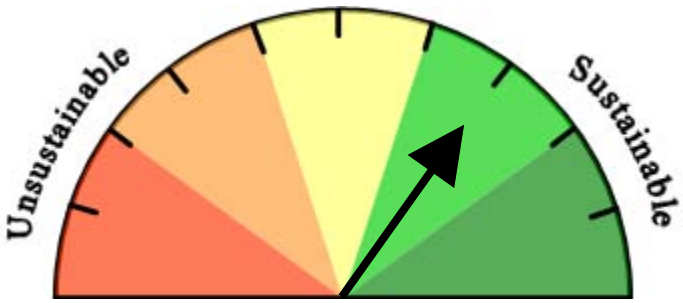
CRITERION 1: CONSERVATION OF BIOLOGICAL DIVERSITY

Indicator 1. Area of total land, forest land, and reserved forest land

Maintaining forest cover is fundamental to providing the full suite of resources and values that Pennsylvanians have come to expect from their forest, including clean water, recreation opportunities, wood products, and habitats for plants and animals. Pennsylvania contains 16.6 million acres of forest, covering approximately 60 percent of the Commonwealth. Recent US Forest Service data suggests that on a statewide basis, Pennsylvania's forestland area is stable. However, a closer look reveals that some parts of the state are gaining forests, while other parts are losing forests. Counties surrounding the metropolitan areas of Philadelphia, Pittsburgh, and Harrisburg lost significant amounts of forestland over the past fifteen years. Statewide, an estimated 28,000 acres of forest are lost to residential and industrial development yearly. While forests are being

converted to other land uses, Pennsylvania is fortunate to contain over 4 million acres of public lands protected from development. Much of this forest occurs in Northcentral PA and along the major ridges that form the Appalachian Mountains. These large, contiguous public ownerships serve as a backbone for biodiversity and other conservation values.

While the amount of forestland is sustainable on a statewide basis, and public ownerships form a solid foundation of reserved forestland, there is significant cause for concern in urban and suburban counties experiencing heavy growth and resulting forest conversion.



Sustainability Meter
Indicator 1. Area of forestland

Indicator 2. Forest type, size class, age class, and successional stages

Forest characteristics occur at various geographic scales (forest communities, landscapes, and eco-regions) and are critical building blocks for (1) diverse plant and animal habitats (2) providing human derived values such as wood and clean water; and (3) resiliency to insects, diseases, and other disturbances.

Pennsylvania's forests support a wide variety of trees—the latest inventory recorded over 100 species. Oak/hickory and northern hardwood forests dominate Pennsylvania's landscapes—each containing unique tree and plant communities that define the overall character of our forest. Oak/hickory forests contain primarily oaks, maples, and hickories and commonly have understories with mountain laurel and blueberry. Northern hardwood forests contain primarily black cherry, maples, American beech, and birch with understories of ferns, striped maple and beech brush. Hemlock and Eastern white pine are common to both forest types and both produce valuable wood products, hard and soft mast for wildlife, and contain diverse plant communities. Recent US Forest Service data suggest that the make-up of our forest types is changing. Red maple, black birch, and white pine are becoming more common while sugar maple, hemlock, beech, and the oaks are declining. These species shifts raise serious questions about the future composition of our forest, including their ability to provide food for wildlife with potential reductions in mast species such as beech and oak.

Except for areas that have been recently harvested, the majority of Pennsylvania's forests originated between 90 and 120 years ago, reflecting the widespread clearing and harvesting that occurred to fuel the industrial revolution. As a result, most forest stands are relatively uniform in structure and are dominated by "sawtimber-sized" trees. Many experts agree that Pennsylvania is experiencing a shortage of both early-succession habitat and habitat exhibiting old-growth characteristics. Acknowledging this general lack of habitat diversity, the Bureau of Forestry, for example, has developed explicit goals in its state forest management plan for achieving a balanced forest age-class distribution across the state forest. Regenerating stands through timber harvesting is the primary means to achieving these long-term goals. Regeneration difficulties related to white-tailed deer browsing and competitive native and invasive plants, along with significant pests and pathogens affecting hemlock, sugar maple, ash, and American beech cause concern for both early-and late-succession habitats.

Overall, the potential changes to tree species diversity, structural components of the forest, and distribution of successional stages suggest that Pennsylvania's forests are moving toward an unsustainable condition. Many factors including harvest practices, insects and disease outbreaks, climate change, and weather events are causing tree mortality, threatening regeneration, and reducing diversity—all of which reduce the health and resiliency of the forest.

Sustainability Meter
Indicator 2. Forest characteristics

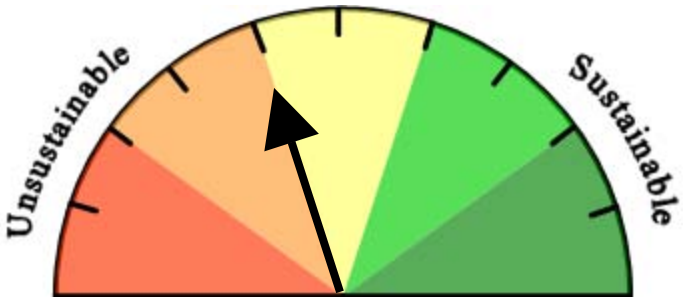
Indicator 3. Extent of forest land conversion, fragmentation, and parcelization

The process of converting forests to other land uses or dividing them into smaller units significantly undermines sustainability by limiting overall ecological functions. Conversion means that a forest is cleared and converted to another use such as housing, commercial, or industrial developments. Fragmentation refers to breaks in forest cover, or openings created by roads, utility corridors, gas well sites, and housing developments; resulting in a loss of interior forest habitat. Parcelization refers to landowners dividing their properties into smaller parcels that are then owned by other individuals or entities. Parcelization may or may not result in fragmentation or conversion.

As stated in Indicator 1, forest conversion is occurring at alarming rates in certain parts of Pennsylvania and represents an unsustainable situation in these locations. Fragmentation of the forest is difficult to quantify and depends on the definition of a fragmenting feature. The resulting size and spatial arrangement of forest blocks define areas as interior forest and edge forest. While a certain amount of forest edge creates habitat beneficial to some wildlife, larger quantities of forest edge are problematic for species requiring expanses of unfragmented, interior forest. Forest fragmentation also creates conduits for the introduction and spread of invasive species. Pennsylvania already contains an abundance of roads and other fragmenting features, with the exception of the large blocks of public forests in northern Pennsylvania. However, Marcellus shale gas development will likely become a major source of fragmentation and potential threat to these interior forest areas of northern Pennsylvania [see chapter 4F]. Analyses such as the Pennsylvania Forest Habitat Connectivity Analysis and the GIS analysis contained in Chapter 5 provide a framework for measuring the extent of forest fragmentation over time.

While parcelization may or may not result in immediate changes to the forest, the process can have longer-term impacts. As forested parcels are subdivided and sold, new owners are often confronted with decisions regarding their forests. Whether new owners choose to develop their newly acquired land or their management objectives simply differ from their neighbors, continuity of forest cover is jeopardized. Landscape-level management with a focus on overall sustainability is extremely difficult with larger numbers of landowners with wide-ranging management objectives. A recent study estimates that Pennsylvania has well over 600,000 forest landowners, with an aging demographic, suggesting the potential for an increased rate of parcelization in the near future. The study estimates that half of Pennsylvania's private forests will change hands in the next two decades. In another study, researchers found that the next generation of landowners have varying viewpoints of forest ownership, thus raising additional uncertainty of future management and stewardship.

Forest conversion, fragmentation, and parcelization are separate but highly related phenomena, individually contributing to an increasing cause for concern as forest ownership continues to change hands and become divided into smaller, less contiguous units. With continued urban and suburban development and new sources of fragmentation surfacing, such as Marcellus shale development, Pennsylvania is is moving toward an unsustainable condition relative to forest conversion, fragmentation, and parcelization.



Sustainability Meter
Indicator 3. Conversion, fragmentation, and parcelization

Indicator 4. Status of forest/woodland communities and associated species of concern

Pennsylvania contains a diverse assemblage of plants and animals including 3,000 species of plants, 400 species of birds, 200 species of fish, 75 species of reptiles and amphibians, and 70 species of mammals. All told there are more than 25,000 species documented in the state—more than half of which are species of fungi and invertebrates (e.g., insects, crustaceans, worms, etc.), and many depend on forests for their habitats.

Plant and animal species of concern are managed by the Pennsylvania Natural Heritage Program (PNHP), which is a partnership among The Department of Conservation and Natural Resources, The Western Pennsylvania Conservancy, The PA Fish and Boat Commission (PAFBC), and The PA Game Commission (PGC). PNHP provides scientific information and expertise, gathers information on the location and status of important ecological resources, and maintains an inventory of species of concern in Pennsylvania. Biota of "Special Concern" include those classified as Endangered, Threatened, or Rare as listed by DCNR, PGC, PFBC, U.S. Fish and Wildlife Service and species recommended by the PA Biological Survey. Natural community types and geologic features are identified and mapped based on the recommendations of PNHP ecologists and the Bureau of Topographic and Geologic Survey, respectively.

The Commonwealth has lost at least 192 species of plants and animals while nearly 500 species have been diminished to endangerment status since European settlement. Species favoring streams and other water bodies have suffered the greatest losses. More than 50 percent of the native fishes known to occur in Pennsylvania are either in danger or already gone, and the same is true for 75 percent of the native freshwater mussels. Roughly half of Pennsylvania's wetlands have been ditched, drained, or modified for a variety of reasons over the last 250 years, exacting a heavy toll on Pennsylvania's wildlife. Still,400,000 acres of wetland remain and host some of Pennsylvania's most imperiled species.

Though some of the data are alarming, significant recoveries have been made (e.g., deer, elk, fisher, and river otter) and awareness and concern for threatened and endangered

species have grown considerably. Since 1988, use of PNHP's screening tool, the "Pennsylvania Natural Divresity Inventory (PNDI)," has become routine in most environmental assessments, and subsequently has prevented losses of species of special concern without adversely affecting the state's economic growth. PNHP also assists conservation organizations by providing information to facilitate and direct land acquisition, conservation easements, and other agreements to more effectively protect significant ecological resources.

While limited funding for habitat improvement projects, incomplete inventories, invasive species impacts, and new concerns such as white nose syndrome of bats and Marcellus shale development worry conservation biologists, significant advances have been made and current protection efforts suggest a “cautionary sustainable” status for species of concern in Pennsylvania. Natural resource managers must pay close attention to forest health and other habitat-related indicators and their resulting effects on plant and wildlife biodiversity.

Sustainability Meter
Indicator 4. Species of concern

CRITERION 2: MAINTENANCE OF PRODUCTIVE CAPACITY OF FOREST ECOSYSTEMS

Indicator 5. Area of timberland

As defined by the US Forest Service, timberland is “forest land producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization by statute or administrative designation. The statutes and designations apply only to publicly owned land. Timberland, formerly known as commercial forest land, may be “nonstocked” so long as no natural condition or human activity prevents or inhibits the establishment of tree seedlings.” Timberland is an important economic indicator as it provides a measure of accessibility to the Commonwealth’s valuable hardwood resource.

Pennsylvania contains 16.1 million acres of timberland, representing nearly 97 percent of the state's forest. While this percentage has decreased slightly since the 1950s, it has remained relatively constant for the past two decades. The decrease results mostly from public agencies designating areas off-limits to timber harvesting, such as State Forest Wild and Natural Areas and Wilderness and Roadless Areas on the Allegheny National Forest.

In addition to US Forest Service data, it is important to consider additional social and environmental variables that affect "access" to timber, a broader assessment of this indicator. A recent study in Pennsylvania examined biophysical constraints (e.g., steep slopes, road access, and riparian corridors) in combination with private forest landowners' attitudes and behaviors regarding timber harvests, both measures of timber access. Results indicate that 68 percent of forestland in Berks County and 55 percent of forestland in Huntingdon County is under a combination of biophysical and social constraints. In both counties, social constraints such as opposition to harvesting and lack of harvesting activity heavily outweighed the biophysical constraints. While limited to two counties, the results of this study confirm anecdotal reports from industrial foresters that it is becoming more difficult to procure quality timber for mills despite US Forest Service reports of adequate amounts of timberland and wood volumes in Pennsylvania.

Although US Forest Service data paints a sustainable picture of timberland in Pennsylvania, recent studies and anecdotal evidence from the forest industry suggest that access to timber is highly complicated, variable, and could become limited in the future.

Sustainability Meter
Indicator 5. Timberland

Indicator 6. Annual removal of merchantable wood volume compared with net growth

Pennsylvania's forests supply raw materials to a global industry producing a wide range of products from paper to hardwood flooring to high-end furniture and cabinetry—with black cherry, oak, and sugar (hard) maple currently being most desired. The forest products industry is an important component of many rural economies and timber provides an important economic value to forestlands that is increasingly competing with other land uses like housing and commercial development. Sustainable production of

quality forest products is critical to both Pennsylvania's economy and working forest landscapes.

A basic measure of timber sustainability is the comparison of wood volume removed to net tree growth. If net growth exceeds the amount of wood removed, then theoretically, the forest is sustainable. According to USFS FIA data, tree growth in Pennsylvania's forest currently exceeds removals, at a ratio of about 2.4:1. On an annual basis, for every board foot harvested, lost due to land conversion, or lost due to mortality (e.g., insects, diseases, and old age), our forests are growing another two board feet. On this measure alone, PA's forests are sustainable.

However, consideration of other factors is necessary to truly evaluate timber sustainability, including species composition, tree quality, and regeneration trends. These indicators suggest harvested stands contain trees of lesser quality, have a different species mix, and are not regenerating to the same species mix harvested. This clearly suggests the mix of species available for harvesting in the future will be different. It is not clear if and how society's product demand will shift to match the changing forest composition. Further, as described in Indicator 5, the willingness of private landowners to manage and harvest for wood products is changing and their decisions will affect the growth to removal ratio. However, how this reservation will affect forest sustainability is unknown. Finally, the current tree species mix provides a critical source of food and cover for wildlife, and the prevalence of preferred mast species is declining, leading to another critical, unanswered question of sustainability.

Based on the ratio of tree growth to removals, Pennsylvania's forests are sustainable. Considering the holistic suite of variables and characteristics of the forest, overall future timber sustainability is a cause for concern.

Sustainability Meter
Indicator 6. Net growth

CRITERION 3: MAINTENANCE OF FOREST ECOSYSTEM HEALTH AND VITALITY

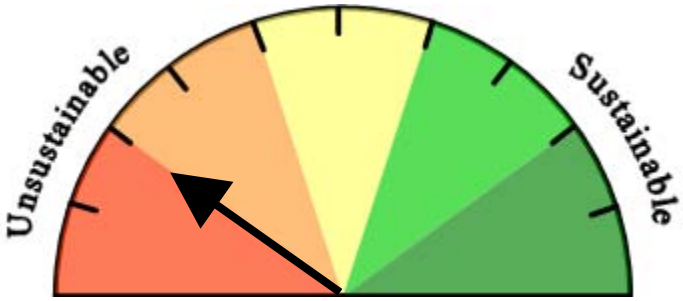
Indicator 7. Area of forest land affected by potentially damaging agents

Considering the large list of potential "damaging agents," including forest insects and diseases, invasive plants, white-tailed deer browsing, weather events, drought, climate change, air pollutants, poor management decisions, and wildfire, nearly every acre of forest in Pennsylvania has been affected by a damaging agent. While the stressors have been ubiquitous both across the landscape and throughout history, Pennsylvania's forests have proven resilient and diverse, but have not escaped unscathed.

At the broadest level, Pennsylvania has fewer acres of forest now than it did 200 years ago, and as addressed in another indicator, forest conversion to other land uses is occurring in some parts of the Commonwealth. Diseases have essentially extirpated the American chestnut and American elm from their natural habitats. Hemlock woolly adelgid and elongate hemlock scale, beech bark disease, emerald ash borer, Asian long-horned beetle, and sudden oak death threaten to do the same to other host species. In addition, native and non-native insects such as forest tent caterpillars and gypsy moth become problematic when combined with drought, deer browsing, and other stressors. In 2009, forest tent caterpillar defoliated 371,000 acres across northern PA and gypsy moth-related tree mortality was estimated at 108,000 acres in oak forests that were defoliated multiple years in a row.

The list of damaging agents is large, while preventative measures and controls are expensive and sometimes ineffective and impractical over large landscapes. The "green veneer" covering much of the state hides the fact that trees are dying, forest types are changing, diversity is declining, and overall forest health is a serious concern.

From a holistic perspective, the health of Pennsylvania's forests is approaching an unsustainable condition in the face of an apparently growing list of damaging agents.



Sustainability Meter
Indicator 7. Damaging agents

CRITERION 4: CONSERVATION AND MAINTENANCE OF SOIL AND WATER RESOURCES

Indicator 8. Soil quality on forest land

Pennsylvania's native soils are generally well-suited to growing trees, as forests historically covered nearly the entire state. Pennsylvania has an extremely diverse set of soils ranging from sandy costal-like soils in the extreme southeast, to deep and fertile limestone valley soils in the central region, to a near absence of soil on rocky ridge tops, to the glaciated soils on the Allegheny Plateau famous for growing the prized black cherry. Left undefined, "soil quality" is a subjective term, as foresters often relate soil quality to growing tall, straight trees of commercial value at fast growth rates. Ecologists may have a completely different definition of soil quality, considering that wetlands, barrens habitats, and riparian areas may not produce high-quality timber trees, but do contain quality soils necessary for their diverse plant communities and associated wildlife. Regardless of the definition of soil quality, soils are obviously critical to growing plants and trees, and thus sustainable forests.

Forest soils are composed of an assortment of materials and organisms that, when viewed in whole, function as a living ecosystem. The physical, chemical, and biological properties of Pennsylvania's forest soils have changed throughout history and continue to change—having the potential to affect conditions for plant and tree growth. Agents of change have included:

- Long-term climate shift
- Glaciation
- Acid precipitation
- Accelerated erosion
- Compaction from equipment
- Exotic earthworms changing flora, fauna and resulting soil chemistry structure
- Fertilization
- Potential reduction in nutrient cycling from unsustainable biomass harvesting

Best management practices (BMPs) designed to protect soils have been developed and are generally widely accepted and followed across Pennsylvania. Forest regeneration in some parts of Pennsylvania is difficult to obtain and has been attributed to "soil quality," but little scientific data exists to characterize the situation. Other complicating factors such as changing chemistry and impacts of invasive flora and fauna raise additional questions about soil quality in the Commonwealth.

More information is needed to fully understand the situation and to develop practices and policies that address the entire soil ecosystem, which includes bacteria, algae, fungi, protozoa, nematodes, arthropods, earthworms, insects, small vertebrates, and plants, as well as physical and chemical properties of the soil.

Sustainability Meter
Indicator 8. Soil quality

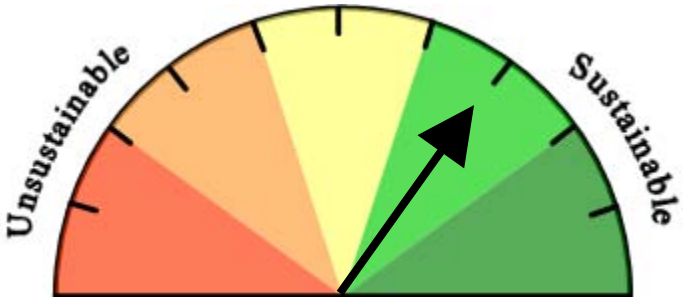
Indicator 9. Area of forest land adjacent to surface water and forest land by watershed

Pennsylvania contains 86,000 miles of streams, 4,000 lakes, reservoirs and ponds, and over 400,000 acres of wetlands. Forests adjacent to these water bodies, commonly referred to as riparian forests, are critical to providing clean water for humans and quality aquatic habitats for plants and animals. Riparian forests serve as buffers and help to reduce the impact of upland land uses by providing overhead shade to cool the water and by trapping and filtering sediment, chemicals, and excess nutrients from agricultural operations. Countless studies have documented the benefits of riparian forests and for maximum benefits, 70 percent or more of streams in a watershed should be protected by a forested buffer. Statewide, Pennsylvania nearly meets this threshold with 63 percent of streams buffered by a forest more than 100 meters wide. However when viewed at a smaller, individual watershed scale, the story is much different. Only a third of the state's small watersheds are protected with buffers, corresponding generally to the overall distribution of forest cover—meaning that areas with less forest cover contain fewer streams with riparian buffers.

In addition to the area of riparian forests, overall forest cover by watershed is another measure of watershed health and a similar threshold exists. In general, watershed health begins to decline as forest cover drops below a range of 65-75 percent forested. Water quality decreases as forests are converted to other uses. Current estimates indicate that slightly more than half of Pennsylvania's small watersheds meet the 65 percent threshold. Forest cover also helps to ease the burden on municipal storm water systems. For example a study conducted in the Delaware Valley region (nine counties surrounding Philadelphia) found that the local urban forests stored 2.9 billion cubic feet of storm water, a service valued at $5.9 billon. An analysis of similar data in Harrisburg found urban forests there capturing 4.1 billion cubic feet of storm water with a savings of over $8 billion.

Overall, heavily forested areas of Pennsylvania are at a sustainable condition relative to this indicator, while areas containing smaller amounts of forest cover and areas

experiencing heavy growth and development as discussed in Indicators 1 and 3 are approaching an unsustainable condition as forests are converted to other land uses. The good news is that many state and federal programs exist, helping to promote streamside tree planting and riparian forest protection.



Sustainability Meter
Indicator 9. Forestland by watershed

Indicator 10. Water quality in forested areas

Forested watersheds are key components of a public infrastructure that provides clean drinking water to millions of Pennsylvanians. Three hundred five (305) surface water supply systems provide drinking water to 7.5 million Pennsylvanians, while the remaining population obtains its drinking water from groundwater systems which are hydrologically linked to surface waters. The quality of the water from these watersheds is of obvious interest. Generally speaking, forested watersheds produce higher quality water than non-forested watersheds. A recent USFS analysis entitled "Forests, Water, and People" confirmed this assumption, highlighting the Poconos and Northcentral PA as areas with the greatest ability to produce clean water.

While our forested watersheds help to provide clean water, Pennsylvania still has many serious water quality issues. Statewide, major issues include increased water temperature, acid mine drainage, sedimentation, storm water runoff, industrial spills, and fluctuations in seasonal water quantity. Efforts to improve water quality and mitigate the effects of pollutants are underway, but face serious challenges such as increasing development, inadequate treatment through combined storm and sewer systems, and a highly modified environment that includes legacy sediments, channelized streams, and impervious surfaces. With general acceptance and implementation of erosion and sedimentation BMPs, forest management activities do not represent a threat to water quality in forested watersheds. While records of no major incidents currently exist,

ground and surface water contamination from Marcellus shale development is also a major concern. [see chapter 4F]

Pennsylvania's special protection waters are classified by Department of Environmental Protection (DEP) into several categories indicating water quality, with exceptional value (EV) and high quality (HQ) being the top two categories. Pennsylvania is fortunate to contain 3,300 miles of EV streams (3.8% of total) and 22,800 miles of HQ streams (27% of total), affording superior waters for aquatic life and abundant fishing opportunities. According to a recent *In Press* study, 56 percent and 73 percent of EV and HQ waters, respectively, are located on private lands, which places great importance on the management decisions of these private owners.

Due to the daily importance of clean water, this is one of the most significant indicators to Pennsylvania citizens. Our forested watersheds have proven their ability to provide clean water and with proper management and BMP implementation will continue to do so. However, impaired streams remain and additional threats loom in the future. Water quality needs to remain a priority issue for natural resource managers and associated stakeholders.

Sustainability Meter
Indicator 10. Water quality

CRITERION 5: MAINTENANCE OF FOREST CONTRIBUTION TO GLOBAL CARBON CYCLES

Indicator 11. Forest ecosystem biomass and forest carbon pools

Worldwide, promoting sustainable forests has been recognized as a key strategy for mitigating potential climate change impacts. Sustainably managed forests can store carbon for decades, while also providing associated co-benefits such as improved water quality, plant and animal habitat, wood products, and recreation opportunities. Durable wood products generated from harvested timber are an important and recognizable source of long term sequestration, with a smaller carbon footprint compared to other, more energy intensive building materials, such as concrete and steel.

Pennsylvania's forests sequester significant amounts of carbon annually, with carbon flowing in and out of identified carbon pools for a number of reasons—all related to disturbance events such as insect and disease mortality, wildfires, storms, and harvesting. Overall, our forests sequester carbon as trees add new growth above and beyond total removals. The US Forest Service estimates that between 1989 and 2002, some 17 million metric tons of carbon dioxide equivalents (MMtCO2e) have been sequestered annually by Pennsylvania's forests. To put this into context, consider that the Commonwealth's annual gross emissions for 2005, from all sources, were 317 MMtCO2e. Our forests clearly provide a critical ecosystem service annually by absorbing and retaining about 5% of the Commonwealth's greenhouse gas (GHG) emissions.

The forest's capacity to sequester carbon is directly tied to its health and overall management—the healthier the forest the more carbon it can sequester. Disturbance events that cause tree mortality release carbon into the atmosphere, thus reducing sequestration rates. Considering the status of Indicator 7 (damaging agents), this indicator could be rated similarly if insects and diseases, invasive flora and fauna, loss of forestland, and other impacts are not appropriately addressed. However, based on net tree growth (Indicator 6), which is the primary measure of carbon sequestration capacity, this indicator receives a sustainable rating. Timely monitoring and suppression programs are vital to accounting for and maintaining the positive carbon balance of Pennsylvania's forests.

Sustainability Meter
Indicator 11. Forest Carbon

CRITERION 6: MAINTENANCE AND ENHANCEMENT OF LONG-TERM MULTIPLE SOCIOECONOMIC BENEFITS TO MEET THE NEEDS OF SOCIETIES

Indicator 12. Wood and wood products production, consumption, and trade

Pennsylvania produces more hardwood lumber than any other state and our working forests, both public and private, contribute significantly to local and statewide economies while providing a suite of other values and services. Pennsylvania produces some of the

finest hardwoods in the world and is well known for its cherry, oak, maple, and ash. Finished products include high-end furniture and cabinets, hardwood flooring, handles and baseball bats, pallets, and railroad ties. In 2007, harvest levels were estimated at 1.6 billion board feet with annual sales of $16 billion and a total economic impact of $27 billion.

The recent economic recession and ongoing housing crisis dramatically affected demand for finished hardwood products, driving 30-50 percent price reductions for many hardwood lumber products by 2009. Sawmills responded by substantially reducing lumber production to work off existing inventory. Most mills operated limited hours in 2009 and reduced their workforce. Some mills closed permanently. Some estimates place Pennsylvania's 2009 hardwood lumber production at about half of its normal volume, or the lowest level since before WWII. By early 2010, the price for most hardwood lumber products improved as supply and demand fell more into balance. A slow recovery initiated, although demand for hardwood lumber remained well below pre-recession levels. The initial recovery was stronger in some export markets than in domestic demand.

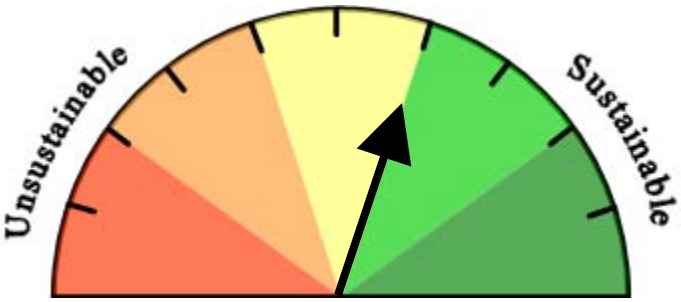
While still impacted by the economic downturn, Pennsylvania's paper producers fared better than their sawmill counterparts. Recovery for higher-end lumber species and grades, such as cherry, has lagged behind more economical species and lower grades, including pallets, ties and industrial products. There is also anecdotal evidence that certified wood products have moved from being a niche product to a relevant part of the overall wood demand.

The future of the Pennsylvania's wood and lumber production industry will depend on demand for hardwood products both domestically and globally. Demand will be influenced by the health of the US and international economies and housing markets, consumer preferences and the success of non-wood competitors. The Pennsylvania producers who will be successful at meeting the growing demand from this recovery will be those that have the management skills and production efficiencies to address the challenges of timber access, logger shortages, restricted access to financing and tax/regulatory burdens in such a way that allows them to remain competitive in the global marketplace.

While this indicator focuses mostly on the traditional forest products industry, several other emerging markets deserve mention: biomass, carbon, and non-timber forest products (NTFP). The need to identify alternative energy sources has put a minor spotlight on Pennsylvania's forests as a potential source of fuel. While debate continues regarding the sustainability of large-scale biomass projects, much support exists for small-scale efforts such as Fuels for Schools and Beyond and other community-level initiatives. Carbon sequestration markets also have the potential to return economic benefits to Pennsylvania landowners. While carbon trading prices are relatively low and entry into the market is complex, the additional revenue could help to offset taxes and other costs to landowners and help to facilitate sustainable management. While small compared to the economic value of timber, NTFP management provides significant

ecological and social opportunities as well as a source of annual income for some landowners. Maple syrup and ginseng are the two most established products and industries, each contributing about $3 million annually to the state's economy. Sustainable collection is of concern for some species.

The production of high-quality hardwoods appears sustainable in the short-run, while long-term sustainability depends on the health of the forest and robustness of the industry to operate in a global marketplace. Emerging markets such as carbon, biomass, and NTFPs all have the potential to be additional sources of revenue and leverage points for sustainable management.



Sustainability Meter
Indicator 12. Wood products

Indicator 13. Outdoor recreational participation and facilities

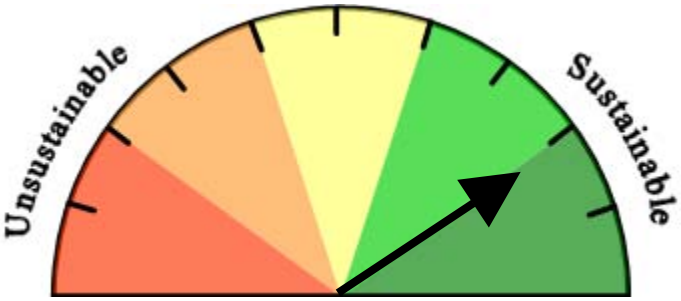
Pennsylvania has always been an "outdoor state," and its forests have long been a destination for recreation, contributing immensely to our overall quality of life. Walking, picnicking, visiting historic sites, and driving for pleasure were recently cited as Pennsylvanians' most popular forms of outdoor recreation. Wildlife watching, night sky viewing, and birding all ranked in the top ten. While less popular than in the past, hunting and fishing still engage many outdoor enthusiasts.

Public ownership protects nearly 4 million acres of forest land open for recreation including State Forests, State Game Lands, the Allegheny National Forest, 117 State Parks and hundreds of county and local parks. Pennsylvanians are fortunate in that most live within 25 miles of a State Park. This accessibility to quality outdoor recreation was recognized in 2009 when Pennsylvania's state park system received the National Gold Medal Award for Excellence in Park and Recreation. The Poconos, Laurel Highlands, and Pennsylvania Wilds are historically well known regions attracting significant recreational visitors to a variety of outdoor, historical, and cultural attractions. From a private lands perspective, landowners consistently cite recreation as a top reason for owning their forestland.

Pennsylvania boasts more than 6,300 miles of trails providing opportunities for hiking, biking, and ATV, snowmobile, and horseback riding. Two thousand miles of water trails provide canoeing, kayaking, and camping opportunities along streams and rivers. Recent

planning efforts have identified gaps in recreation trails and efforts are underway to fill the gaps and provide connections through greenways and other corridors.

Land management agencies and numerous volunteer organizations spend considerable time and money maintaining facilities and planning events to support this excellent level of recreation opportunities. Current budget shortfalls, increasing infrastructure use, and potential impacts from Marcellus shale development are causes for concern. However, with attention and support garnered by the recently completed Statewide Comprehensive Outdoor Recreation Plan, outdoor recreation opportunities appear sustainable in Pennsylvania's foreseeable future.



Sustainability Meter
Indicator 13. Recreation

Indicator 14. Investments in forest health, management, research, and wood processing

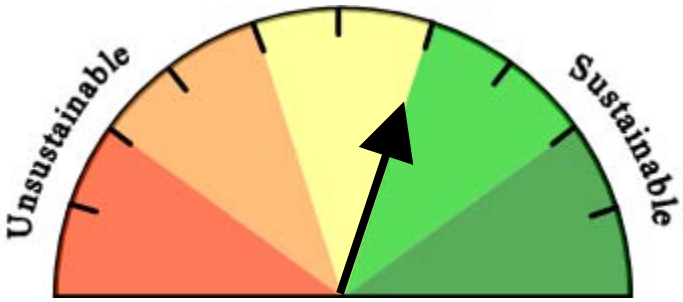
Sustainable funding and continuous investing are vital for organizations to remain strong, connected, and have the ability to improve and adapt to changing conditions and needs. Historically, Pennsylvania's state forest managers and forest industry have built a solid foundation of investing in forest resources; but like all agencies and organizations, the recent recession has caused a considerable slowdown and reductions in some cases.

Fueled by increased revenues from the surging timber markets and Growing Greener bond initiatives, DCNR and other PA public and private organizations greatly expanded programs over the past 15 years. State land acquisition, grants to communities and non-profits, additional personnel, equipment and infrastructure upgrades, regeneration projects, and research and partnerships all benefited from an expanding budget. Pennsylvania's forests have benefited greatly from a research partnership including DCNR, Penn State School of Forest Resources, and the USFS Kane Experimental Forest. Penn State Cooperative Extension established a forward-thinking program and investments in rural and community forestry. Peer-based education and outreach such as the PA Forest Stewards Program for private forest landowners and Tree Tenders for community residents are now beginning to pay dividends. The PA Hardwood Development Council and PA Forest Products Association both worked to improve utilization, efficiency, and marketing of Pennsylvania hardwoods. The Sustainable

Forestry Initiative of PA was established and received considerable support from the forest products industry. All of these programs continue to function, albeit with currently reduced funding and extremely limited abilities to invest in or expand programming.

State and Federal funding for forest health monitoring and suppression fluctuates and is, overall, inadequate to address the cumulative list of needs ranging from gypsy moth spraying to emerald ash borer surveys to invasive plant control. State funding for gypsy moth suppression has been eliminated from DCNR's current budget as well as the proposed budget for 2011. Federal cost-share programs have provided a mechanism to engage private landowners, but the overall impact is questionable.

Despite the recent economic downturn, significant opportunities exist for future investments. DCNR initiatives such as TreeVitalize [see Chapter 4c] and Conservation Landscape Initiatives [see Chapter 5] are proving successful and gaining public support. Work is underway to establish a "Growing Greener III" bond initiative and Marcellus shale development has the potential to provide significant revenues through royalty payments to DCNR and through a proposed severance tax. Overall, while funding is questionable for many organizations, (1) a solid foundation, (2) recent successes and "returns" on past investments, and (3) opportunities for new funding sources provide an optimistic outlook for continued investments in forest resources.



Sustainability Meter
Indicator 14. Investments in forest resources

Indicator 15. Forest ownership, land use, and specially designated areas

Pennsylvania's public and private forest landowners have extremely diverse sets of objectives, capacities, knowledge, and resources for managing their land—understanding these dynamics is critical to evaluating overall forest sustainability. A recent study suggests that over 600,000 entities own Pennsylvania's 17 million acres of forestland. Private forest landowners control about 70 percent of the forest while public agencies own the remaining 30 percent. The following table shows Pennsylvania's forest ownership distribution:

Category	Acres
Private	
Individuals 8,906,400	
Miscellaneous corporate	1,658,400
Non-corporate 698,100	
TIMO* 246,900	
Forest industry	234,000
Subtotal	11,743.800
Public	
State 3,813,500	
Federal 611,100	
Local 413,700	
Subtotal	4,838,300
Total	16,582,100

*Timber Investment Management Organization

Major public owners include DCNR (State Forests and Parks), the PA Game Commission (State Game Lands), and the US Forest Service (Allegheny National Forest). While each of these agencies has a specific mandate, they share overarching visions rooted in long-term conservation. Each agency manages for multiple values including recreation, timber, wildlife, water, and oil and gas while also designating portions of their land base for special uses such as Wild/Wilderness Areas, Natural Areas, and National Recreation and Scenic Areas. Protected land bases and mandates, long-term management plans, and professional, multi-disciplinary staffs provide for sustainable futures for Pennsylvania's public forests.

The diversity of ownership of Pennsylvania's private forests poses several challenges to achieving sustainability. While private forest landowners often cite objectives such as wildlife, solitude, and enjoyment, few have professionally-developed management plans to guide on-the-ground decisions. Recent survey results estimate the majority (63%) of forestland owners in Pennsylvania own between 1 and 10 acres. However, these small-acreage owners only control 11 percent of the state's privately held forestland. A small percentage of owners (8%) control a large percentage of private forested acreage (55%). With increasing frequency, however, timber operations with large forest land holdings are divesting themselves of ownership, potentially resulting in parcelization and development.

The average age of Pennsylvania forest landowners is 57, and the Penn State study predicts ownership of approximately half of Pennsylvania's private forests will change hands over the next two decades. As ownership of forested parcels of any size changes, further subdivision and perhaps development are very possible, if not likely. Subdivision

of forestland into smaller acreages and subsequent increases in the number of private forest landowners are projected to continue, having profound implications for the future of Pennsylvania's forestlands and complicating outreach and assistance efforts. Further, Penn State researchers noted that most harvesting and parcelization takes place during ownership exchanges. Education and incentive-based programs will have to adapt and likely become more resource-intensive to encourage forest stewardship among a growing number of private forest owners and across increasingly parcelized forests.

While the challenges are enormous, many opportunities such as woodland owner associations, certification systems, carbon markets, oil and gas revenues, and new approaches for fostering stewardship have the potential to improve forest management on private lands. However, if current trends continue, and considering the ecological complexities and looming forest health threats, sustaining Pennsylvania's private forests represents a major challenge.

Sustainability Meter
Indicator 15. Ownership

Indicator 16. Employment and wages in forest-related sectors

Sustainable management of our forests depends on a community of professional resource managers working in partnership with a robust and vibrant forest products industry. Pre-recession employment estimates for forest-related sectors placed employment at about 80,000 workers with an estimated total economic impact of $27 billion. In these sectors, secondary wood product manufacturing is the largest source of employment with an estimated 37,000 jobs, followed by sawmills (7,400 jobs), paper, board, and fiber (7,100), and logging and forestry (1,000).

Entry-level foresters earn an average of $37,000 per year with first-line managers earning about $50,000 per year. Forest industry wages vary, but are similar to other manufacturing wages, averaging $25,000 to $35,000 annually. Log graders and scalers earn an annual salary of $37,000.

The recent economic recession affected the forest products industry similarly to other manufacturing sectors. Total forest product industry employment in Pennsylvania dipped

to about 62,000 jobs by the end of 2009. Industry experts have seen some slow signs of recovery. Anecdotal evidence suggests that Marcellus shale development has recently begun to affect forest-related employment. The gas industry has afforded job opportunities for construction workers, truck drivers, and other service-related workers. Longer-term there is concern that highly-trained and skilled workers in the forest industry will move to the natural gas industry, which tends to pay higher wages.

The forest products industry, related government agencies, and professional consulting firms provide good sources of forest-based employment in all parts of Pennsylvania. Long-term employment sustainability ties to both the ecological condition of the forest and the overall economic climate. As discussed in Indicator 12, Pennsylvania industries are operating in a highly-competitive global market with many forces at play. Alternative energy initiatives such as biomass could provide additional employment opportunities. Overall, the forest-related employment sector appears relatively flat, with recovery and expansion occurring at a slow pace.

Sustainability Meter
Indicator 16. Employment and wages

CRITERION 7: LEGAL, INSTITUTIONAL, AND ECONOMIC FRAMEWORK FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT

Indicator 17. Forest management standards/guidelines

Comprehensive standards and guidelines provide a shared vision and source of technical information to the general public, forest landowners, the industry, and resource professionals. This common framework stimulates dialogue on latest research findings, management challenges, and innovative solutions—all essential to long-term forest sustainability. Pennsylvania's collection of standards and guidelines generally fall into four categories: best management practices (BMPs), certification systems, education and outreach, and public lands serving as models for sustainable management.

BMPs take many forms in Pennsylvania. Erosion and sedimentation BMPs for timber harvesting and road building were one of the earliest forms to be developed and adopted.

Silvicultural BMPs such as SILVAH (Silviculture of Allegheny Hardwoods), Oak SILVAH, Penn State regeneration guidelines, and the Treatment Unit Sustainability Assessment Form (TUSAF) model provide detailed guidance for developing silvicultural prescriptions. Additionally, Pennsylvania is proud to have developed an interdisciplinary set of BMPs that address silviculture, aesthetics, recreation, and wildlife. BMPs also exist for specific topics such as biomass harvesting, quality deer management and browse impact assessment, wind energy development, and prescribed fire planning and prescription development. The Pennsylvania Horticulture Society's Tree Tendors program has established BMPs for planting and maintenance of urban trees. And finally, efforts are underway to develop BMPs for managing surface activities related to Marcellus shale development.

Certification systems (Forest Stewardship Council, Tree Farm, and the Sustainable Forestry Initiative) offer independent, third-party verification of sustainable management. Each system has a set of management standards that landowners must follow and are evaluated against during audits of management practices. In Pennsylvania, 2.4 million acres are FSC-certified, followed by Tree Farm (296,000 acres), and SFI (207,000 acres).

In addition to forest certification, two programs assess communities' adoption of standards and guidelines for managing trees in community settings. DCNR reports that 238 communities in PA have active, "managing" urban and community forestry programs, while another 581 have programs classified as "developing." Additionally, Pennsylvania contains 111 communities participating in the Tree City USA program, which is based on a set of standards for community forestry management.

Several organizations and agencies work to provide education and outreach to forest landowners and a host of other audiences. Educators include Service Foresters, PSU Forestry Extension, the SFI of PA program, Game Commission Diversity Biologists, landowner associations, and conservancies. The *Forest Stewardship Bulletins*, often used by educators, is a set of comprehensive guidelines addressing a wide range of forest management topics. PSU Forestry Extension also publishes the *Forest Leaves* newsletter, hosts periodic webinars, and conducts countless workshops and landowner meetings with help from other partners.

Another source of guidance often utilized by educators includes plans and guidelines developed and implemented on Pennsylvania's public forestlands. The Bureau of Forestry, Game Commission, and Allegheny National Forest all have management plans and demonstration sites serving as models for forest and habitat management.

For municipalities and community residents, a partnership exists including Penn State Extension Urban Foresters, and a number of other valued partners reperesented on the PA Community Forestry Council. Timely information and articles of interest are provided through periodic publication of an urban forestry magazine, "Sylvan Communities," and the "Urban Forest News" newsletter. In addition, Penn State Extension produces excellent publications available at little to no charge to the public. A recently released booklet entitled "Managing Natural Resources: A Guide for Municipal Commissions"

has proven invaluable to community Shade Tree Commissions as well as Environmental Advisory Com mittees.

Overall, Pennsylvania has a wealth of information on forest management and an assortment of efforts aiming to educate and communicate the value of managing according to standards and guidelines. However, considering the assessment of other indicators, questions emerge regarding the widespread adoption and implementation of standards and guidelines across Pennsylvania's forests.

Sustainability Meter
Indicator 17. Standards and guidelines

Indicator 18. Forest-related planning, assessment, policy, and law

Forest Planning
Forest planning provides a mechanism to achieve long-term ecosystem sustainability while obtaining the benefits and services society currently needs and desires. Comprehensive planning includes inventories and resource information, public input (for public lands) and landowner objectives, and is adaptive to incorporate changing conditions and research findings.

Planning in Pennsylvania occurs at multiple scales ranging from statewide to individual tree care in urban settings. Pennsylvania has several state-level plans including the State Forest Resource Management Plan (specific to state forests), the Statewide Comprehensive Outdoor Recreation Plan, the State Wildlife Action Plan, the State Water Plan, the Pennsylvania Greenways Action Plan, and the Pennsylvania Invasive Species Management Plan. These plans provide a statewide context and help to set priorities for funding projects aimed to achieve state-level goals and objectives. Intermediate-level planning includes eco-regional and landscape-level plans such as DCNR's seven Conservation Landscape Initiatives (CLIs) [see Chapter 5], watershed planning such as the Chesapeake Bay Initiative [see Chapter 5], and regional councils of government. County comprehensive plans, municipal planning, and local zoning and ordinances occur

at the local level and are highly variable considering that Pennsylvania has 2,562 municipalities.

Property-specific planning comes in many forms including Forest Stewardship and Tree Farm Plans, custom plans developed by consultants, and plans tied to conservation easements. DCNR and other organizations have adopted and support a common template for developing conservation easements in Pennsylvania. Most experts agree that forest planning guided by resource professionals is lacking for most of Pennsylvania's private forests and that landscape-level planning is particularly needed to achieve ecosystem management.

Accurate and timely inventory information is a foundation for any planning effort. Several natural resource inventories exist on a large scale in Pennsylvania, including the US Forest Service Inventory, State Forest and State Game Land inventories, Pennsylvania Natural Diversity Inventory, and County Natural Areas Inventories. Agencies and landowners conduct smaller-scale inventories to meet project-specific needs. Resource managers continuously cite inventory and monitoring as an overall need for improvement.

Forest Policy and Law

Well-designed and properly administered policies and laws can help to conserve forest resources. It is important for governments to acknowledge the importance of forest values and accordingly develop policies sufficient to ensure the protection of public benefits, such as wildlife and clean water, as well as sustainability for future generations.

Pennsylvania's strongest regulations provide protection for soil and water resources. DEP's Chapter 102 Erosion and Sediment Control regulation under authority of the Clean Streams Law mandates an erosion and sediment control plan and measures for timber harvesting and other disturbance activities. Timber harvest operations are also governed by DEP's Chapter 105 Dam Safety and Waterway Management regulations and the Fish and Boat Code, Act 175, which govern stream crossing and other impacts to water courses and wetlands. Water use and withdrawals are governed by major river basin commissions such as the Susquehanna and Delaware River Basin Commissions.

In Pennsylvania, several state agencies have jurisdictional responsibilities of natural resources, including:

Plants:	DCNR
Animals:	Game Commission
Aquatics:	Fish and Boat Commission
Water:	DEP and river basin commissions
Soil:	DEP
Air:	DEP
Oil, gas, & minerals:	DEP

While there is no statewide, comprehensive regulation for forest management or silvicultural activities, the following statewide regulations have the potential to affect forest management activities:

- Municipal Planning Code
- Prescribed fire law
- Timber trespass law
- OSHA safety regulations
- Pesticide application regulations
- Timber and firewood quarantines
- Clean & Green preferential tax
- Clean Streams Law (Chapters 102 and 105)
- PNDI clearances for certain DEP permits
- Oil and gas ownership laws

At the local level regulations vary, but fall into a few general categories. First, some municipalities have enacted local ordinances to control timber harvesting to some extent through the Pennsylvania Municipalities Planning Code. However, the Right to Practice Forestry Act prohibits local governments from using a zoning ordinance to unreasonably restrict forestry activities. Local municipalities also enact land use, road bonding and street tree ordinances. Working with Pennsylvania's 2,566 individual municipalities represents a formidable challenge when working to establish comprehensive, well-informed policies for managing natural resources.

In addition to laws and regulations, many committees and organizations provide policy guidance to legislators and government agencies. Legislative committees include:

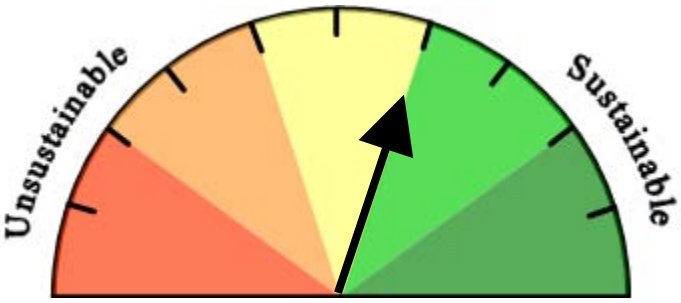
- Senate Agriculture and Rural Affairs Committee
- House Agriculture and Rural Affairs Committee
- Senate Community, Economic, and Recreational Development Committee
- House Environmental Resources and Energy Committee
- Senate Environmental Resources and Energy Committee
- Senate Game and Fisheries Committee
- House Game and Fisheries Committee
- House Tourism and Recreational Development Committee
- Joint Legislative Air and Water Pollution Control and Conservation Committee, including the Forestry Task Force

DCNR has several advisory committees that provide guidance to the department and other stakeholders regarding the management of both public and private forests:

- Conservation and Natural Resources Advisory Council
- Recreation Advisory Committee
- Ecosystem Management Advisory Committee
- Snowmobile ATV Advisory Committee

- Forest Stewardship Committee
- Urban and Community Forestry Council

Many efforts and organizations provide direction and oversight of Pennsylvania's forests. Planning and policy both occur at multiple levels with varying degrees of acceptance, implementation, and effectiveness. Marcellus shale development will challenge existing policies and guidelines. Interagency cooperation and partnerships among stakeholders are critical for establishing and implementing guidelines and policies designed to ensure forest sustainability. Considering the assessment of other indicators and in the absence of major changes, the current framework for planning and policy is questionable for ensuring the long-term sustainability of Pennsylvania's forests.



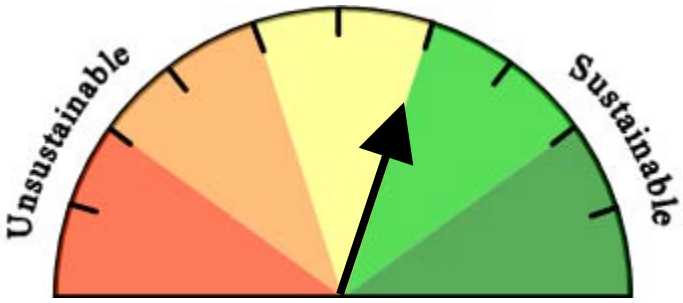
Sustainability Meter
Indicator 18. Planning and policy

Conclusion

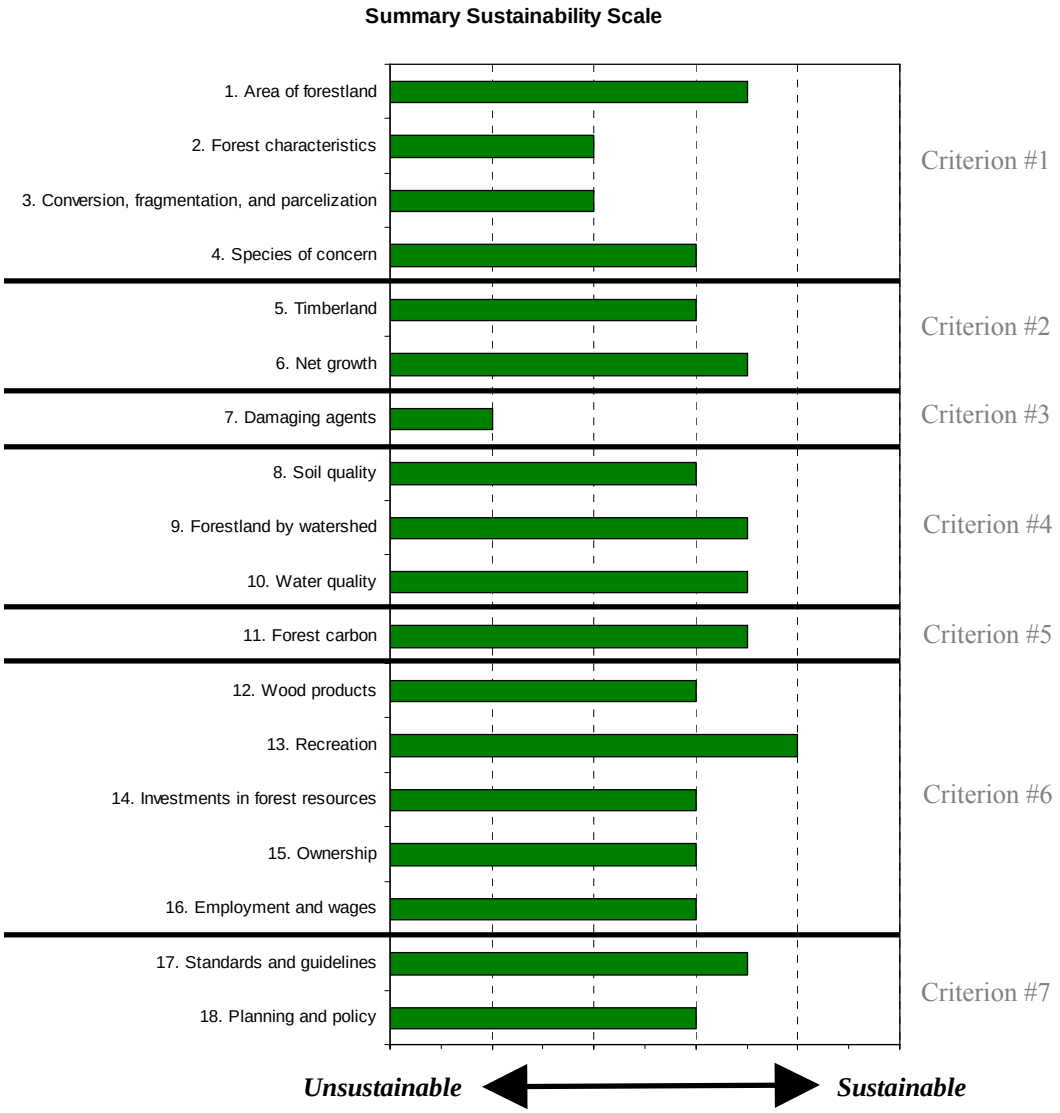
Pennsylvanians are fortunate to live among nearly 17 million acres of forest covering 60 percent of the state. Our forests currently provide countless benefits and services to society while supporting habitats for thousands of plants and animals. Assessing our forests against an established set of indicators is a crucial step for developing programs and policies aimed to ensure their sustainability for future generations.

Pennsylvania's forests face many challenges and threats. The evaluation of many indicators resulted in sustainable conclusions, but with major causes for concern. Threats associated with development and conversion, ownership dynamics, and health impacts are real, but perhaps not insurmountable. The good news is that many organizations, agencies, and individuals are collaborating on many fronts to develop solutions toward sustainability. The overall sustainability meter shown below represents a combined look at all of the indicators. The bar chart on the following page shows the assessment of all the indicators presented together.

This analysis is intended to represent an initial, snapshot view of Pennsylvania's forests. Much more work is required to adequately assess forest conditions and establish consistent, measurable metrics for each indicator. A major objective of this analysis was to present an initial assessment and stimulate dialogue on the current condition and future sustainability of Pennsylvania's forests.



Sustainability Meter
Overall Assessment


Summary Sustainability Scale
1. Area of forestland
2. Forest characteristics
3. Conversion, fragmentation, and parcelization
4. Species of concern
5. Timberland
6. Net growth
7. Damaging agents
8. Soil quality
9. Forestland by watershed
10. Water quality
11. Forest carbon
12. Wood products
13. Recreation
14. Investments in forest resources
15. Ownership
16. Employment and wages
17. Standards and guidelines
18. Planning and policy
Criterion #1
Criterion #2
Criterion #3
Criterion #4
Criterion #5
Criterion #6
Criterion #7
Unsustainable
Sustainable

References

McWilliams, William H.; Cassell, Seth P.; Alerich, Carol L.; Butler, Brett J.; Hoppus, Michael L.; Horsley, Stephen B.; Lister, Andrew J.; Lister, Tonya W.; Morin, Randall S.; Perry, Charles H.; Westfall, James A.; Wharton, Eric H;. Woodall, Christopher W. 2007. *Pennsylvania's Forest, 2004.* Resour. Bull. NRS-20. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 86 p.

Metcalf, Alexander L.; Finley, James C.; Luloff, A.E.; Stedman, Richard C. Pennsylvania State University. 2010. Pennsylvania Private Forest Landowners, Results from a Statewide Survey. Unpublished dissertation.

Pennsylvania Department of Conservation and Natural Resources. 2009 Forest Insect and Disease Conditions in Pennsylvania. http://www.dcnr.state.pa.us/forestry/fpm.aspx.

Pennsylvania Department of Conservation and Natural Resources. State Forest Resource Management Plan. http://www.dcnr.state.pa.us/forestry/sfrmp/update.aspx.

Pennsylvania Department of Conservation and Natural Resources. Statewide Comprehensive Outdoor Recreation Plan. 2009. http://www.paoutdoorrecplan.com/.

Pennsylvania Department of Environmental Protection. 2010 Pennsylvania Integrated Water Quality Monitoring and Assessment Report, Clean Water Act, Section 305(b) Report and 303(d) List.

Pennsylvania's Forests: Changes in the woods and why we should care. 2010. Unpublished draft report.

Pennsylvania Forest Habitat Connectivity Analysis September 2007, Ephraim Zimmerman1, Beth Brokaw 1, and Tamara Gagnolet2, 1 Pennsylvania Natural Heritage Program, Western Pennsylvania Conservancy, 209 Fourth Street, Pittsburgh, PA 15222, 2 The Nature Conservancy in Pennsylvania, 2101 North Front Street, Building, #1, Suite 200, Harrisburg, PA 17110

Pennsylvania Forest Products Association. 2010. Personal Communication.

Pennsylvania State University, College of Agricultural Sciences. 2001. Best Management Practices for Pennsylvania Forests: Promoting forest stewardship through education, cooperation, and voluntary action.

Pennsylvania Natural Heritage Program. http://www.naturalheritage.state.pa.us/.

Strauss, Charles H.; Lord, Bruce, E.; Powell, Michael J. 2007. Economic Impact and Timber Requirements of the Wood Industry in Pennsylvania.

United States Bureau of Labor Statistics. http://www.bls.gov/.

USDA Forest Service, Northeastern Area State and Private Forestry. 2009. Forests, Water and People: Drinking Water Supply and Forest Lands in Pennsylvania.

USDA Forest Service, Northeastern Area and Northeastern Area Association of State Foresters. 2003. Base Indicators of Forest Sustainability: Metrics and Data Sources for State and Regional Monitoring.

Weigle, Jason L.; Finley, James C.; Luloff, A.E.. 2010. Pennsylvania's Public Lands and Designated Water Uses: A Closer Look. *In Review*.

Chapter 4A

Issues, Threats, and Opportunities - Land Use

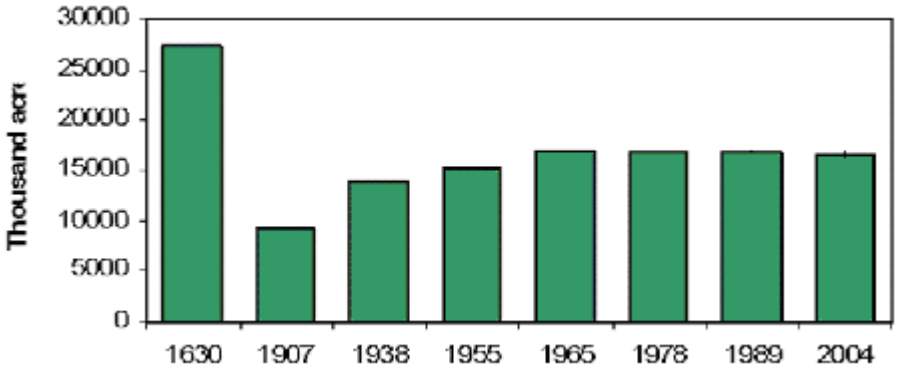
Introduction

Maintaining Pennsylvania's forest land base is fundamental to conserving the array of resources and values our forests provide. Pennsylvania's landscape has changed dramatically over the past several decades in certain parts of the state as forests and farms are converted to residential and commercial developments. While economic growth is critical to improving our quality of life, unplanned and poorly planned development negatively impacts natural systems and causes permanent forest loss. This "issue" of the PA Forest Assessment provides an overview of land use dynamics in the Commonwealth and a framework for developing strategies geared toward conserving forestland and promoting informed growth and development decisions. It also provides a predictive glimpse into the future land-use choices of the next generation of private forestland owners based on recent surveys and trend analyses.

Data

Forest-Land Base: Distribution and Trends

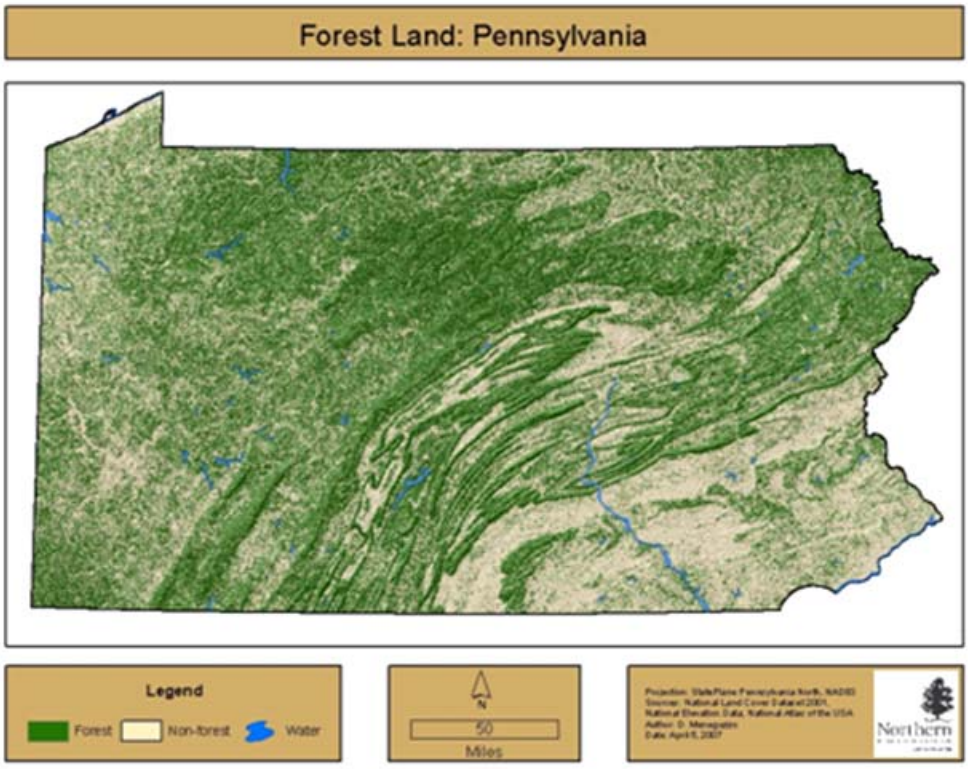
Historical data suggest that forest once covered more than 90 percent (27.3 million acres) of Pennsylvania's land area in the pre-European settlement era (1630's). (Pennsylvania's Forest 2004; NRS-20, 2007) By the early 1900's, industrial timber harvesting and agricultural land clearing had diminished the forest land base to only 32 percent (9.2 millions acres).(USFS, Forest Inventory Analysis, 2004) Following this period of extensive reduction, forest land increased steadily as it reclaimed former sites.



Area of forest land in Pennsylvania, 1630, 1907, 1938, 1955, 1965, 1978, 1989, and 2004.

The forest-land base has been relatively stable for the last half century and now is the dominant land class at 58 percent. The 16.6 million acres of forest land reported for Pennsylvania's 2004 inventory represents a slight but not statistically significant decrease from the 1989 FIA estimate (16.7 million acres).

Patterns in forest-land cover can be seen from satellite imagery taken in 2000 (Warner 2002). Large, contiguous patches of forest extend across the Allegheny Plateau in the north-central portion of the State. In central Pennsylvania, forest-land distribution follows the topographical contours of the ridges that divide agricultural valleys. Smaller, more fragmented blocks of forest land are noticeable in more urban and agricultural regions, especially across southern-tier counties.

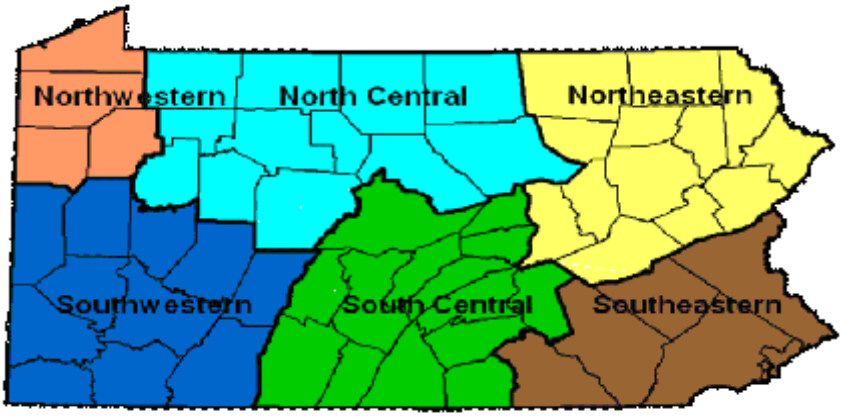


Forest land in Pennsylvania, 2000.

A complex mix of biotic and abiotic factors determines forest composition, structure, and function. Traditional geopolitical boundaries, e.g., county maps, are not always correlated with these natural phenomena or specific resource issues. The figure below shows ecopolitical regions developed by the Bureau of Forestry to address sustainability issues. These regions partition Pennsylvania's diverse landscape into meaningful areas that address ecological differences, e.g., Plateau versus Ridge and Valley forests, as well as cultural and political concerns, e.g., issues germane to the urban southeastern region versus the rural north-central region. These regions provide context for other maps and analyses in this report.

There was little net change in total area of forest land within all ecopolitical regions between 1989 and 2004. Although not statistically significant, all of the southern regions posted smaller acreages of forest land in the 2004 inventory.

Eco-Political Regions



Ecopolitical regions of Pennsylvania.

North Central

The north-central region, which includes the Allegheny National Forest and large tracts of state-owned forest, predictably contains the highest percentage of forest land (79 percent). It has by far the largest acreage of state forestland, and the highest number of Exceptional Value watersheds and streams. This 12-county region was designated The Pennsylvania Wilds, DCNR's first Conservation Landscape Initiative, to promote sustainable economic development while conserving the region's outstanding natural resources. It has the largest land base of any region but only 4% of the state's population, only one city over 15,000 in population, and the lowest per capita average income and housing prices. (Econsult, The Pennsylvania Wilds Initiative: Program Evaluation, 2009) Recent loss of manufacturing jobs continues to depress the regional economy.

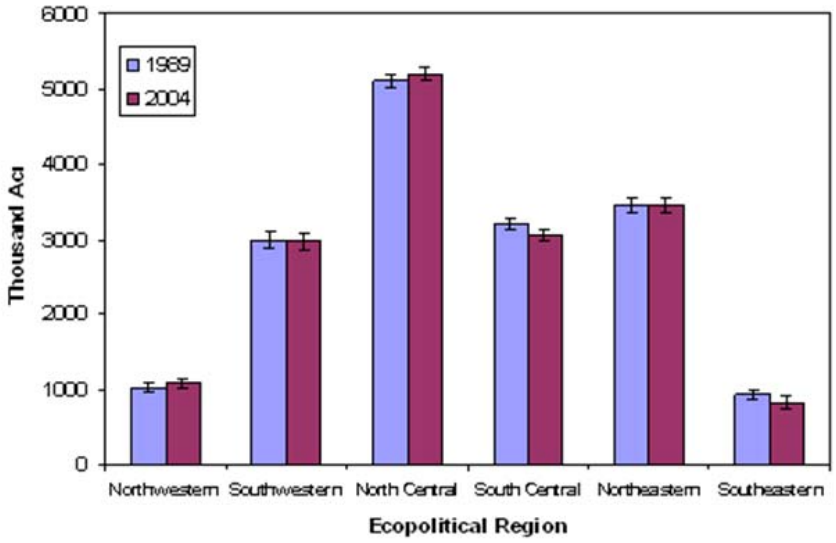
Southeastern

The southeastern region is the least forested at 22 percent. This is not surprising given that the region includes the Philadelphia metropolitan area and is host to the greatest proportion of agricultural land uses (35 percent) of any region in Pennsylvania. In fact, there is more agricultural land than forest in most of the counties in this region. Over the past 20 years, adjacent counties to Philadelphia, including Montgomery, Bucks, Delaware and Chester, have aggressively pursued open space protection – including a significant amount of forested lands -- through bond initiatives which county residents have supported consistently – passing 91% of all bond initiatives between 1988 and 2008 (Delaware Valley Regional Planning Commission, 2009). In 2008 alone, voters approved

open-space protection bonds in Montgomery County of $30 million and two in Bucks County totaling $35 million (DVRPC).

Northwest

This three-county region anchored by the city of Erie is characterized by smaller pockets of forestland and has some of the richest plant diversity and abundance of rare plants in the state. Its watersheds, particularly French Creek, boast some of the highest fisheries and mussel diversity in the Northeast. This region is influenced by Lake Erie and glacial topography, and has the highest acreage of lakes and ponds in the Commonwealth (National Wetlands Inventory), and second highest concentration of wetlands habitats (Tiner, 1990). Its small forestland gains since 1989 primarily reflect afforestation of agricultural lands.



Areas of forest land by ecopolitical region, Pennsylvania, 1989 and 2004.

Southwest

The southwestern region of the state is a mosaic of forestlands and agricultural lands. Allegheny County and the city of Pittsburgh dominate the region in terms of urban land use and population, but the region has experienced a net loss of population over the last decade (Brookings 2003). Coal mining is still among the dominant industries in the region, which has a legacy of abandoned mine lands and acidic streams. Concentrations of intact forestlands are found in the Laurel Highlands area along the mountainous eastern edge of this region, which is home to a complex of state-owned parks and forests and privately owned resort holdings, and includes the highest mountain in Pennsylvania, Mt. Davis.

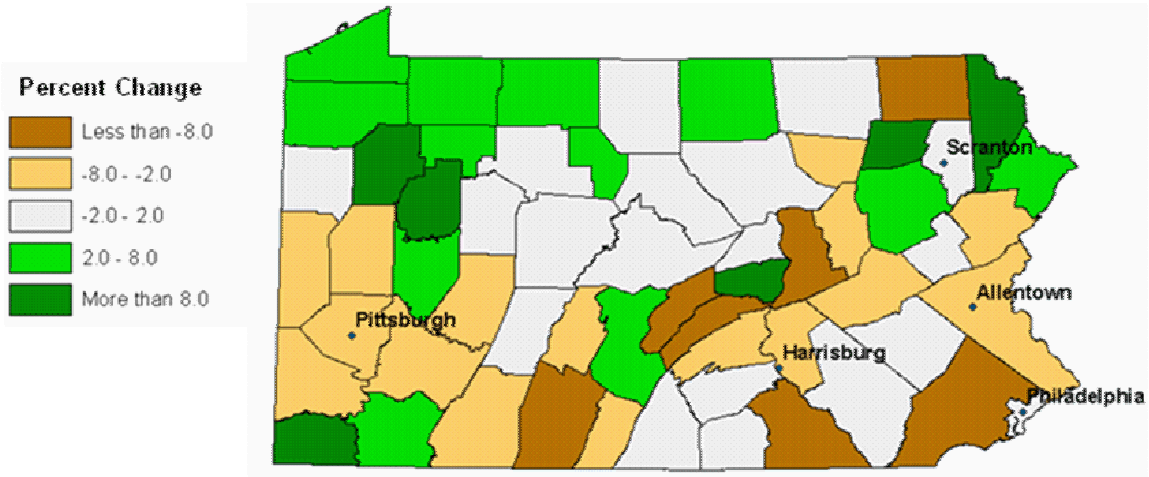
South Central

This region still has a number of large forest tracts intact, protected primarily through state forest and state parks. Recent acquisitions of privately owned timberlands have

bolstered state forest holdings. However, development pressure from Maryland and even Washington, D.C. on border counties is accelerating fragmentation and forest loss in this Chesapeake drainage region. A state focus on acquiring forested riparian lands along the lower Susquehanna River in York and Lancaster counties, currently owned by utility companies who operate hydroelectric dams in this region, may help preserve forested corridors in this region in coming years.

Northeastern

The Northeast region of Pennsylvania has the second largest expanse of remaining forestland, and the highest concentration of wetlands habitats (Tiner, 1990). It has also experienced the highest levels of population growth in the state since September 11, 2001, as part of an out-migration from New York City and suburbs to the Pennsylvania/New Jersey border area. The Pocono Mountains area in this region is experiencing a wave of primary-residence development following decades of second-home development that is causing increased forest fragmentation. This region contains a high concentration of important mammal and important bird areas (Pennsylvania Game Commission, Second Breeding Bird Atlas, 2009).



Percent change in area of forestland, Pennsylvania, 1989 to 2004.

Forest-Land Loss and Gain

Although no significant net change has occurred in Pennsylvania's total forest area, both losses and gains in forest continue at various scales. In such a dynamic, the total acreage of forest area may remain the same while shifts occur in the forest-land base. Therefore, characterizing this base as having "no net change" may not accurately represent actual changes in forest distribution, character, and composition. County-level changes in forest land are shown in the above figure. Many counties in the north-central and northeastern regions indicate an overall gain in forest land. Losses in forest land at the county level are prevalent in more urbanized counties, particularly in the southeastern region and in some counties in the south-central region. Many counties that show a net loss of forest land are located near urban centers or major connecting highways. Eastern Pennsylvania

is part of the band of urban development that follows Interstate 95 along the East Coast. These areas are characterized by large cities, e.g., Philadelphia, with little forest land. Surrounding areas often include development patterns that have led to small patches of highly fragmented forests.

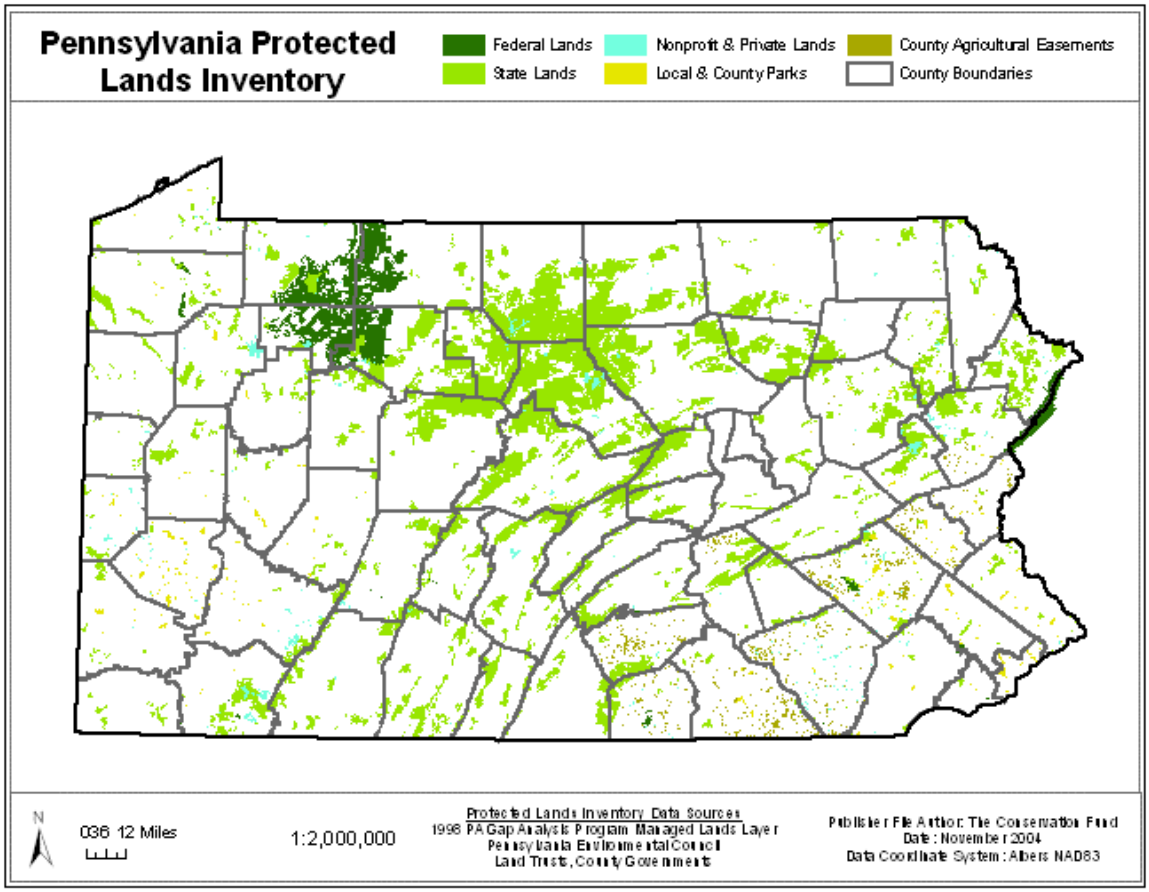
NRS-FIA data indicate that more than 663,000 acres of forest land were lost from 1989 to 2004, an average of about 44,000 acres per year. Nearly two-thirds of the forest land, or 28,000 acres per year, was diverted to residential and industrial development and likely is permanent.

During the same period, there was a 617,500-acre gain in forest land. About 350,000 acres (58 percent) of the gain was from agriculture. In this situation, abandoned fields commonly revert to forest through natural succession. This trend has offset most of the observed permanent loss of forest land and has allowed for the stable acreage in forest. That the most common agricultural land conversion is to urban land uses might limit this land type as a source for gain in forest land in the future. Reclaimed mined land and rights-of-way were other significant sources of forest gains.

Forestland Conserved To Date

The Commonwealth has a rich history of land conservation that includes early heroes of the conservation movement in the United States, such as Gifford Pinchot, Joseph Rothrock, Myra Lloyd Dock, and many others. These pioneers had the foresight to purchase land for the public good many years ago, giving today's Pennsylvanians one of the premier state park and forest systems in the country.

The tradition of forestland conservation in Pennsylvania is alive and vibrant today. In addition to public lands owned by the PA DCNR, PA Game Commission, various local municipalities and educational institutions, and non-profit organizations – particularly land trusts – have played an active role. Today's conserved landscape has expanded to include lands on which conservation-related entities hold the development rights via conservation easements. As of June of 2005, there were 4,657,211 acres of conserved land in the Commonwealth.


Pennsylvania Protected Lands Inventory
Federal Lands
State Lands
Nonprofit & Private Lands
Local & County Parks
County Agricultural Easements
County Boundaries
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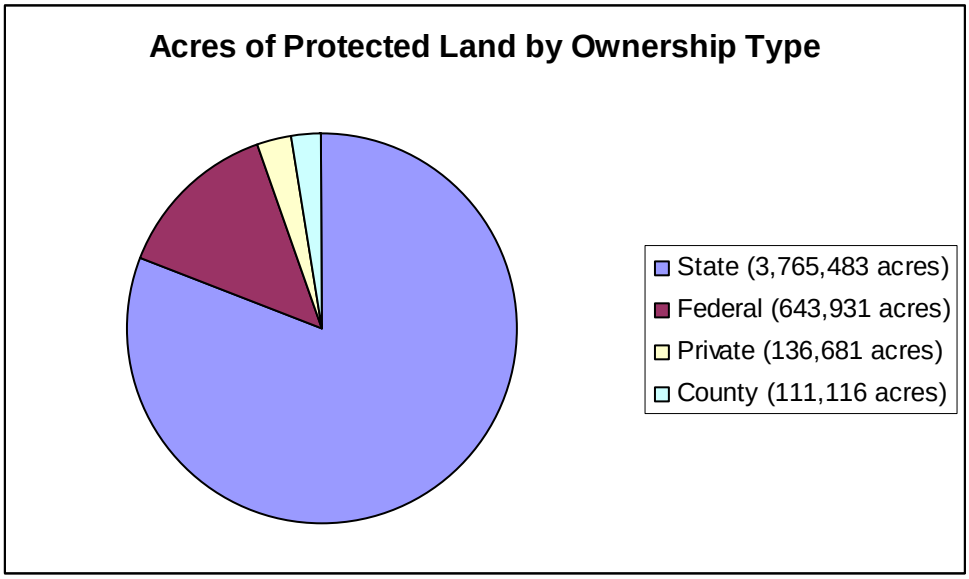
Protected Lands Inventory Data Sources
1998 PA Gap Analysis Program Managed Lands Layer
Pennsylvania Environmental Council
Land Trusts, County Governments
Publisher File Author: The Conservation Fund
Date: November 2004
Data Coordinate System: Albers NAD83


Acres of Protected Land by Ownership Type
State (3,765,483 acres)
Federal (643,931 acres)
Private (136,681 acres)
County (111,116 acres)

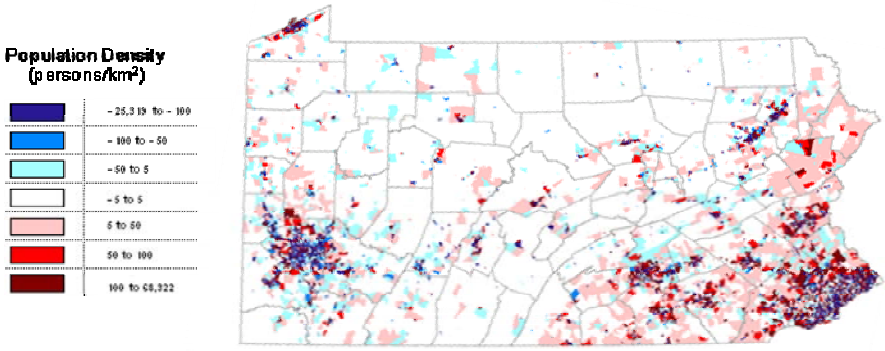
The conserved forestlands of the Commonwealth, both public and private, provide Pennsylvania citizens with many benefits that reach far beyond the boundaries of the properties. In addition to the very obvious benefits of the public recreation that occurs on public lands and private lands with public access, these properties provide:

- Protection of the Commonwealth's water resources, affecting quality and quantity production of raw materials for renewable forest products that citizens use every day
- The ability to sequester carbon and assist with climate change mitigation
- Cleaner air and oxygen
- Wildlife habitat
- A source of renewable energy
- Jobs for Commonwealth citizens

In the current economic climate, funds for conserving lands are becoming increasingly scarce. Future decisions to conserve forestland will need to be as strategic as possible.

Urbanization

Urbanization of the landscape significantly affects the amount of forest land and also its species composition, health, and overall sustainability. Urbanization of forest land is the process of increasing urban (versus agricultural) development, either replacing or coming into increasing proximity to forest land. The process of urbanization is illustrated by comparing county-level estimates of forest area loss between 1989 and 2004 and change in population density over roughly the same period. Many areas with the greatest loss of forest land also experienced the highest urbanization rates, supporting the finding that most forest is being lost to residential and commercial development.



Change in population density, Pennsylvania, 1990 to 2000.

In a report by the Brookings Institute (Back to Prosperity: A Competitive Agenda for Renewing Pennsylvania, 2001), researchers found a pattern throughout the 1990s of an accelerated rate of land development relative to other states despite a very slow rate of population growth. During that decade, open space was consumed at a rate equivalent to 209 acres/day, or 9 acres an hour every hour. This constituted the fastest rate of land conversion per capita of any state except Wyoming. Pennsylvania's overall population rate from 1982-1997 grew at a tepid 2.5%, while its urban footprint grew by 47%.

According to the Brookings report, this pattern was due to a combination of factors; fractured government divided into more than 2,500 municipalities which control land-use decisions; a lack of zoning and region-wide land-use coordination; and public funding, business subsidies and tax incentives that encourage development of undeveloped "greenfields" rather than urban infill and "brownfield" development. The result has been rapid expansion of development in Pennsylvania's outer townships – where most remaining forestland exists - and little growth in urban centers and established suburbs. Population growth has followed this trend, with outer townships capturing 92% of the state's household growth and 72 % of new housing construction in the 1990s (2000 US census data).

A recent abatement of land conversion during the 2008-2009 economic recession in Pennsylvania and nationwide has slowed this rate, although not altered the general trend of greenfield development as opposed to urban infill development.

Future Growth

The rate of growth in Census-classified urban areas in the United States over the next several decades was modeled by Nowak and Walton (2005). Counties on the East Coast, including those in Pennsylvania, are projected to have some of the highest rates of urbanization over the next 50 years. The study projected that U.S. urban land will increase from 3 percent in 2000 to 8 percent in 2050. This growth could significantly transform the Commonwealth's forests and attitudes regarding those forests, particularly in the northeastern and southern regions.

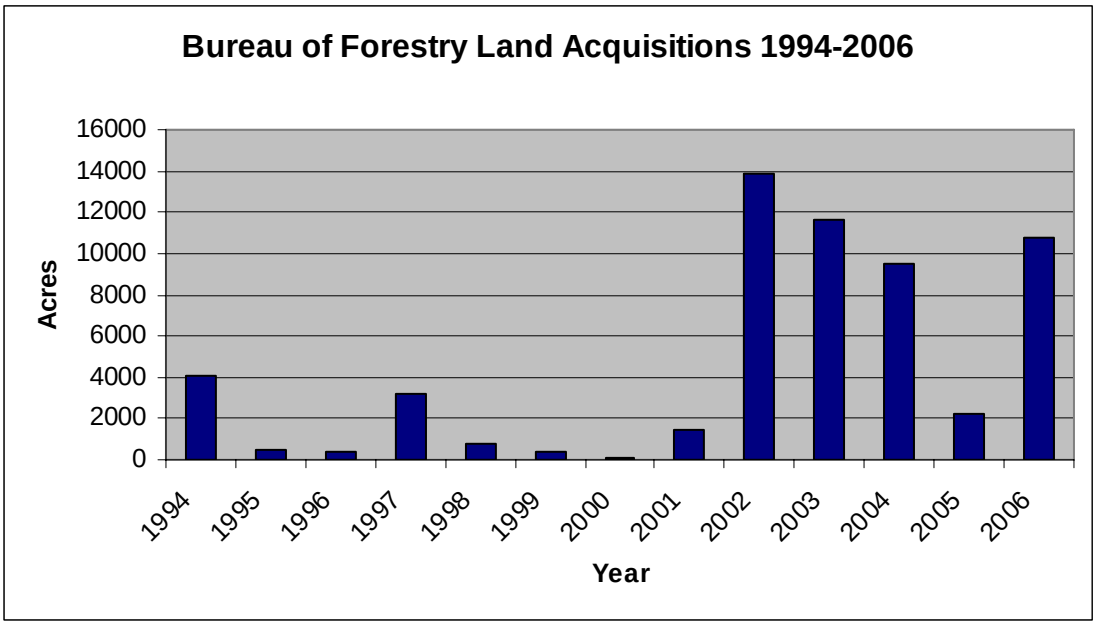
Public Conservation of Forestland through Acquisition

While Pennsylvania has one of the most successful land-preservation programs of any state for farm conservation, there is no corresponding state-level forestland protection or easement program. Pennsylvania's Agricultural Easement Purchase Program has protected farmland under long-term easements since 1988. Through 2008, the program has preserved 3,579 farms and protected 395,636 acres in the state (Pennsylvania Department of Agriculture, 2009).

Federal funding of programs for forestland conservation like Forest Legacy has been dramatically reduced over the past decade, and doesn't begin to meet the demand here in the Commonwealth. Private foundations, state Growing Greener funding and Keystone Parks, Recreation and Conservation Fund (Key 93) money have provided considerable funds for forestland conservation, but Growing Greener funds and Key 93 are also declining. Ironically, county planners explain that agricultural preservation can actually create additional pressures on forestland as conservation easements put farmland off limits, leaving only forested land available for development in areas like Lancaster County, according to DCNR service foresters in that region.

One of the ways Pennsylvania has helped to maintain its steady percentage of forest cover in the midst of high sprawl and development rates is through public acquisition of threatened forestlands to add to the state forestry and parks systems. While private forestland acreage continues to diminish, state-owned forestland acres have increased

over the past dozen years. Between 1994 and 2008, DCNR worked closely with municipal, industrial, and non-profit partners to secure an additional 81,217 acres for its state forest system, bringing the total acreage to 2.2 million acres. This investment came to a total of $38,227,773. The figure below shows the annual increases in state forestland acquisitions from 1994-2006, with largest gains coming in recent years. Because the source of funds that support these acquisitions began declining in 2008 – with the gradual expiration of Growing Greener II funds by 2011 and an ebb in real-estate-tax-transfer funds (Key 93) due to the economic recession -- the rate of future forestland acquisition into the state forestland system is expected to also decline over the next 2-3 years and beyond, unless a new source of state acquisitions revenue is secured.



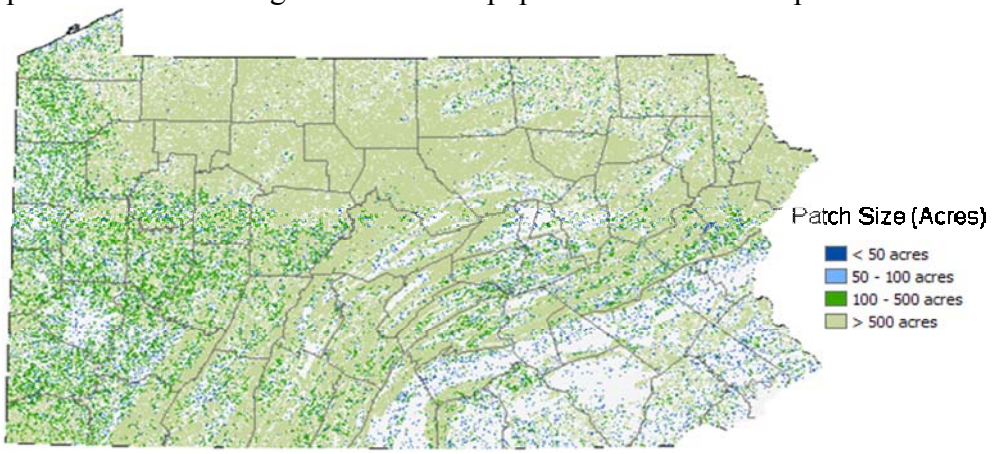
Fragmentation

Forest fragmentation is defined as the division of contiguous or adjoining forest land into smaller patches. Fragmentation can be caused by urbanization, or as in Lancaster, Lebanon, and York counties, agriculture can be a cause of fragmentation of forest land, as farm protection programs displace development pressure onto remaining forests, or strapped farmers sell off woodlots to keep their agricultural operations intact (DCNR service foresters, personal communication). Increased gas well drilling within the Marcellus Shale formation has the potential to further accelerate forest fragmentation in the state. Additional access roads into forest land may be required and the use of existing roads will increase dramatically, potentially disrupting wildlife movement and opening avenues for the spread of invasive plants.

Losses of forest land to development can fragment remaining forest lands into smaller patches that are farther apart, decreasing the chance that remaining wildlife populations are sustainable. And as the amount of direct interface or “forest edge” increases, interior or core forest areas are lost, increasing the chances for invasive species to be introduced and reducing the amount of habitat available for interior forest species. Fragmentation

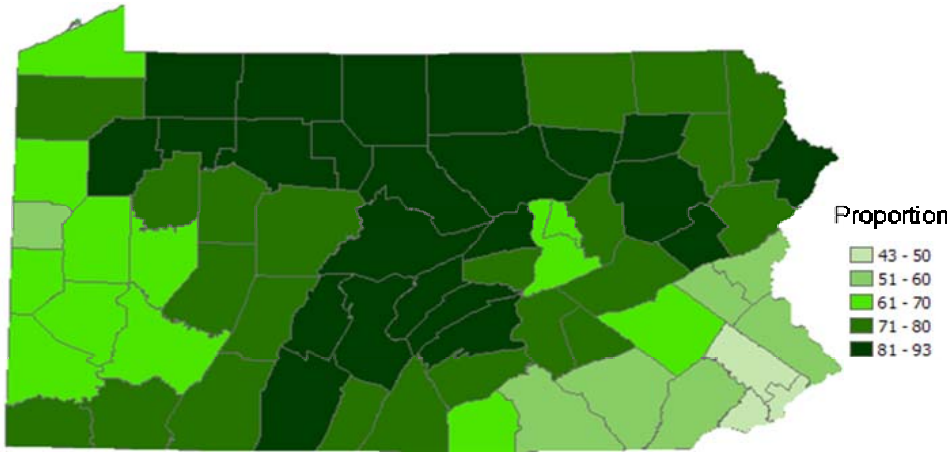
also limits migration opportunities for many wildlife species, a concern that will continue to grow with the impacts of climate change.

NRS-FIA researchers conducted a forest fragmentation assessment of Pennsylvania based on the 2001 National Land Cover Data project (Yang 2003). Calculating patch size from this data set provides an indication of the continuousness of the state's forest cover. In general, patches less than 100 acres in size depend on the amount and proximity of other forest patches for sustaining viable wildlife populations of interior species.



Average forest patch size by county, Pennsylvania, 2001.

Core forest is defined here as forest more than about 100 feet from a non-forest edge. The figure below shows the proportion of core forest by county. Forests in the north-central region contain the highest proportion of core forest and also the least amount of fragmentation. Not surprisingly, the region hosts the largest forest-patch sizes. The Allegheny National Forest and State Forests contain the largest patches in Pennsylvania. Forest land in the southeastern region is the most highly fragmented, with small patches and minimal core forest.



Proportion of forest that is core forest by county, Pennsylvania, 2001.

Private Ownership of Forestland

Forestland ownership in the Commonwealth is highly dynamic, and highly fractionated. A recent Penn State University study (Metcalf, unpublished thesis, 2009) estimates there are more than 600,000 forestland owners in the state. Seventy percent of Pennsylvania's 17 million acres of forestland are privately owned (McWilliams 2007). Metcalf survey results estimate the majority (63%) of forestland owners in Pennsylvania own between 1-10 acres. However, these small-acreage owners only control 11% of the state's privately held forestland. A small percentage of owners (8%) control a large percentage of private forested acreage (55%). This subdivision of forestland into smaller acreages and more numerous ownerships is a trend projected to continue, according to researchers. PSU predicts fully half of private forestlands in the state will change ownership hands within the next 22 years (Metcalf 2009). This has profound implications for the future of Pennsylvania's forestlands. PSU researchers note that most harvesting and parcelization takes place during ownership changes. The de-centralization of ownership also has implications for future forest management; state and federal influence on private forest management through incentive-based voluntary programs becomes more resource-intensive with more and smaller-parcel ownerships than fewer, larger ownerships. PSU survey data also notes a correlation between forestland ownership acreage and an owner's willingness to allow commercial harvesting on the property.

The average forestland owner in Pennsylvania today is 57 years old, male, and politically conservative (PSU). He is, on average, employed either full-time (55%) or retired (32%). Average income levels and education levels exceed those for Pennsylvanians as a whole. Most forestland owners in Pennsylvania actually live on their forestland (55%). The majority live on or within a mile of their lands (73%). Absentee landowners are few but tend to own large forested tracts.

The reasons forestland owners give for owning forest land in Pennsylvania have not changed significantly over the past 5 years. Survey data from PSU (Metcalf, 2009) shows that an interest in wildlife ranked highest among landowners surveyed (62%), followed by enjoyment of solitude (59%), and enjoyment of owning (58%). Timber production (38%) was ranked 9th of 10 factors. Similarly, 2004 date results (National Woodland Owner Survey, FIA, 2004) ranks aesthetics highest (68%), followed by privacy, family legacy, and nature protection. Timber production is ranked 10th of 10 factors at 28%.

A new study (Gruver, unpublished thesis, 2009) found there is a strong correlation between property size and a private forestland owner's willingness/ability to conduct a timber harvest. The study surveyed forestland owners in Huntington County, a heavily forested, rural, and not rapidly developing county, as well as in Berks County, also heavily forested but experiencing much more rapid growth. While the counties also differ in their share of biophysical constraints to access [steep slopes, location of roads, wetlands, etc] the more significant difference to timber access was found in landowner attitudes toward harvesting. Opposition to harvesting among private forestland owners was greater in Berks (22%) than in Huntington (11%). Researchers also looked at

frequency of timber harvests over the past 10 years as a predictor of future forestland owner willingness to harvest. They found that nearly 75% of Pennsylvania private forestland statewide is owned by landowners who have not conducted a commercial thinning in the past 10 years. As developing areas like Berks County continue to fragment and produce more small-acre forestland ownerships, social and biophysical constraints to timbering access are likely to increase.

Future Ownership Trends

A not-yet published Penn State University study on parcelization forces (Gruver 2009) surveyed private forestland owners in Centre County, Perry County, and York County, all experiencing pockets of rapid growth. They sorted landowners into groups based on the reasons they gave for keeping, bequeathing, or selling their forest lands. In general, landowners fell into one of several camps; those who kept forestland to maintain their rural lifestyle; those who viewed themselves as "stewards" of the land to be protected – usually by conservation easement – for future generations; those who planned to subdivide and sell off part of their lands in order to keep the portions they valued most; and a final group waiting to decide what to do, based in part on opportunity and heir interest.

A 2008 study by the Pinchot Institute for Conservation (Mater) provides more in-depth analysis of how the next generation of forestland owners in Pennsylvania view, and may manage, private forestlands. The study interviewed more than 100 landowners typed as "non-joiner," not associated with a forestry or woodlot owner organization. These owners named lack of offspring interest, rather than tax concerns, as the top reason they were concerned with keeping their forestlands in family hands. The study also revealed significant gender differences. Male offspring were more likely to participate in the management of family forests (56%) versus female offspring (37%), and male offspring were generally more often involved in a decision-making role as opposed to a discussion-only role. Of those surveyed, 87% of all offspring expected to inherit their family forestlands, but a larger percentage of female offspring believed the land would be divided among siblings (24%) than male offspring (15%). Most significant among gender differences were responses about future management intent. Male offspring reported more interest in timber production for income generation (91%) than female (65%) while female offspring looked to farming and grazing on family forestlands (43%) for income generation more than male offspring (31%).

Other significant findings of the Pinchot study include the following:

- Current-generation owners of forestland rank stewardship highest among reasons for owning forestlands (45%), while offspring ranked it third (28% male, 23% female)
- Offspring named labor and time to manage as their top constraint to owning forestland in the future. There is evidence that offspring equate labor/time management with the term "stewardship."
- Sibling disagreements on how and what to manage may indicate a bumpy road ahead as offspring inherit family forestlands; more than 50% of families with multiple siblings indicated intra-familial disagreements in five critical areas.

- Offspring interviewed did not, as a group, express much interest in managing future forestland for biomass production or biofuels; at 32% it ranked last. Tax relief (60%) ranked highest.
- Offspring did, as a group, show more interest in ecosystem services (54%) as an important tool for managing the forest.
- Economic pressure from health care costs was listed high among factors influencing future offspring management decisions on their forestlands (46%), followed by money needed to pay taxes (25%)

Resources/Framing for Potential Solutions

This snapshot of Pennsylvania forestland in 2009 shows several clear trends. Overall, total forestland acreage across the state is holding steady as losses in urbanizing areas are counterbalanced by afforestation, primarily of agricultural lands. Recent expansion of natural gas drilling in the state and pipeline and overhead transmission line expansion for energy conveyance will likely accelerate forest fragmentation at higher rates in the next few years relative to the past 10-20 years. Forestland ownership patterns are changing even more rapidly. Half of private forestland acreage may change ownership in the next 22 years, with increased opportunity for harvesting as well as parcelization and fragmentation. Increasingly, smaller ownerships may mean fewer opportunities for timber harvest. While private landowners' reasons for ownership have not changed in recent years, there are many more landowners, making centralized planning and forest-resource decision-making more difficult and resource-intensive. Finally, the lack of available state-level programs and federal funding to conserve forestland through fee-simple or easement acquisition means current funding cannot keep pace with the need or demand for forestland conservation in the state.

Despite the lack of ready cash for forestland conservation, there are a number of promising programs and approaches that bode well for future efforts in the state. These include multi-state regional approaches, new sources of federal funding and policies, state-level initiatives, and county and local initiatives.

<u>Regional level</u>

A renewed emphasis on watershed protection through the federal Chesapeake Bay Program will provide new opportunities for Pennsylvania, where almost 50% of the state is located in the Bay watershed. Chesapeake Bay Presidential Executive Order 13508, adopted in 2009, calls on federal agencies and states in the Bay watershed to better prioritize and target resources to protect the Bay and its tributaries, including implementation of stronger storm water management practices, addressing climate change, expanding access to waters and open space, and better protection of Bay living resources. The order is likely to result in higher levels of federal funding for the Bay region, and renewed or new programs. Pennsylvania will play a key role in defining its state priorities and practices, which can and should include funding and programs to conserve and enhance forestland for water quality, wildlife habitat and interception of airborne pollutants.

Another regional model for forestland protection of interest to Pennsylvania is Woodnet, developed by government and nonprofit partners in New York State's Catskills region. This innovative program recognizes the value forests play in protecting water quality and invests funding that would have gone toward expanded water treatment plant capacity into preserving the forested watershed region where drinking water originates and flows through. The program also recognizes the importance of preserving a working forest landscape and integrating local timber operations, furniture making, and other wood-products industries to develop economic incentives for forestland preservation. Pennsylvania has introduced the program to two pilot areas of the state, South Mountain and the Poconos, although it currently lacks a funding mechanism similar to the New York model.

Federal

The primary source of federal funding for forest improvement practices in Pennsylvania is the Farm Bill. The 2008 Farm Bill added forestland owners as "producers" eligible for many Farm Bill programs, including EQIP, WHIP, CSP, and the Healthy Forest Reserve Program. In early 2010, the Natural Resource Conservation Service in Pennsylvania was awarded a $1.3 million grant to protect habitat for the federally endangered Indiana bat in 10 centrally located counties. Forest Legacy was reauthorized separately and continues to provide limited funding for acquisition. The Environmental Quality Incentives Program (EQIP) provides annual payments to landowners who implement practices on forestlands that benefit water quality primarily, and wildlife secondarily. In 2009, the first contracts for forestland owners were signed, allocating $425,000 of the $17 million available to Pennsylvania under this program. Practices funded included wildlife habitat enhancements, riparian buffers, and forest stand improvement practices. The Wildlife Habitat Incentives Program (WHIP) provides cost-sharing dollars to landowners who improve their forestlands for wildlife. This program has not been allocated extensively to forestland owners in the state but has strong potential to grow. Similarly, the Conservation Stewardship Program (CSP), which funds more intensive best management practices than EQIP, has been made available for the first time to forestland owners in 2009-2010 and should provide limited funding ($6-$12/acre/year) for good stewardship practices that may provide some incentive for owners to keep their lands in forest. The Healthy Forest Reserve Program, created in 2008, provides funding for conservation easements on forested lands to states on a competitive basis, but overall funding is limited. In 2009, there were 8 eligible states, including Pennsylvania, competing for a total of $9 million nationwide. This program emphasizes conservation of forestland for federally or state listed threatened or endangered species. Pennsylvania has focused on protecting lands for the federally endangered Indiana Bat under this program.

The Land and Water Conservation Fund, which has dropped off in state-level funding significantly over the past 10 years, was reauthorized in 2010 at a higher level than in recent years at $1.26 million, and provides states with funding to protect open space, including forestlands. In 2009, Pennsylvania received $897,138 in state-side LWCF funding. Additional federal funding may become available to Pennsylvania in 2010-2011 through Forest Legacy and the Highlands Act.

State

At the state level, a combination of new tax incentive programs and multi-faceted planning and investment strategies have helped fill the funding gap in recent years. Most recently, the Resource Enhancement and Protection program (REAP), adopted by the state in 2008, provides tax credits to landowners who implement measures to improve water quality. The program is targeted to farm owners, but includes incentives for establishing wooded riparian buffers along streams.

In 2006, DCNR inaugurated the TreeVitalize urban tree-planting program in the state's largest metropolitan area, Philadelphia, and has since expanded coverage to Pittsburgh and 12 other metropolitan regions. The program's goal is to plant 1 million trees in urban areas through cost-sharing with local governments. The program also requires local participation and emphasizes education of urban residents and municipal leaders.In 2009, DCNR helped a number of local partners across the state successfully compete for federal stimulus funding through PennVEST to expand urban tree-planting programs in their regions.

The Conservation Landscape Initiative was established by DCNR as an approach to large-scale landscape conservation while promoting sustainable economic development. There are currently 7 such initiatives in the state, focused on areas of high conservation importance, including areas of high forest fragmentation pressure – the Poconos region, South Mountain in the southcentral region, and the Schuylkill Highlands in urbanizing southeastern PA.
View map of the regions (pdf, 441kb)

Because Conservation Landscape Initiatives are collaborative in nature and depend upon a variety of state, local, and private investments to succeed, they are chosen strategically and include the following elements:

- Presence of DCNR-owned lands – large blocks of state parks and forests provide the foundation for the landscape and a staffing presence that can help guide the initiative
- Sense of Place - regions with a sense of place and identity - many cases based on shared landscape not political boundaries
- Readiness - made more ready by opportunity or threats -- changes in the economic base, depopulation, or sprawl
- Engagement - Civic engagement process that brings people of the region together to identify common values and concerns;
- Strategic Investments – State agencies with regional and statewide partners provide high-level leadership, financial support and technical assistance to build better communities, to conserve identified values and to invest in "sustainable" economic development.

Finally, the state as a whole has signaled its support for sustainable economic development and conservation of natural resources by encouraging agencies to adopt the Keystone Principles and Criteria for Growth, published in 2005. These guidelines encourage state agencies to invest and support programs and projects that adhere to

principles of sustainable development and resource protection, including redevelopment before new development of open space; concentrating development instead of sprawl development, and encouraging restoration and enhancement of the environment. Many agencies, including DCNR, have built these principles into their investment strategies and grant programs, which result in less development pressure on forested lands.

Finally, changes to the state's water quality regulations in Chapter 102 anticipated in late 2010 would further protect, enhance or establish forested riparian buffers along streams classified as "high quality" or "exceptional value" by requiring 150-foot buffers on both sides of these streams where development is to occur. DEP guidance developed in association with these proposed regulations addresses issues such as continued timbering of these buffer areas, access, and other topics that will be finalized once the regulations are promulgated.

County/Local

There are a number of initiatives at the county level that contribute to forestland protection, directly and indirectly. Most directly are recent county-level and township level bond initiatives that borrow funding to protect open space [see discussion above under Southeast ecopolitical region]. In addition, most Pennsylvania counties have developed county-level Natural Resource Inventories mapping and documenting critical habitats and ecosystems within their borders for future conservation. Most counties have also completed and adopted Greenway Plans that delineate and develop conservation and recreation measures for critical natural resources.

Working directly with communities to conserve or augment forest acreage, and with private landowners, should be a key part of any overall strategy to conserve forestland. Pennsylvania's Bureau of Forestry, through the efforts of its Private Lands Section and service and extension foresters, are working on several fronts to do outreach and education to municipal leaders and private owners on options to protect their lands. One successful strategy has been working with private owners to develop forest stewardship plans. At present, there are more than 3,100 private landowners in the state with completed stewardship plans, and many have begun or even completed implementation practices. Another approach at the community level in the Commonwealth has been the development and recognition by DCNR of "managing communities," which have to meet a minimum of four competency levels, including having a dedicated staff person to work on forest issues and adopting a forest zoning ordinance.

Additionally, as emerging markets for timber and non-timber products are developed, and as ecosystem service payments for stored carbon, nutrient reduction, and other functions of forests begin to materialize, private landowners and communities will have more good options and incentives to preserve forestland.

Conclusion

While none of these measures alone is enough to reverse the increasing land use pressures and fragmentation of forestlands across the Commonwealth, they present an

array of options and planning tools that, with higher levels of state and federal funding, can play a critical role in the future to conserve forests and their multiple benefits.

Chapter 4B

Issues, Threats and Opportunities - Forest Health

Introduction
Forest insects and diseases, invasive plants, inadequate forest regeneration, and over-abundant deer populations are the principal factors affecting forest health in Pennsylvania. Fire and climate change, while considered threats to forest health, are covered as separate issues in this assessment. DCNR has the responsibility for "*protecting forestlands in Pennsylvania from harmful insects, diseases, and other factors*" under authority of Act No. 18 of 1995. Providing leadership in the field of forest health management will lead to sustainable and healthy forests in Pennsylvania.

Sub-Issue: Forest Insects and Diseases
Non-native invasive species are very serious threats and can have significantly devastating impacts on the long-term health and sustainability of Pennsylvania's forests. Diseases, such as chestnut blight and Dutch elm disease, and insect pests, such as gypsy moth and hemlock woolly adelgid, have already significantly changed the forests and urban landscapes of Pennsylvania. Many of the invasive insects and pathogens in the United States have initially become established in urban forests.

Oaks continue to be at risk from gypsy moth (over 108,000 acres of oak mortality in 2008 and 2009) and from sudden oak death, caused by the pathogen *Phytophthora ramorum*, which could devastate oaks as understory hosts of the pathogen are prevalent in Pennsylvania's mixed-oak forests. Beech bark disease continues to expand and combined with other stressors, such as drought, could increase beech mortality. Threats to oaks and beech are especially important because they are the most important sources of hard mast for wildlife. Hemlock woolly adelgid (HWA), introduced into Pennsylvania in 1967, continues to spread westward and is affecting the hemlock resource, so continued monitoring will be critical to research and management efforts aimed at understanding and ameliorating the impact of this insect pest. Sixteen counties in western Pennsylvania are not yet infested with HWA and a national HWA Initiative and Strategic Plan guides national and regional efforts to manage this pest. The emerald ash borer (EAB) was detected in Pennsylvania in 2007 and has been detected in 12 counties (as of May 2010). It is a serious threat to the 323 million ash trees and urban communities throughout the Commonwealth including a state species of concern, pumpkin ash, and ash seen orchards managed by the DCNR Bureau of Forestry. The development and implementation of an EAB Management in the next two years is a high priority. *Sirex noctilio*, a European woodwasp, was detected in Pennsylvania in 2006 and has the potential to be a serious

pest of pines. Should it enter Pennsylvania, the Asian longhorned beetle is another insect pest that could cause considerable harm to the maple resource, already under stress due to sugar maple decline. Other tree species, such as walnut and butternut, are threatened by invasive species that are established in North America.

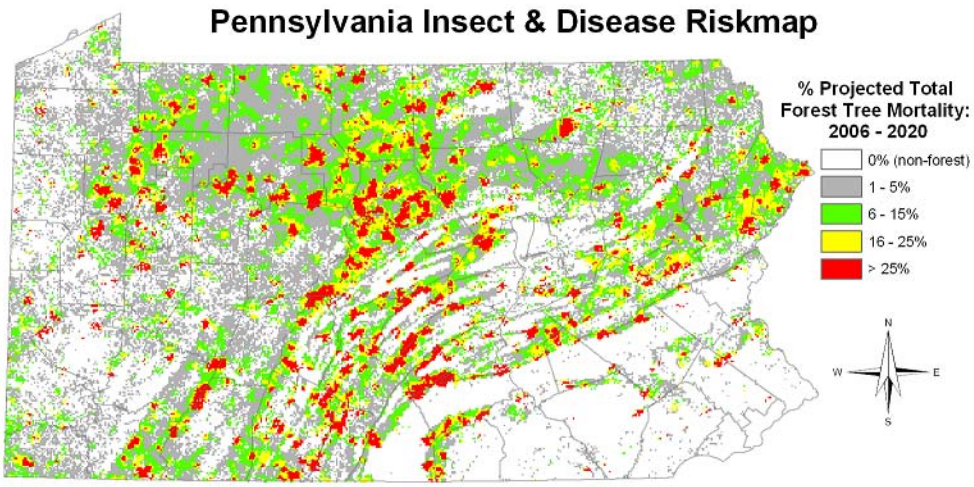
Many native diseases and insect pests cause severe defoliation and mortality during intense outbreaks in local areas (such as the forest tent caterpillar and anthracnose disease on maples in northern and northeastern Pennsylvania), or when they occur in conjunction with other stressors, e.g. drought and acidic precipitation. Climate change adds an additional level of uncertainty to the future impacts of both native and exotic forest pests. Some secondary pests that attack stressed trees may become more prevalent if certain tree hosts are exposed to increased drought or other stress factors due to climate change (e.g. bark beetles in pines and wood borers in hardwoods). (McWilliams, William H.; et al. **Pennsylvania's Forest, 2004.** Resour. Bull. NRS-20. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 86 p.)

The tree mortality risk map shown below indicates the Pennsylvania forests at risk for mortality due to various damage causing agents from 2006 to 2020. Prioritizing the forests based on susceptibility to damage and vulnerability to mortality is a key piece of information that needs to be developed to better manage the forests and to focus and prioritize future efforts in forest management. Key host species in Pennsylvania and damage causing agents threatening those hosts are listed in the table below.

Major Host Species and Damage Causing Agents in Pennsylvania.

Host Species	**Major Damage Causing Agents and Potential New Invasive Species**	**Regions at Risk**
Oaks (all species)	Gypsy moth; drought; oak wilt; bacterial leaf scorch; red oak decline; white oak decline; *P. ramorum* (SOD); oak leaf-tier; climate change	All CLI regions; Ridge & Valley; Kittatinny Ridge; and all Private Lands Regions; DCNR State Forest Lands; DCNR State Parks; PA Game Commission forestlands
Maples (all species)	Forest tent caterpillar/anthracnose; Asian longhorned beetle; Sugar maple decline; fall cankerworm; elm spanworm; drought; acid precipitation; climate change	PA Wilds CLI; Pocono Forests & Waters CLI; Northeast Private Forestland Region; Northcentral Private Forestland Region; urban forests statewide; DCNR State Forests; DCNR State Parks; PA Game Commission forestlands
Eastern hemlock	Hemlock woolly adelgid; elongate hemlock scale; drought; *Fabrella* needle cast; climate change	All CLI regions; all trout streams in PA and in the Chesapeake Bay, Delaware and Ohio Watersheds & River Basins; Ridge & Valley; DCNR State Forests; DCNR State Parks; PA Game Commission forestlands; all Private Forestland Regions
Ash (all species)	Emerald ash borer; ash yellows; ash decline; drought; fall cankerworm; climate change	All CLI regions; urban forests; DCNR State Forests; DCNR State Parks; All Private Forestland regions; Erie Watershed
American beech	Beech bark disease (scale insect, exotic and native *Neonectria* cankers); drought; elm spanworm; climate change	All CLI regions; Northcentral, Southwest, Northeast Private Forestland regions; DCNR State Forests; PA Game Commission forestlands
Walnut, butternut, and elm	Thousand cankers disease & walnut twig beetle; butternut canker; elm yellows	Riparian areas statewide; All CLI regions; Southwest and Southcentral Private Forestland regions; Ridge & Valley; DCNR State Forests; DCNR State Parks; PA Game Commission forestlands
Pines (white, red, other *Pinus* spp.)	*Sirex noctilio*; Common pine shoot beetle; *Orthotomicus erosus* (Mediterranean pine engraver); *Ips pini*; other exotic bark beetles; drought; climate change	All CLI regions; DCNR State Forests; DCNR State Parks; PA Game Commission forestlands; Northcentral, Southwest, Southcentral and Northeast Private forestland regions; Ridge & Valley

CLI = Conservation Landscape Initiative areas



Tree Mortality Risk Map for Pennsylvania 2006-2020.

Sub-Issue: Invasive Plants

Many non-native invasive plants currently threaten the forests of Pennsylvania. Terrestrial species such as Japanese stilt grass, mile-a-minute weed and multiflora rose have been adversely affecting biodiversity and forest regeneration throughout the state. Japanese knotweed, garlic mustard and purple loosestrife are choking out native plant populations found in riparian areas. Aquatic invasive species like Eurasian water-milfoil and European water chestnut can block waterways and reduce the capacity of these waterways and lakes to support native aquatic life.

These invasive plant species alter nutrient cycling, hydrology, fire regimes, light penetration levels, regeneration of native species populations, and physical habitat structure throughout once healthy ecosystems. The long-term effects of these changes are unknown, but their rate of occurrence raises concern about the ability of native species to adapt, particularly in the face of reducing habitat availability and increasing human encroachment. We have anecdotal evidence that a number of Pennsylvania's special concern species are declining and may be lost to the state as a result of invasive species. Further, recent research has shown that some invasive species can interact to cause the populations of even common species to collapse.
Many invasive plant species do not directly nor immediately destroy native habitats. Rather, these pests weaken native species and increase their susceptibility to secondary attack or invasion by a different species.

Beyond the threat to biological systems, invasive plants directly impact a range of human activities and values such as the contact burns caused by the invasive giant hogweed plant, first detected in Erie County in 1985.

In addition to these dangers, invasive plants constitute a threat to our economy and overall quality of life. There are many opportunities for outdoor recreation in natural landscapes in Pennsylvania. Invasive weed species like Japanese knotweed and mile-a-minute now create nearly impenetrable walls of vegetation along many miles of Pennsylvania's most scenic waterways.

In our many historic landscapes, the vegetation encountered at the time of an event or period of interest has often been replaced by more recent arrivals from around the world. Our shared heritage and the quality of visitor experiences are at risk following the encroachment of invasive species into an historic area.

Controlling invasive plant species is profoundly expensive. Many parks and forest districts have identified the need for additional resources to address the invasive species problems that threaten the quality of park habitats and visitor experiences. The impact of invasive species challenges the abilities of land managers to provide natural resource stewardship for public and private lands. (Pennsylvania Department of Conservation and Natural Resources Invasive Species Management Plan, 2005. DCNR Working Document, Harrisburg, PA. 79 p.) An increasing concern is the growing demand for drilling rights to access Marcellus shale beneath forest land. New access roads as well as increased use of existing roads into forest land serve as vectors for the movement of invasive plants.

Sub-Issue: Inadequate Forest Regeneration

The capacity of the forest to renew itself through natural regeneration is a key indicator of forest health and a necessary component of a sustainable managed forest. Ensuring desirable regeneration throughout Pennsylvania's forest is a significant management challenge. Across the state, only 47 percent of sampled stands have adequate regeneration to develop into high-canopy forests (FIA, 2004). When only considering commercially desirable species, the number drops to 34 percent.

The extent and quality of forest regeneration has far-reaching impacts on forest health and the suite of values the forest provides to society. The natural replacement of forests helps maintain and enhance Pennsylvania's nearly 60 percent forest land base that recharges water within watersheds, stores carbon, and provides incalculable ecological services. The habitat structure that young forests provide is essential to many wildlife species, such as American woodcock, golden-wing warblers and Appalachian cottontails. The species mix in these regenerating forests impacts the future availability of wood products. Some of today's commercially valuable timber species, for example – such as oak and sugar maple – are not strongly represented in the regeneration component of today's forest.

A myriad of both ecological and social factors underlay the fundamental lack of regeneration in Pennsylvania forests. The lack of planning and sound forest management practices on a majority of private forestland contributes widely. Deer population out of balance with habitat conditions is a significant factor, as are changing fire regimes, alterations in soil chemistry, acidic deposition, the proliferation of both native and non-native invasive species, and introduced insect pests such as gypsy moth and hemlock woolly adelgid. Addressing Pennsylvania's forest regeneration deficit will require managing and mitigating these various impacts and stressors across state and federal agencies and natural resource program areas.

Sub-Issue: Over- abundant deer populations

White-tailed deer (*Odocoileus virginianus*), as a wild, native ungulate, is an integral part of the evolutionary history of Pennsylvania's forest ecosystems. The extirpation of large predators, land use changes, and the status of the whitetail as a game animal under regulatory protection have all profoundly changed the population dynamics and thus the level of influence foraging by white-tail deer has on species abundance and composition of forest plant and animal communities.

For many years, the difficulty of managing deer from both social and ecological perspectives has consumed the energies of Pennsylvania's land management, scientific, and conservation communities. The challenge is to better integrate research and management to address forest ecosystem issues.

Studies of the effect of deer browsing on forest plant communities have primarily used deer exclosures to study differences in forest plant communities when deer are absent versus ambient deer densities (e.g. Hough 1949, Marquis 1974, Alverson and Waller 1997). Although this research approach can document the effects of deer browsing, forest plant species composition under zero deer is not natural and makes it difficult to quantify long-term effects of deer browsing (Horsley et al. 2003). In contrast, research in which deer densities have been manipulated within enclosures and tree regeneration has been measured, have demonstrated an effect of deer browsing on forest regeneration and have even identified critical deer densities in which certain tree species can be successfully regenerated for the forest type studied (Horsley et al. 2003). Consequently, research that has studied forest vegetation in the context of known densities of deer in an experimental framework has contributed enormously to our understanding of the effects of deer herbivory on forest conditions, especially with respect to tree regeneration.

However, the available scientific knowledge about the interactions of Pennsylvania's deer herd and the health of its forest ecosystems cannot easily be translated to a management context, given its basis primarily in experimental research. Forest managers and agency policy makers' efforts to positively effect forest health and regeneration by addressing deer impacts include many other uncertainties not addressed in the experimental methodologies that contributed to current knowledge on deer/forest health interactions. In particular, three other factors are discussed in literature and the press as affecting tree regeneration and forest health: acid deposition, lack of fire as a disturbance regime, and the legacy impacts of excessive deer herbivory (competing vegetation layers, depauperate seed sources, etc.). While the importance of any one of these factors may be promoted to the exclusion of all others proponents of the different hypotheses usually recognize that multiple factors influence forest regeneration and forest health interactively (e.g. Abrams 1992, Sharpe and Drohan 1999).

Demographic changes in Pennsylvania's hunter population coupled with studies done on the use of hunting as a deer population management tool have also begun to provide a better understanding of the difficulty policy makers face in managing deer through hunting from a forest health or ecosystem management perspective. Pennsylvania hunting license sales have declined 28 percent since their peak in 1981, which reflects national

demographic trends of declining hunter numbers. Inherent limits on hunter efficiency and effectiveness due to social and economic constraints (e.g. urbanization, time to spend afield, competing recreational activities, etc.) and recent research into the effectiveness of hunters in reducing deer numbers at varying levels of density provide evidence that deer density thresholds necessary for healthy forest regeneration to occur at a system wide level may be difficult to achieve, even when supported by aggressive herd reduction policies and strategies (Van Deelen and Etter, 2003). Additional studies on the un-willingness of Pennsylvania hunters to harvest antlerless deer further illustrate the difficulty of achieving or sustaining deer densities that are sufficiently low to sustain long-term ecological recovery or forest health (Bhandari et al., 2006).

Controversy over the effect of deer browsing versus other factors is unlikely to disappear given current levels of understanding of forest ecosystems and the social and political issues surrounding deer and forest management. However, if stakeholders can agree on forest and deer management objectives, an adaptive management program has advantages in resolving conflicts and improving our forest and deer management. It integrates research and management in recognition that management decisions are ongoing, there is much uncertainty in the system being managed, and management actions provide opportunities to learn about the system being managed. Adaptive management would allow different ideas of how deer and other factors influence the forest ecosystem to be investigated at the same time allowing data to drive management decisions.

In Pennsylvania, deer management is the responsibility of the Pennsylvania Game Commission. On DCNR Bureau of Forestry lands, deer fencing is sometimes needed in order to regenerate a forest where high deer populations densities exist. This need requires funding and resources to implement.

Chapter 4c

Issues, Threats, and Opportunities - Forest Management

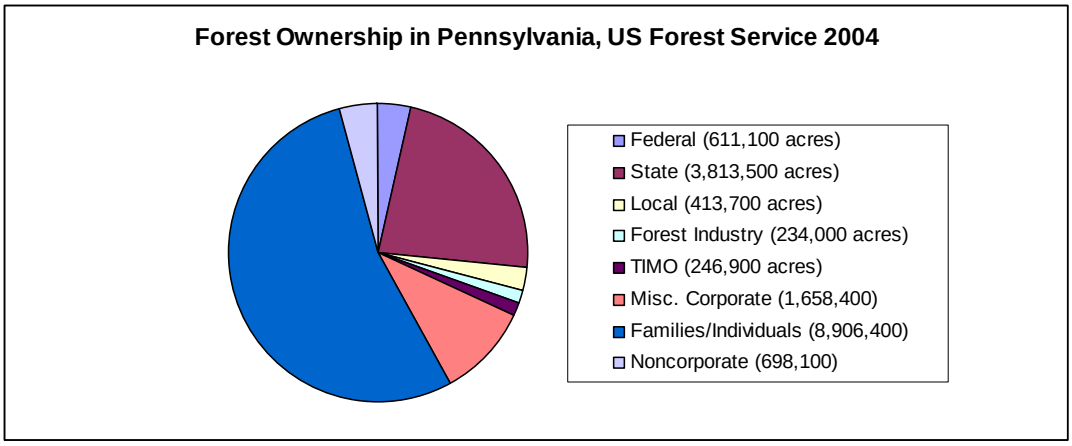
Introduction
The sustainable management of rural and urban forests, both public and private, is a significant issue facing the Commonwealth today. Major challenges and opportunities face the state's forest managers, ranging from fragmented and parcelized forest ownership, unsustainable timber harvesting, forest certification, marketing of forest products, and participation in carbon markets, to interest in biomass energy, management of community forests, water concerns, and the continued monitoring of forest conditions. Because Pennsylvania is nearly 60% forested, these challenges and opportunities affect a significant portion of the state. Apart from the health of the forests, the management of these landscapes is integral to the health of the Commonwealth's waters and directly affects all its citizens.

This chapter is organized by sub-issue. The sub-issues to be discussed are:

- Ownership
- Unsustainable Timber Harvesting
- Certification Systems
- Marketing of Forest Products and Services
- Carbon Markets
- Biomass
- Community Forest Management
- Water
- Monitoring

Sub-Issue: Ownership (see also "Ownership" in Chapter 4a)

Rural Forestland Ownership
According to 2004 US Forest Service data, there are 16,582,100 acres of forested land in the Commonwealth. This forestland is distributed among ownerships and across the landscape as per the following chart:



The 8,906,400 acres (54%) of forestland in Pennsylvania owned by families and individuals pose special challenges for sustainability and good forest management:

- The average age of a Pennsylvania landowner is currently 57, indicating that a large shift in landowners is likely to occur in the near future.
- Many landowners bequeath their property to a child or, often, multiple children, which often leads to property subdivision. Oftentimes, heirs are not interested in owning forestland, or cannot agree on how to manage the property and it ends up being sold to a new owner or developer in order to liquidate and fairly distribute assets.
- A recent study of the next generation of landowner conducted by the Pinchot Institute indicates a waning interest in active stewardship of family lands (see the "Future Ownership Trends" section of Chapter 4a).
- The increasing parcelization of private lands creates challenges for forest managers, in many cases resulting in additional work for potentially smaller income.
- Most landowners indicate that they do not own land for the purpose of harvesting timber (Metcalf 2009). Most landowners do not have a background in forestry and therefore lack knowledge of forest management principles.
- Though most landowners do not own land for its timber value, many can be swayed by seemingly large financial offers for their timber, or may feel forced into an unsustainable harvest due to pressing financial obligations.

Urban Ownership Issues

Though not often discussed, the ownership issue affects the Commonwealth's urban and community forests as well. Grant funding is generally available for use on public land or "quasi-public land" only. This includes parks and greenways; a narrow strip along roadways within the public rights-of-way; and sometimes on school grounds, churchyards, and cemeteries. While much can be accomplished toward increasing tree canopy cover by better utilizing public space available, the majority of property is privately owned. This heightens the importance of urban planting and educational efforts, such as Pennsylvania's TreeVitalize Program, that can engage average homeowners and motivate them to plant on their own property.

Sub-Issue: Unsustainable Timber Harvesting

The majority of Pennsylvania's forests are between 90 and 120 years old, reflecting the widespread clearing and harvesting that occurred to fuel the industrial revolution. As a result, most forest stands are relatively uniform in structure and are dominated by "sawtimber-sized" trees. But these even-aged stands are not all equal in timber or mast quality.

There is a concern among all sectors of Pennsylvania's forestry community that high-grading – the harvesting of only those trees that will give the highest immediate economic return – may lead to widespread decline in forest resource quality. Two practices, diameter-limit cutting and selective cutting, generally fall into this category. In diameter-limit cutting, all salable trees above a certain diameter are harvested. Selective cutting usually removes the largest, most valuable trees and may leave large-diameter, poor-quality, and low-value trees. In each case, most of the trees that remain after the harvest are genetically inferior or physically defective. Neither method gives any thought to the composition of the future forest.

For example, targeting large-seeded mast trees such as oak for removal creates gaps in the canopy that light, wind disseminated seed such as black birch or maple quickly fill. And, by removing the most vigorous seed stock (i.e. the biggest trees), residual oak seedlings are less able to compete for water, nutrients and sunlight. The loss of healthy, productive mast species from the forest canopy impacts its ability to provide food for wildlife, further increasing predation on desirable seedlings.

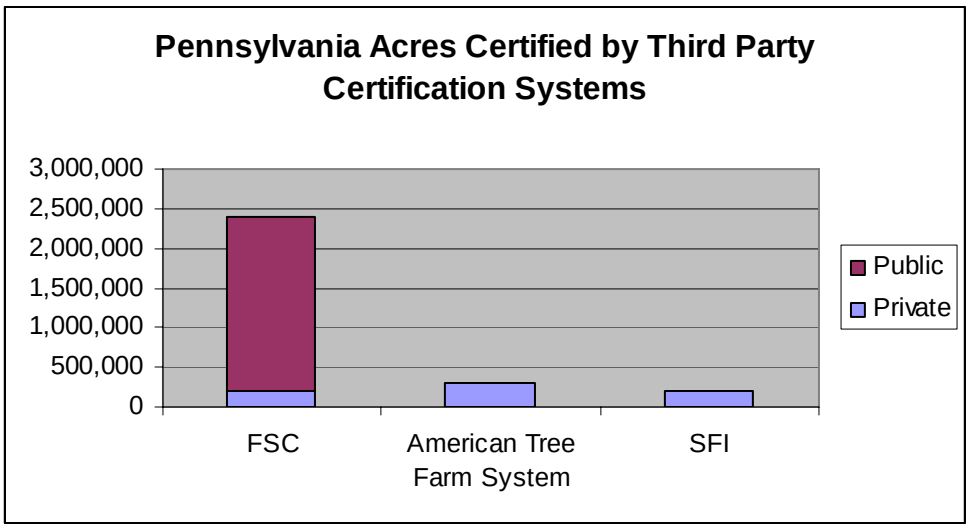
Though there is need for additional data and reporting to make final conclusions as to the cause, the US Forest Service data do indeed suggest that the make-up of our forest types is changing. Red maple, black birch, and white pine are becoming more common while sugar maple, hemlock, and the oaks are declining. Overall, the changes we are seeing in the Commonwealth related to tree species diversity, forest structure, and age-class distribution are signs of an unsustainable condition and strong evidence exists to indicate that this is not due solely to insects, diseases, and lack of fire, but that unsustainable harvesting does indeed play an important role in these unsettling trends.

Good stewardship requires that landowners consider the future consequences of their decisions and that resource professionals and harvesters recommend sustainable forest management practices. Education and awareness is needed to improve harvesting practices. Advances in carbon and other ecosystem markets, as well as expansion of forest certification efforts, may also help curb these devastating practices.

Sub-Issue: Certification Systems

Certification of State Forestland
For the 12th consecutive year, Pennsylvania's management of its approximately 2.1 million acres of state forest lands has met or exceeded the standards for environmentally responsible stewardship. SmartWood verified that the Commonwealth's operations in State Forests comply with the principles and criteria developed by the Forest Stewardship Council (FSC): the international gold standard for environmentally and socially responsible forestry. This independent scientific review process scrutinizes timber resource sustainability, forest ecosystem maintenance, and financial and socioeconomic considerations. The certified public forest base provides a sound foundation for certified product production and marketing; without it, Pennsylvania's solid wood products would be only a niche market and certified paper production would likely become infeasible.

Certification of Private and Industry Lands
Third party certification of private land is slowly gaining traction in Pennsylvania. Of the Commonwealth's 12.5 million acres of privately held land (including industry lands), only 700,276 acres, or 5.6% are certified through a third party system. These properties are primarily certified under the Forest Stewardship Council (FSC), the American Tree Farm System (ATFS), and the Sustainable Forestry Initiative (SFI) (discussed below). While certified wood does not currently seem to have a price advantage in the marketplace, it does offer the "green conscience" advantage of being sought after (over and above non-certified wood) even in the midst of the recent economic crisis.



Wide-spread third-party certification could engender better stewardship and management of the Commonwealth's forested land, but since the direct and indirect costs to a landowner for entering into such an agreement are prohibitive one of the challenges will be discovering how to motivate landowners to go through the certification process and then maintain their certified status into the future. One effort to address this is the ATFS

move into the group certification arena, whereby all Tree Farmers in good standing are now considered third-party certified. To remain in the program, Tree Farmers must meet set standards of sustainability. Properties from 10 contiguous acres to 10,000 contiguous acres are eligible for ATFS certification, which currently meets SFI standards. The ATFS certification option may give landowners, especially those of smaller acreages, the opportunity to participate where they may not have otherwise been able.

The Nature Conservancy (TNC) is currently working on a pilot project called *Working Woodlands*, which combines certification with active participation in carbon markets. In this model, landowners holding as little as 200 acres can be aggregated under TNC and certified under FSC while at the same time meeting the criteria for trading carbon credits. All of this is planned to cost the participant landowners little to no out-of-pocket expense.

A group of stakeholders has begun to meet to discuss the certification opportunities in the Commonwealth and how best to partner for the good of the forest. The group consists of representatives from the three major certification systems, the DCNR Bureau of Forestry, Penn State Extension, The Nature Conservancy, and Forest Industry. Additional work is necessary to expand the number of properties in Pennsylvania under third party certification.

Sub-Issue: Marketing of Forest Products and Services

Traditional Forest Products

Pennsylvania is known throughout the world as a leading source of high quality hardwood products and is home to the nation's largest concentration of hardwood growing stock: high quality black cherry, northern red oak, red maple, sugar maple, white oak, poplar and ash.

Pennsylvania leads the nation in the production of hardwood lumber, accounting for about ten percent of the country's annual production. The state typically produces more than a billion board feet of hardwood lumber annually and ranks nationally in the production of value added wood products such as millwork and flooring, kitchen cabinets, and pallets and containers. Wood products produced in Pennsylvania are diverse and include veneer, paper and consumer paper products, railroad, mine and landscape ties, housing timbers, engineered wood products, tool handles, baseball bats, wood fuel pellets and landscape mulch.

The sale of timber provides private forest landowners with hundreds of millions in revenue annually, and industry purchase of timber from public lands also provides Pennsylvania taxpayers with tens of millions annually that helps support the operations and activities of the Pennsylvania Department of Conservation and Natural Resources and the Pennsylvania Game Commission. According to the Pennsylvania Forest Products Association, for every additional million board feet of sawtimber supplied to

Pennsylvania sawmills, an additional $10 million of industrial output is realized and 71 new jobs created.

The current economic climate poses significant challenges to the Commonwealth's forest industry. Although it continues to be a driving force in Pennsylvania's economy, the last few years have brought significant business challenges. In recent years, Pennsylvania sawmills and value-added wood manufactures have seen declining demand for their products. Causes include weakened housing and remodeling markets, the continued impacts of the outsourcing of furniture production, increased foreign competition in both value-added products and lumber, shifting consumer taste away from certain species (example: red oak), and softening demand in key overseas markets. At the depths of the recession, many species of hardwood lumber declined in price by 30-50 percent. Recent months have seen price stabilization and recovery as supply and demand came back into balance and lumber production increased somewhat to fill depleted mill inventories and meet the slow increase in demand. Domestic demand for hardwood products continue to lag well below what were previously considered usual levels. Some export markets have moved more rapidly towards recovery. Demand for low-grade lumber for pallets and industrial applications outpaced the recovery of high-end species and grades. There is also anecdotal evidence that the certified wood products have moved from a niche product to a relevant part of the overall wood demand.

While demand and prices for their product had declined, sawmills and secondary processors experienced, and continue to experience, higher energy, transportation, labor and other production costs, and less ready access to capital, impacting overall company profitability. Additionally, timber costs have not declined as fast as lumber prices, leaving a smaller profit margin.

Pennsylvania hardwood production was at 1.4 billion board feet per year in the late 1990's. By 2006, production was down to 1 billion board feet. Some industry experts suggest that 2009 was Pennsylvania's lowest hardwood production year since before WWII, with hardwood lumber production about half of its normal level. Lumber production began a slow recovery by the beginning of 2010. The speed and extent of this recovery will depend upon the demand for hardwood products both domestically and globally, as well as the ability for Pennsylvania hardwood lumber and wood producers to remain competitive in the global marketplace.

Although also impacted by the recession, Pennsylvania's paper producers fared better than their sawmill counterparts.

A strong forest products industry is very important to Pennsylvania's forest sustainability and to its forest landowners. A landowner's best opportunity to have a positive impact on his/her woodlot is at the time a timber sale is undertaken. The most viable economic models for biomass energy development require associated income derived from continued strong markets for hardwood sawtimber. Road construction, maintenance and timber stand improvement work can be incorporated in a sustainable manner. This can

only be accomplished through the aid of a strong forest products industry. It is also important to note that much of the sustainable management on state forestland is accomplished through the forest products industry. Without this industry, proper management of state forestlands would be difficult.

The PA Sustainable Forestry Initiative (SFI) program has been a vital part of Pennsylvania's efforts toward forest sustainability. The program began in the mid-1990's and is the primary source for professional logger education and training. The SFI curriculum emphasizes personnel safety throughout the forest industry, which contributes to a sustainable workforce, while being heavily geared towards best management practices (BMPs), forest ecosystems, and helping loggers understand how they can contribute to forest sustainability. While forest sustainability involves many players, including landowners, researchers, forest managers, wood product manufacturers, consumers, etc., the persons actively harvesting forest products can have the biggest impact on forest sustainability through their on-the-ground decision making and actions. With a logging force well-trained in the SFI Inc. Standards of Sustainability, preventing soil erosion, silviculture, maintaining water quality, preventing residual stand damage, protecting sensitive natural communities, good business management, identifying exotic and invasive plants/insects/diseases, communicating with the public, and host of other important forest management faculties, we have the ability to tie together all the pieces of forest sustainability and influence how all the players interact with each other. The PA DCNR Bureau Forestry accepts and supports these efforts by requiring that PA SFI trained operators on all state forestland timber sales.

In addition to SFI's focus on the logging community, they provide educational outreach to forest landowners, the general public, the wood manufacturing industry, and other resource professionals. A variety of techniques are used, including newsletters, workshops, informational displays, partnerships, and more to promote the benefits of sustainably managed forests and the value of the forest industry in Pennsylvania.

Non-timber Forest Products

A significant challenge to both ecological and economic sustainability of forest systems is the fact that relatively few of the goods and services provided by forests provide an annual or even short-term income. Forest - based cultivation of ginseng and similar plants, and sustainable collection of non-timber forest products (NTFP) are two practices with potential to create a growing annual income stream for private forestland owners.

Broadly speaking, non-timber forest products (NTFP) are plants or plant parts that have perceived economic or consumption value sufficient to encourage their forest cultivation or collection. As of March 2003, The Institute for Culture, Society and Environment's non-timber forest products database listed 695 plants, fungi and lichen, which occur in Pennsylvania, and have been or are currently being commercially collected. In Pennsylvania, maple syrup and ginseng are the two most well established NTFP products and industries, each contributing approximately $3 million annually to the state's economy depending on market price. Harvesting of other well known commercial and

edible products such as wild mushrooms, ramps, and berries also provide significant but largely unmeasured economic and recreational benefits.

The monitoring and regulation of non-timber forest products is a challenge both because of the range of species and issues involved, and because many vested NTFP stakeholders have been resistant to government regulatory involvement. Past regulatory approaches were rarely based on data driven understandings of market signals, collector activities, or product/species inventories and have done little to either ensure the sustainability of the resource or build trust among NTFP stakeholders or between stakeholders and government agencies. To begin addressing these issues, the Bureau of Forestry initiated research into NTFPs using ginseng as a model NTFP species. This research encompassed seven years of investigation into the structure of the ginseng marketplace and industry, collector and grower behaviors and concerns, and historic and current price trends and other market signals.

Concurrently, promoting an awareness of the recreational and economic opportunities provided by NTFP cultivation, collection, and stewardship is also becoming a significant part of the Bureau of Forestry's outreach to forest landowners and other stakeholders (i.e. loggers, natural resource professionals, landscapers). The Bureau has also partnered with the Pennsylvania Association for Sustainable Agriculture (PASA), Pennsylvania State School of Forestry, and Shaver's Creek Environmental Center over the past four years to provide field days and conference workshops on NTFP, sustainable timber management, agroforestry, and forest-based permaculture practices designed to provide hands-on skills training to early adopters and entrepreneurs within the sustainable agriculture community and the state's rural, suburban, and urban communities.

There is also a need for non-commercial forest management for the purpose of supporting wildlife needs. One model is the Pennsylvania Game Commission's Private Landowner Assistance Program (PLAP), which helps landowners create or maintain habitat for the birds and mammals in danger of and suffering from population declines.

Sub-Issue: Carbon Markets

The trading of forest-related carbon credits in existing markets requires the implementation various planning tools, such as inventories of the resource and management plans. Due to direct market ties and subsequent payments to landowners for continuing to properly manage the resource, there is much anticipation that entry into carbon markets or other markets linked to environmental services will have a positive effect on the management and stewardship of the Commonwealth's forests. There are currently three types of projects that are eligible to participate in existing carbon markets: afforestation, improved forest management, and avoided conversion.

DCNR is currently evaluating the viability of pilot projects on public land, most of which are likely to fall under the "avoided conversion" category. As mentioned under "Certification of Private and Industry Lands," The Nature Conservancy has recently

launched a pilot project called *Working Woodlands*, which combines certification with active participation in carbon markets. This model will utilize carbon credit payments to provide an incentive to landowners to keep their forests as forests and to manage those forests properly. Additionally, a portion of the revenue generated from the credits will serve to support the work of The Nature Conservancy as an aggregator of these credits.

There is very high potential for Urban and Community Forestry to contribute to carbon offsets and energy efficiency. Of actions that are recommended by the Commonwealth to combat green house gas emissions, the December 2009 "PA Climate Change Action Report" indicates that Urban Forestry ranks 11 out of 43. This same report also ranks the same 43 actions in regards to their cost effectiveness. Urban Forestry is ranked third of 43, providing an actual cost savings while ameliorating green house gasses (see page 1-22, Figure 1-7 where "F-7" refers to urban forestry.)

Research through the US Forest Service in recent years has resulted in highly useful techniques for assessing and analyzing urban tree canopy cover, thereby quantifying benefits provided by urban trees. Ecological and economic services provided by trees can provide powerful incentives for increased public awareness and appreciation for urban forestry. Carbon is sequestered in the wood, and energy and air quality savings are significant. Trees directly cool cities and reduce the urban heat island effect through shading and transpiration. The reduction in heat also results in lowered production of ozone, which facilitates better air quality.

Additional information about carbon can be found in Chapter 4D-Climate Change.

Sub-Issue: Biomass

Forest biomass, which is woody material that generally refers to trees and tree branches, can be used commercially as a combustion fuel for heat and steam.

DCNR is currently advocating small-scale energy projects, such as wood boilers for institutions like schools or municipal facilities or personal use of firewood by landowners.

The Pennsylvania Fuels for Schools and Beyond Program is a great example of a small-scale biomass energy initiative. The program promotes the use of local, renewable resources to provide reliable energy for Pennsylvania schools and businesses. For an in-depth discussion on the issues and challenges associated with using biomass sustainably for heat and energy generation, please refer to the "Energy Development" section of this chapter, where you will also find a link to a comprehensive document generated by DCNR – "Guidance on Harvesting Woody Biomass for Energy in Pennsylvania."

Biomass in the Context of Stand Level Forest Management

When forests are harvested in Pennsylvania, the great majority of forest managers rely on advanced natural "regeneration," or young tree seedlings that will comprise the future forest. The term "advanced" implies that the seedlings are present prior to any harvesting

activity. Most of our forests are "even-aged," where the majority of trees became established at roughly the same time and are the same age.

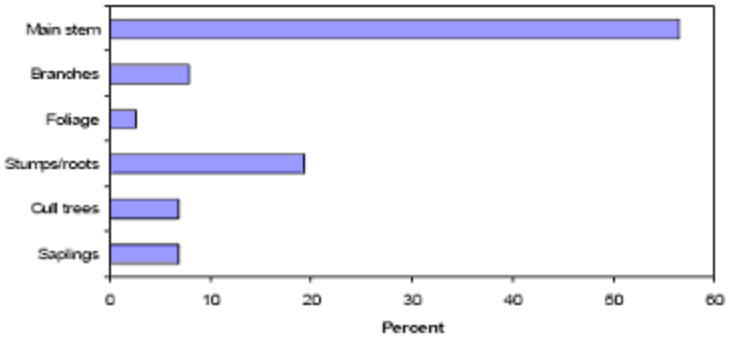
In early decades of development, seedlings and saplings grow closely together, competing for the limited resources of sunlight, moisture and space. Some trees begin to exert their dominance, while others die or begin to lag behind in growth. This dynamic continues for several decades. As trees grow taller and larger in diameter, the growing site can support fewer trees per acre.

Commercial timber harvests are generally not conducted until the stand is approximately 50 years old. A "stand" is a forestry term that refers to a defined area that allows managers to develop plans. It usually contains trees of a similar species mix and age class, or may be defined by topography. When a stand reaches 50 years or so, poorly formed trees can be harvested to concentrate the site's growing potential on the most dominant and desirable trees. Several light thinning harvests may occur until the stand reaches an approximate economic maturity age of 80 to 120. These "thinnings" can be applied as "timber stand improvements" or "improvement thinnings." A useful analogy is to think of it in terms of a vegetable garden. An "improvement thinning" removes the weeds and those individuals that are less healthy, of poorer form, or in direct competition for space and light with a desirable specimen. These types of operations can aid in promoting the health of the forest and improve the long term condition of the residual trees.

Forests cannot be thinned or harvested indefinitely. They must be cut and regenerated at some point when stocking levels grow low or seed trees grow scarce. Establishing regeneration for the future forest can require considerable planning and effort. A common regeneration practice called a "shelterwood" harvest removes approximately one-third to one-half of the lower quality trees on the site to encourage the stand's highest quality trees to produce seed. By opening the forest canopy through the removal of poorer quality trees, more sunlight reaches the forest floor, providing the limiting resources of space and light to allow young trees or "regeneration" to become established for the next forest. These thinnings, supported by markets for low-grade biomass materials, can aid in successfully and sustainably managing forestland.

Woody Biomass Availability

How much woody biomass exists in Pennsylvania, and how much is actually physically available for harvest, are two distinct questions. It is important to recognize these realities: the wood is not free, and it is often not easy to get to.



Distribution of tree biomass (green weight) on forest land by component, all species. Source: PA's Forests, 2004.

Pennsylvania grows high-value hardwoods. Using a rough approximation, the proportion of high value trees, on a per-acre basis, is out-numbered 2:1 by less valuable trees. The cost of extracting harvested timber is normally justified by the value of 1/3 of the trees on a site. There are considerable costs associated with constructing forest haul roads, log landings and associated skid trails to get the trees out. To an operator, if sufficiently valuable timber is not available in a forested area, it does not make economic sense to enter a forested site and harvest it. The cost to harvest low use wood [LUW] is no less expensive. Standing LUW may be acquired for $2 to $3 per ton, but delivered LUW will cost, at June 2008 estimates, at least $24 to $30 per ton (2008 DCNR data) after harvesting and trucking costs are included. Given the rising cost of fuel and steel (products associated with timber harvests, i.e., gates, culverts, bulldozers, tri-axle log trucks) these costs are likely to rise incrementally into the future.

Recent research by Penn State's School of Forest Resources estimates that approximately 70 percent of Pennsylvania's forestland is owned by over 600,000 private forest landowners (PFLs). Private forest landowners include individuals, joint owners, clubs, associations, non-profits, and non-timber businesses. Collectively, these owners' willingness to harvest woody biomass will have a significant impact on availability.

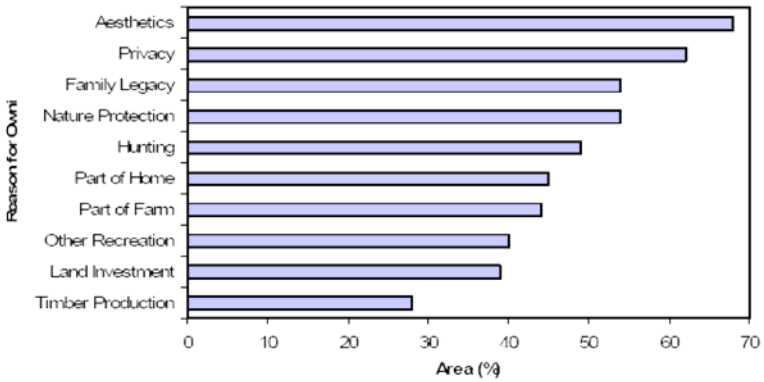
While the USFS estimates that timber volume has increased over the past several decades, recent anecdotal information from the timber industry suggests overall reduced access to private lands and general difficulty locating high volume, high quality stands. A recent statewide survey of PFLs conducted by the Penn State Human Dimensions Unit (Metcalf 2006)[5], along with a collaborative effort with Juniata College to explore forestland ownership patterns in Huntingdon and Berks Counties using GIS parcel ownership data (Metcalf et al. *pending*), found that:

- Forestland ownership patterns and management of private forests differ geographically across Pennsylvania. For example, 58 percent of the forestland in Berks County is owned by PFLs with 20-acre or smaller properties, while 59 percent of the forestland in Huntingdon County is owned by PFLs with 100-acre or larger properties.

- Larger properties often afford more economical harvesting as economies of scale reduce costs. These properties also tend to be owned by PFLs more willing to conduct harvests and allow access.

As more fully discussed in Chapter 4a, as forestlands trend toward further subdivision, there are likely to be more PFLs and less overall access. This trend is stronger in more developed areas of the state. In more rural counties, 57 percent of PFLs owning 20 acres of forestland or less are either "opposed" or "very opposed" to harvesting, while in more developed counties that number increases to 72 percent. [Metcalf et al, pending]

Scaling this up to the statewide level, the U.S. Forest Service's Forest Inventory and Analysis program's National Woodland Owner Survey, whose goal is to better understand family forest owners and their motivations and intentions, reports that "amenity values" are more important to these owners than financial objectives (Butler et al. 2005, see figure below). Timber production is last among the top ten reasons for owning forestland. Twenty-three percent of owners, who cumulatively own 50 percent of the family forest land, have commercially harvested trees one or more times since purchasing their land (FIA 2007).



Family forest owners' motivations and intentions.

Given these trends, many areas of the state will require new, innovative approaches if access is to be maintained. Harvesting operations for biomass must consider approaches appropriate for small properties and respect PFL preferences (i.e., most do not want to see clearcuts or unsustainable harvesting). PFLs, local policymakers, and the timber industry must work together to address access in the context of an increasingly parcelized forest.

Additional information on biomass can be found in Chapter 4F-Energy Development.

Sub-Issue: Community Forest Management

Background

According to the most recent census, close to 9.5 million people, or 77% of Pennsylvania's population, live in urban areas. Urban areas are defined as cities with a population of 50,000 or more and the area surrounding the city proper with a population of at least 500 people per square mile. The land classified as urban in Pennsylvania increased from 8.2% in 1990 to 9.5% in 2000, and is projected to more than double by 2050, to 22.1% of the total acreage. From a human equity standpoint, it clearly makes sense to invest in the nation's cities, and investing in natural resource management in urban areas makes sense from a conservation standpoint—making communities more livable is probably the best strategy for combating urban sprawl and the loss of working forests.

The PA Department of Conservation and Natural Resources' current action plan includes a goal to "build and maintain sustainable and attractive communities." The plan states that "DCNR should target its assistance to projects that invest in older communities, build green infrastructure and greenways connections, and encourage new outdoor recreation- and heritage-based business development." A Department priority policy is to "Make reinvestment in our older communities a priority by targeting DCNR programs and leveraging other state and federal agency program activity."

Research has documented tremendous ecological, economical, and sociological benefits to humanity from re-greening urban areas. Environmentally, trees improve air and water quality, reduce stormwater runoff, reduce the urban heat island effect and the formation of ozone, and reduce energy usage. Economically, trees increase property values, increase business in downtowns, reduce health and energy costs, reduce the need for engineered solutions to air and water pollution, and extend the life of paved surfaces shaded by trees. Socially, trees have been shown to have a calming effect on people: slowing traffic, reducing recovery time from illness, encouraging creative play in children, and even reducing crime.

Urbanized settings present numerous challenges to trees and their management. Concerns that are particularly challenging in urban settings are placing the right tree in the right space, to accommodate for stressors such as poor soil conditions, excess salting of roadways, and to account for future resources that will be needed to support proper pruning to ensure the safety of people and property, among others. Because of these special concerns, the management of trees in urban settings takes specific training and planning. To date, Pennsylvania's premier tree planting and educational program, TreeVitalize, has trained 7,000 citizens and municipal officials in proper planting and

maintenance of urban trees via the Tree Tenders™ program (registered trademark of the Pennsylvania Horticultural Society).

While the TreeVitalize Program is available to the majority of the population of the state, it excludes communities in more than half the state which are outside of the 14 "metropolitan areas." In those counties, grants are still available through the PA Urban and Community Forestry Council, also known as Pennsylvania Community Forests (PCF). PCF is an urban forestry advisory board to the Bureau of Forestry, as well as an independent non-profit organization.

For nearly twenty years, the PCF has awarded grants to communities for tree planting, tree improvement, inventories, and management plans. These grants have been funded almost entirely with federal funds from the US Forest Service, and administered by the Bureau of Forestry's Urban Forestry Coordinator, the PCF's Executive Secretary, and the PSU Extension Urban Foresters. Unfortunately, federal funding to the state has been significantly reduced in recent years, and there has been only limited publicity about the availability of grant funds in the state.

The vital partnership between the Bureau of Forestry and Penn State Extension Urban Foresters, is key to the success of the Urban and Community Forestry Program in the state. These staff members, which have received essential funding via pass-through federal grants for nearly 20 years, continue to offer high quality workshops on a variety of subjects relative to urban forestry throughout their entire regions. The DCNR emphasis on TreeVitalize since 2004 has consumed a considerable amount of their time.

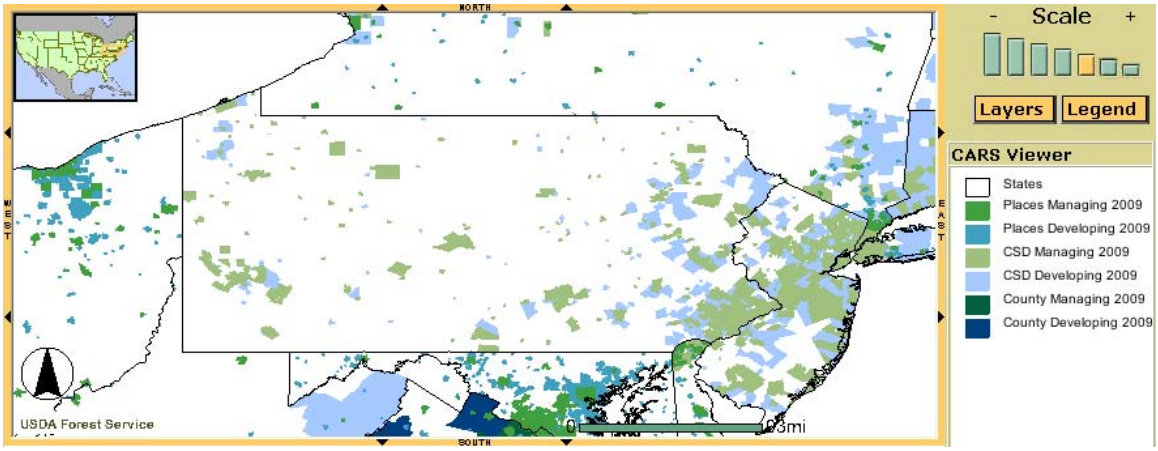
Current Status

Presently there are an estimated 136,600,000 trees in Pennsylvania's urban areas. They are estimated to remove 22,450 metric tons of pollutants each year, providing a benefit worth $178,000,000 in ecological services. Impervious surfaces now occupy an average of 17.9% of the urban land in the state, or nearly half a million acres. A single mature tree is estimated to take up 4,000 gallons of water per year-- recharging the water table, reducing pollutants entering streams, and cooling the air through both transpiration and shading. It has been estimated that for every 5% increase in canopy cover, stormwater drainage is reduced by 2%.

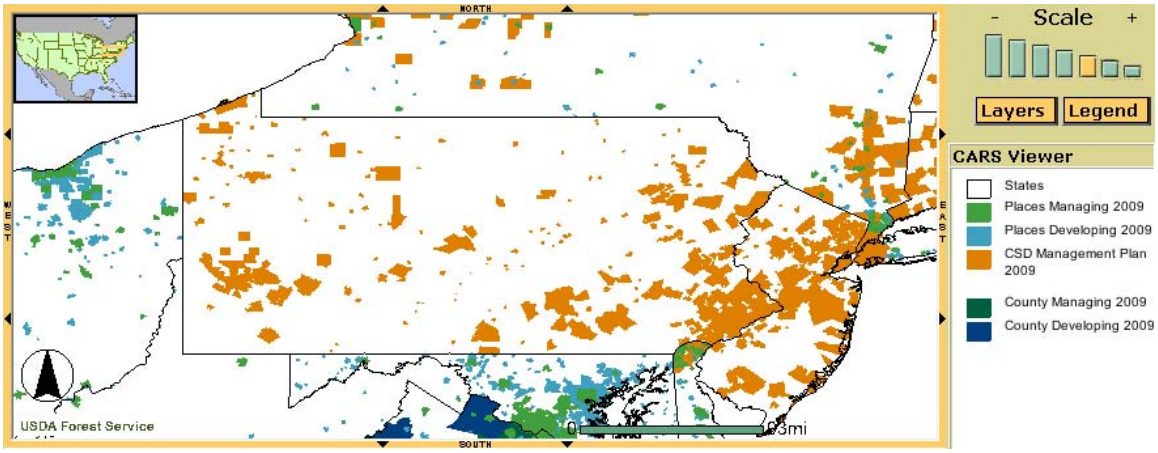
Pennsylvania includes over 2,500 municipalities and 12.5 million people (per the 2000 Census). The DCNR Bureau of Forestry, with the help of its partners, has made good progress toward establishing urban forest management programs in communities throughout the state. Current figures show 238 communities as "managing," accounting for 5.2 million people; and another 581 communities, representing 3.4 million people are considered to have "developing" urban forestry programs. "Managing communities" were found to have in place a community forestry management plan, in-house or contracted professional staff, an ordinance, and a tree board or advocacy organization. "Developing communities" meet one or more of the four criteria, but not all four. Combined, the state program has reached 800 communities, and 6.7 million people, no small feat. At the same time, though, more than 2/3 of the state's communities have

received no service and only a small minority of communities follow any sort of written management plan to ensure the sustainability of the urban forest.

The Bureau of Forestry employs approximately 25 full time equivalent service foresters. These individuals are available to assist municipalities as well as forest landowners, but for most, their time is primarily consumed with providing rural forestry assistance. The urban and community forestry program relies heavily on five urban foresters employed through Penn State University Extension Service, with funding from the US Forest Service provided through the Bureau of Forestry. The vast majority of urban forestry information, education, and technical assistance in the state is provided through Penn State. Yet, available funding fluctuates from year to year, depending on US Forest Service appropriations to the state, and the threat of layoffs is ever present.



Managing and Developing Communities in Pennsylvania.



Communities with some form of Forest Management Plan

Needs

The direct benefits from increasing tree canopy cover in urban areas are substantial, but the indirect benefits to forest conservation are also many. If we are to provide assistance to all the state's communities, the DCNR Bureau of Forestry and its partners need to dedicate more personnel resources to urban forestry. The Bureau of Forestry employs only 25 FTE service foresters to cover 67 counties, 750,000 private landowners, over 2,500 municipalities, and 12 million citizens. None of the service foresters focuses entirely on urban forestry, and many spend little to no time providing urban forestry assistance. If the Bureau of Forestry is to strengthen its role in urban forestry, it will be necessary to dedicate field staff to this program.

At present, Pennsylvania's program depends heavily on the knowledge and expertise of five urban foresters employed through Penn State with federal funds. As federal funding decreases each year, and a larger percentage goes toward the support of the Extension Urban Foresters, there is increasingly less money available for community grants to implement desired urban forestry practices. One way or another, it is critical to the long term success of the program to establish urban forestry staff positions within the Bureau of Forestry and to secure permanent funding for the Penn State Extension Urban Foresters.

While only a small percentage of the state's land area is classified as urbanized, the large majority of the population resides in urbanized areas or in smaller communities. Community trees are readily accessible to all Pennsylvania residents, while rural forest land is less so. It is likely that the large majority of urban resident and many rural residents are completely unaware that forestry assistance is available. Providing assistance with community shade tree programs is one efficient way to introduce the Bureau of Forestry to the majority of the population. Opportunities to assist in the development of conservation-wise local ordinances increases when a relationship is established with these local communities.

Sub-Issue: Water

Pennsylvania's abundant water resources have historically been, and will continue to be, key factors in the economic development, community health, recreational opportunities, and ecological wealth of the state. These resources include roughly 86,000 miles of streams; 4,000 lakes, reservoirs, and ponds; 80 trillion gallons of groundwater and over 400,000 acres of wetlands. According to the PA Department of Environmental Protection's State Water Plan (2009), Pennsylvanians withdraw about 9.7 billion gallons of water per day from both surface and ground water sources. Over 70 percent of water withdrawn from these sources is used in the production of electricity, 16 percent for public water supplies, and nine percent for industry. Mining, agriculture, and commercial uses currently comprise four percent of withdrawals.

Pennsylvania is a headwaters state and is connected through our rivers to the Great Lakes, Gulf of Mexico, and Delaware Estuary and Chesapeake Bay drainages. Land management choices we make impact not only Pennsylvania's 12 million citizens, but hundreds of downstream communities as well. Pennsylvania has committed to Chesapeake Bay enhancement goals for stream buffer planting, urban tree canopy expansion, and forest land conservation that will benefit millions of people downstream.

Background/Issues

In a recent (2009) report, "Forests, Water and People: Drinking water supply and forest lands in the Northeast and Midwest United States," the USDA Forest Service restated the importance of source water protection as the single most influential fact in protecting drinking water supplies, and identified healthy forests as the critical first defense for source water protection.

The Commonwealth of Pennsylvania began protecting water resources over 100 years ago, when the legislature passed an act authorizing the purchase of lands for forest reservations in the headwaters of each of the main rivers of the Commonwealth, including the Delaware, Susquehanna, and Ohio Rivers. This foresight, along with subsequent legislation, helped to acquire and establish the present state forest system, which today serves as a 2.1 million-acre source of clean water for Pennsylvania.

This protection, however, does not extend to the Commonwealth's private forest lands. Although today's forests cover about 58 percent, or 16.6 million acres, of the total land area statewide, Pennsylvania forest cover has declined by about 200,000 acres since 1978, and most of this forest loss is occurring on private lands in the rapidly developing southeast and south-central parts of the state.

Conversion of Private Forestland

Intergenerational transfer of ownership is likely to expedite land conversion and parcelization as current owners retire from farming. And, farmers may sever their woodland from their conserved agricultural lands to sell for development. The potential impact of this practice is by no means small. Estimates within the Chesapeake Bay watershed alone suggest that as much as 43 percent of family owned forests are associated with a farm (The Conservation Fund, 2006). Effective efforts to conserve farmland have increasingly forced development onto forested tracts.

As forest land development and impervious surface area increases, infiltration, recharge and buffering capabilities decrease. Further, the demands for clean water, and the costs of stormwater management and water treatment increase for communities within the developed landscapes. Most communities remain unaware of these connections (USDA, 2009).

Erosion and Sedimentation

Soil erosion from large-scale forest clearing for agriculture in the years following European settlement poured masses of soil into Pennsylvania's streams. At the same time, hundreds of mill dams were constructed across the state, trapping tons of sediments

behind these barriers. As centuries-old mill dams were removed, these deposits became a legacy of unstable sediment and contributed to bank erosion, pouring down tributaries into other downstream waterbodies, such as the Chesapeake Bay, the Ohio River, and the Delaware River, among others. These deposits produce scouring effects and reduce water clarity, smother shellfish and spawning beds, and eliminate substrate for macroinvertebrates. Pennsylvania has removed more dams than any other state in the country, but an estimated 3,000 un-breached, regulated dams remain in the Commonwealth (DEP, Personal Communication).

Other factors, such as unbuffered and unfenced streams with no barriers to control livestock or surface or stormwater runoff lead to destabilized banks, erosion, sedimentation, and nutrient contamination of streams in agricultural as well as developed lands. (Blankenship, 2007)

While floodplain remediation of affected streams is one way to address siltation, not everyone agrees that is the most desirable way to deal with the problem. Research conducted at the Stroud Water Research Center in Avondale, PA suggests that by fully restoring riparian forests buffers, even without changes to existing point and non-point pollution source runoff, Pennsylvania would significantly decrease the overall levels of stream pollution.

The Importance of Riparian Forests

Streamside forests provide woody debris and leaf litter that is the basis for the aquatic food chain. Stroud scientists have discovered that when combined with rainwater, this debris produces a mixture of dissolved organic matter or “watershed tea.” This “tea” nourishes riparian communities and provides the basis for communities that are uniquely adapted to the local “blend.” These "teas" are so distinctive that migrating salmon use them to navigate when spawning. (Stroud, retrieved 12/2009 http://www.stroudcenter.org/research/watershed.htm).

Riparian forests reduce flooding by improving infiltration of rainwater and slowing stormwater flow. Tree roots hold soil, trap debris and create deep holes that shelter fish and mammals alike. Trees shade and cool streams to the benefit of cool and cold water fisheries and provide habitat for aquatic communities ranging from bacteria and macroinvertebrates to crayfish and otters. Finally, forested streams are valued by human visitors for the myriad of recreational and aesthetic benefits they offer.

The TreeVitalize Program includes a riparian buffer component to encourage the replanting of streamside forests, particularly in urbanized areas. A key partner in this endeavor is the water company, Aqua America, which provides funding in the Philadelphia area; and Alcoa Foundation, which provides funding for other parts of the state. Other partners include the county Conservation Districts and the Alliance for the Chesapeake Bay, which work with local conservation groups to establish buffer plantings.

Forest cover increases on-site infiltration rates which in turn reduces stormwater runoff going into streams, reduces scouring, improves water quality and serves to filter airborne pollutants. Forests allow localized groundwater recharge and promote slowed release of rainwater into watersheds. Recharge and consistent stream flow helps to neutralize chronic water quality problems like air-depositional nitrogen, abandoned mine discharge, and the impact of combined sewerage overflow. Promoting pervious surfaces by maintaining and restoring vegetative cover is key to reducing and mitigating stormwater runoff that carries nutrients and pollutants.

Despite these benefits and the efforts Pennsylvania has made toward retaining and expanding streamside forests, significant threats remain. Introduced insects such as the hemlock woolly adelgid and the emerald ash borer could further decimate ash and hemlock riparian forest ecosystems. Land clearing for land development, agricultural field expansion, or aesthetic preference threatens to diminish both existing and newly established buffers.

The Impact of Stormwater Runoff

Even if riparian buffers are carefully protected during land development, natural infiltration and groundwater recharge is reduced when forest land is converted to impervious surfaces. Traditionally, the approach to stormwater management in urban areas has been to collect and channelize runoff, moving it as quickly as possible away from the developed area and into the nearest waterway. However, reduced flooding in one location often leads to increased flooding downstream, as well as a gradual depletion of the water table beneath the development. In addition, sediments and pollutants from roadways are washed directly into waterways, and result in significant degradation of surface water quality. Yet, the vast majority of rain events in the state are small events producing less than an inch of rainfall. Such small events would rarely result in flooding and yet contribute the majority of non-point source pollution from urban areas. If small rain events were handled differently, drastic reductions in non-point source pollution could result. As in forested situations, trees have the capacity to intercept and take up vast quantities of water, reducing stormwater runoff, filtering out pollutants, and recharging ground water. BMPs including increasing urban tree canopy cover, establishing rain gardens and reducing impervious cover can result in tremendous improvements to water quality.

The Chesapeake Bay

Although it is not contiguous to the Chesapeake Bay, Pennsylvania provides an estimated 50% of the Bay's fresh water supply through its Potomac and Susquehanna drainages and comprises over 35% of the total Chesapeake Bay watershed acreage.

The Chesapeake Bay Executive Council, including Pennsylvania's governor, has signed three directives that relate to forestry and are designed to improve water quality in the Bay. These directives include a riparian forest buffer goal, a forestland conservation goal for priority watersheds, and an urban tree canopy expansion goal. Pennsylvania committed to planting over 3,300 miles of riparian forest buffers by 2010. To date, Pennsylvania has recorded 3,524 miles of riparian forest buffers within Pennsylvania's

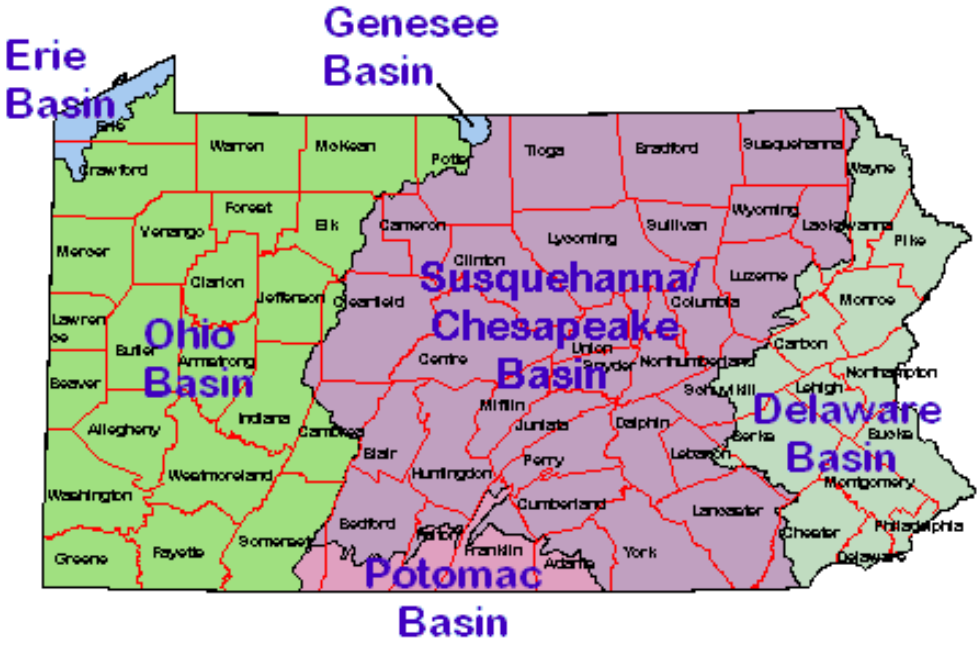
Bay drainage and is the only signatory state to achieve this goal prior to the 2010 deadline. In addition, the Commonwealth has agreed to conserve an additional 100,000 acres of forested land within priority Bay watersheds by 2020 and to work with 10 Bay communities to assess existing urban tree canopy cover and to assist communities in setting and attaining new canopy goals.

Although meeting these commitments could significantly contribute to the future health and water security of the Bay and its surrounding communities, watershed forestry programs often suffer from a lack of funding and the shortage of technical service providers. Financial support for restoration programs has historically been focused on agricultural, municipal sewerage, and stormwater best management practices and retrofits instead of on viable and economical forestry-related solutions.

On May 12, 2009, President Obama issued Executive Order 13508 on Chesapeake Bay Protection and Restoration, further strengthening the Federal focus on Bay restoration, and creating the opportunity for additional funding of Bay restoration projects within Pennsylvania.

Priority Watershed Landscapes

Using a number of different criteria, including forests in watersheds containing public water supplies and streams with special designations (Wilderness Trout, Scenic Rivers, etc.), the DCNR Bureau of Forestry has identified over four million acres of priority landscapes for water quality. Most of this land is located in forested areas in the central and northeast parts of the state and riparian corridors throughout the state.



Watershed Protection and Land Conservation

Water quality in any watershed is closely tied to the forests within its boundaries. Given that forests are the natural cover in most of Pennsylvania, watersheds and many of the native species they support are apt to be healthiest with forests to stabilize and replenish the soils, and to keep the water cool. Forest canopies temper hard rainfall. Forest litter protects the soil surface, and forest soils develop good porosity that allows rainwater to infiltrate and to recharge aquifers and streams. Forest buffers filter pollutants from storm runoff before they get to the water, and although forests in Pennsylvania have changed over the centuries as a result of altered land use, climate, fires, and storms, they continue to function to provide abundant and excellent quality water.

Because of these benefits, forests are a critical element of the "green infrastructure" that produces clean water without expensive treatment:

> *A study of 27 water suppliers conducted by the Trust for Public Land and the American Water Works Association in 2002 found that more forest cover in a watershed results in lower treatment costs. According to the study, for every10 percent increase in forest cover in the source area, treatment and chemical costs decreased approximately 20 percent, and approximately 50 to 55 percent of the variation in treatment costs can be explained by the percentage of forest cover in the source area.* (Protecting the Source: Land Conservation & the Future of America's Drinking Water, Trust for Public Land, 2004)

Conserving existing, intact and working forest land for watershed protection is one of the most cost-effective and sustainable ways to provide clean water to Pennsylvania's citizens and to ensure healthy ecosystems.

Historically, Federal programs such as Forest Legacy and CREP helped to fund forested land and buffer conservation, and state initiatives such as Growing Greener have significantly contributed to land conservation programs in Pennsylvania. For example, since December 1, 2007, 19,609 acres of Pennsylvania forestland have been conserved in the Chesapeake Bay alone. Tax incentive programs such as Clean and Green encourage forest landowners to retain working forests.

In 2003, the Land Trust Alliance conducted a survey of land trusts in Pennsylvania. Their survey indicated that at the time, 43 land trusts held 1,434 conservation easements across the state. These NGOs not only conserve forested land, but help to promote the value of land conservation. Still, more opportunities for land conservation are missed because of lack of funding for technical assistance and land acquisition.

Programs designed to market local wood and wood products also contribute to good stewardship land conservation within a watershed, like the Delaware Highlands Conservancy's local wood products guide to encourage consumers to "Shop Local, Save Land" and the Central Pennsylvania Conservancy's partnership with Penn State to develop a similar guide for wood products within the South Mountain region. These

programs are broadly based on the "Woodnet" Watershed Agricultural Council's (WAC) model for the New York City Watershed.

The WAC has strived to encourage land conservation and best management practices in agricultural and forest lands within the New York City watershed. DCNR is working with the US Forest Service and the Pennsylvania Association for Sustainable Agriculture (PASA) to promote sustainable woodlot management on member's farms. These efforts include a workshop and field days to teach farmers about diverse topics including silviculture, woodlot and timber sale management, chainsaw safety, nut culture, and forest farming. This landscape approach to sustainable land use is geared toward advancing the integration of "working farms, working forests, and working watersheds."

Needs

If we are to meet current water quality demands and commitments, and continue to provide abundant water to meet today's and future water demands, the DCNR Bureau of Forestry and its partners need to work strategically to promote and educate communities on the need for watershed forestry. We need to strengthen our connections with state and federal agricultural agencies and communities to both maximize funding for private forestry practices and to promote forestry education and programs. Where practical, we should look to New York's WAC model as an example of how to integrate forest and agricultural best management practices to provide for the municipal, industrial, and ecological water security of Pennsylvania.

In addition, the Department needs to strengthen its ties to federal and state agencies that regulate stormwater runoff and fund infrastructure improvement projects. Total maximum Daily Load (TMDL) limits are presently being established for waterways throughout the Chesapeake Bay Watershed, and practices to help meet these limits are being identified and quantified by the federal Environmental Protection Agency (EPA). Tree planting has been shown to be among the simplest and most cost-effective measures communities can undertake to reduce urban non-point source pollution. Yet, at present, regulatory agencies award far more credit for engineering solutions than for tree planting. It is critical for research verifying the importance of urban forestry to be effectively communicated to EPA at the national level and DEP at the state level.

The Pennsylvania Infrastructure Investment Authority (PennVest) provides funding to communities for infrastructure improvement projects. In 2009, the agency began including urban tree planting as a practice eligible for PennVest funding. However, what has not been satisfactorily accomplished is to quantify the benefits that can be expected to result from tree planting. Many variables contribute to the effectiveness of stormwater uptake by trees: tree species, age, growing space, soil type, quantity of rainfall, and surrounding impervious cover. Unlike engineered solutions, precise measurements of expected results are more difficult. Continued research is needed to provide data needed for this purpose, and increased communication between scientists and regulators is needed.

Sub-Issue: Monitoring Conditions

Forests are dynamic systems and are constantly changing in some fashion. Trees grow, die, expand or contract their range and presence in any of the number of situations that were covered in this chapter, from forestland in the "wilds" to the street trees in your neighborhood. It's extremely important for natural resource managers to have quality information on these dynamics in order to implement programs that aid in maintaining and sustaining the health and vitality of the forest resource. This section will provide an overview of those programs.

US Forest Service – Northern Research Station – Forest Inventory & Analysis

The following text provides an excellent overview of the US Forest Service's Forest Inventory & Analysis Program. It was borrowed from the Society of American Foresters (SAF) Position Statement on the FIA Program.

The National Forest Inventory and Analysis Program of the USDA Forest Service has been in continuous operation since 1930, based initially on authorities in the McSweeney-McNary Forest Research Act of 1928. The FIA Program conducts and continuously updates a comprehensive nationwide inventory and analysis of the status and trends of America's forest resources. Information collected and analyzed under this Program are the primary source of ecological data on the conservation and sustainable management of forests across all ownerships in the United States.

FIA conducts the nation's continuous forest census, collecting, analyzing, and reporting information on the status and trends of America's forests. The quality of this information will not be attained, as Congress intended, without full funding. Information provided by FIA on how much forest exists, where it exists, who owns it, and how it is changing (growth, mortality, removal, and successional trends) have many uses for SAF members, partners, policy makers, and research analysts. Data collected and analyzed by FIA on insects, diseases, and other types of forest damage help characterize current health and potential future risks. Such information serves as the foundation for landscape-level policy decisions and economic and ecological management decisions, and offers substantial utility to land managers in devising better forest management plans and developing an understanding of future ecosystem changes.

The latest report for Pennsylvania, *Pennsylvania Forest 2004*, is available online at http://www.nrs.fs.fed.us/pubs/2990 .

DCNR – Bureau of Forestry's Continuous Forest Inventory

The purpose of the inventory is to provide basic biological data on plants, shrubs, trees, tree growth and mortality, forest stand structure, volume, and change on state forestlands. Inventories are a continuous process to provide data for developing periodic updates to resource management plans, as well as for long range planning and monitoring.

All forest inventories prior to the current cycle were designed specifically as timber inventories, with monitoring the components of growth and yield as the primary objective. The release of the bureau's strategic plan in 1996 advanced a policy of employing ecosystem management concepts for managing state forestlands. As a result the inventory was redesigned to include monitoring of herbaceous plants, woody shrubs, mid-canopy trees and saplings, regeneration, seedlings, and coarse woody debris. The bureau's forest inventories were originally conducted on a 15-year cycle. The last of these 15-year inventories began in 1985. At that time personnel from each of the state forest districts collected all inventory field data. With the decision to shorten the resource management planning process to 5-years it became necessary for a more rapid monitoring cycle of forest ecosystems. The Bureau of Forestry's Inventory and Analysis Section now manages the design, data collection, and analysis of large permanent plot based inventories.

During the 2003-2006 inventory cycle 1633 plots were measured, 706 of which were newly established. Thirteen of the plots were harvested between Cycle 1 and Cycle 2 visits and have been dropped from this current cycle. An additional 60 plots were established in the Quehanna Wild Area in 2008 as part of that Wild Area survey. All 1693 plots will be remeasured during the current cycle (2009 -2014); however, the sampling design provides for replacement of plots that have been harvested between Cycle 2 and Cycle3. This is to assure that the inventory plots are representative of State Forests at the time of measurement. New plots established during this cycle will be located in forest stands of size class 4 (Overstory DBH between 4.5"- 6.0"). Twenty-five percent, or approximately 420 plots will be visited each year.

Urban Forest Monitoring

The health of our urban areas is also of prime importance. DCNR and its partners are working to assess tree canopy in the Commonwealth's metropolitan areas, but more monitoring of urban tree canopy/urban forest health is needed in order to evaluate what is occurring in our populated areas. This will help us target efforts to the places that need the most assistance as well as help us assess whether or not our efforts are making headway. Funding is a major issue in procuring and analyzing the appropriate imagery.

Marcellus Shale Monitoring

There is need for additional monitoring of increased gas development on state lands in the Marcellus shale formation will be needed. The DCNR is currently working on evaluating all aspects of this issue and deciding which elements are both essential and practical to monitor. An official monitoring plan will be produced out of this effort.

Monitoring of Conservation Easements
In order to ensure compliance, it is imperative that all conservation easements owned by the Department of Conservation and Natural Resources Bureau of Forestry be monitored at least once per year. The Bureau currently holds three conservation easements through the Forest Legacy Program and will hold additional conservation easements through the Highlands Conservation Act. It is not yet known what the Bureau's capacity is in terms of the number of conservation easements it can hold and still be able to complete its other existing obligations to the citizens of the Commonwealth.

Other Monitoring
Monitoring assures the continued certification of our state forests. The Bureau of Forestry also currently monitors a subset of Forest Stewardship plans yearly in order to determine approximate compliance with the program.

Challenges
One of the greatest challenges in the monitoring arena is that there is a great amount of important work to be done, but very little support, personnel resources, or financial resources exist to complete it.

Summary
The sustainable management of rural and urban forests, both public and private, is a significant topic of discussion, innovation, and action for the Commonwealth's natural resource managers and citizens alike. Managing the approximately 2.2 million acres of third-party certified state forest in the Commonwealth is a challenge in itself, where carefully balancing a wide variety of sometimes competing uses on the land is paramount to success. The Commonwealth's natural resource managers work to strike this balance - from working with industry to satisfy societal demand for wood products; to opening the land to the public for various types of outdoor recreation; to the challenges of leasing oil, gas, or other mineral extraction on publicly-owned property to help meet the financial and energy needs of the Commonwealth.

Whether the land is publicly or privately owned, Pennsylvania's natural resource managers are facing many challenges in the management of forested landscapes within the urban to rural continuum. Major challenges and opportunities include fragmented and parcelized ownership, unsustainable timber harvesting, third-party certification of forests and forest products, marketing of forest products, participation in carbon markets, an increased interest in biomass energy, the management of community forests, water concerns, and the continued monitoring of forest conditions. Because Pennsylvania is nearly 60% forested, these challenges and opportunities affect a significant land mass area of the state. The state must continue to use current successful strategies, expand on these strategies, and formulate additional creative ways to ensure the sustainability of its forests.

Chapter 4D

Issues, Threats, and Opportunities - Climate Change

Introduction

Global Climate Change is a process driven by irradiative heat retention or loss in Earth's atmosphere. The process is influenced by the physical and chemical properties of Earth's atmosphere leading to alteration of global temperature and precipitation patterns that influence the integrity and function of terrestrial, aquatic, and marine ecosystems. The current period of global warming represents a confluence of natural and anthropogenic factors leading to a significant period of climate warming. As a result variable warming of ocean water and reductions in global ice sheets are affecting weather patterns and subsequent ecosystem composition, integrity, and function.

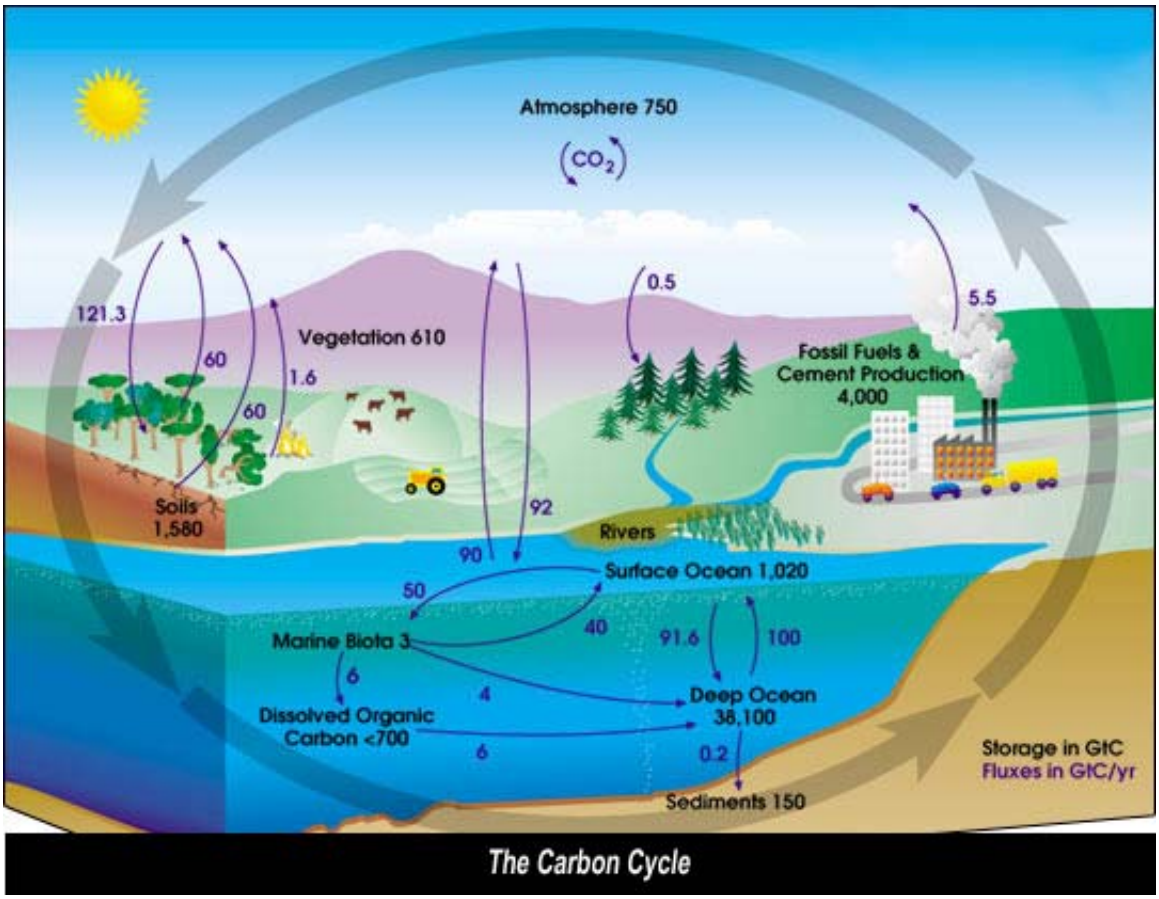
Over the past two decades there has been a groundswell of information and policy generated on the issue of climate change at the international, national, and state levels. The first action on climate change is recognized as the forming of the IPCC, or Intergovernmental Panel on Climate Change in 1988, with their first report issued in 1990 indicating that climate change was occurring. This was followed in 1992 by the Rio Earth Summit which produced the first international treaty on the issue, the United Nations Framework Convention on Climate Change (UNFCCC). This established a non-binding goal for industrialized countries to reduce their greenhouse (GHG) gas emissions. Following the Rio summit was the first binding agreement in 1997, the Kyoto Protocol, which set mandatory GHG reductions for participating countries.

At the national level, voluntary GHG reporting was initiated by the Energy and Policy Act of 1992, in Section 1605 (b). This was established to introduce the concept to the US economy and allow major GHG emitters to begin to understand the accounting protocols for tracking their emissions and associated "carbon footprints." As the international community grappled with implementing new policies to meet their obligations under Kyoto, climate and carbon policy maintained a presence in the political undercurrent of the United States, with significant debate surrounding the equity of the Kyoto agreement on industrialized and developing nations, and their associated carbon emissions.

The first decade of the new millennium has brought climate change and GHG emissions to the forefront of politics and resulted in a mountain of new actions and policies, led by various states, and interestingly, some of the worlds largest energy companies. This has spawned a number of emissions protocols, for example, The Climate Action Registry, and emission offset protocols, such as the Chicago Climate Exchange, the Climate Action

Reserve, and the Voluntary Carbon Standard, to name just a few. California formally adopted a carbon policy with the successful passage of AB 32, the Global Warming Solutions Act of 2006, signed in to law by Governor Schwarzenegger in September of 2006. Many other states have developed or are currently developing state level climate action plans. Pennsylvania's Climate Action Plan, required by Act 70, was completed in 2009.

The Role of Carbon



Carbon is the most abundant element on the planet and consequently the carbon cycle is one of the largest and most vital processes occurring on earth. We human beings, as well as all other plants and animals are mainly constituted of carbon, generally 50% of our dry weight. The carbon cycle is regularly referred to as four major reservoirs of carbon linked together by corridors of exchange. These reservoirs include the atmosphere, the terrestrial biosphere, the oceans, and sediments. The balance of carbon on the planet, or the carbon budget, is the distribution of carbon within these reservoirs, in the form of sequestration (a carbon sink) and emissions (a carbon source). A sink is defined as something that stores carbon for some period of time. A source is defined as some activity that is actively moving carbon from one of the defined reservoirs to another.

Carbon's role in the context of climate change is expressed in the role of carbon dioxide (CO2) and a group of other gases which are referred to as greenhouse gases (GHG). These groups of gases has been identified as contributors to irradiative heating in the earth's atmosphere, and in the terms of the climate change discussion, are translated into carbon dioxide equivalents, or CO2e. For example, a unit of methane has 21 times the heat trapping ability as CO2, so it would be expressed as 21 units of CO2e. There is widespread scientific acknowledgement that there has been a significant increase in the amount of GHG in the atmosphere over the last 150-200 years.

Projected Impacts on Pennsylvania Forests

Due to the pace and breadth of activity on the climate change subject, it is the current focus of a tremendous amount of research. There is a growing body of information on what the potential impacts on Pennsylvania forests may be over the next century. This section will borrow from the following reports to establish this context.

- Draft Report on Chesapeake Bay watershed Climate Change Impacts: This report was drafted by the Department of Commerce and Department of Interior in response to Executive Order 13508 (EO) to make recommendations to the Federal Leadership Committee for an adaptation strategy in response to climate change impacts in the Chesapeake Bay watershed. The report recommends a range of technical, management and adaptation strategies across multiple timelines
- Pennsylvania Climate Change Impact Assessment: This report was generated as a requirement to fulfill the obligations of PA SB 266, Act 70 – the Pennsylvania Climate Change Act of 2008. The major points of Chapter VII – Forests and Wildlife form the basis of this chapter of the Assessment.

Pennsylvania is named for its forests. Forests once covered more than 90 percent of the land area of the state, and even today they are the dominant land use, covering some 58 percent of the state's land (McWilliams et al. 2007). The decline in overall forest area occurred in the 19th and early 20th centuries when the state's forests were cleared for agriculture and almost completely logged over; the area of forest land in the state has been stable or increasing for the past century. While less than one percent of the state's original forests remain untouched today, the state once again has extensive, relatively mature forest cover the northern part of the state is heavily forested and dominated by northern hardwoods – maple, beech and birch forests. Land cover in the southern part of the state is more mixed, with forestland interspersed with agricultural and urban land. Mixed oak forests dominate in southern Pennsylvania.

Forests are important to the economy of the state and the local economies of many rural communities. The state's forest products industry generates revenues of more than $5.5 billion annually and employs about 90,000 people, more than 10% of the people employed in manufacturing in the state (PFPA 2004). Forests are also important for recreation such as hiking, camping, hunting, fishing, canoeing, horseback riding, bird-watching, and the like. And, the state's forests provide a number of important ecosystem

services, including refuges for a host of wildlife species, provision of clean water, and carbon sequestration and storage.

Multiple forest resources are threatened by climate change. A growing body of evidence indicates that global climate change is already negatively affecting ecosystems in general (Parmesan and Yohe 2003, Parmesan and Galbraith 2004) and forest ecosystems in particular. For example, van Mantgem et al. (2009) document higher rates of mortality in northwestern forests, which they attribute to climate change. Soja et al. (2006) document species migrations, increased mortality of some species, and increased insect and disease outbreaks in the boreal forests of Siberia, Canada and Alaska, changes consistent with the predictions of GCMs. Also, increased fire frequency and severity (Westerling et al. 2006) and dramatically increased mortality rates from bark beetles (Breshears et al. 2005, Logan and Powell In press) in the forests of the western US have been linked to climate change. Changes in eastern US forests are less well documented, although Woodall et al. (2009) identify much higher seedling densities for northeastern tree species in the northern parts of their ranges than in the southern parts of their ranges, suggesting that tree migration in response to climate change is occurring through better regeneration success at the northern end of the species' ranges. Furthermore, GCMs, coupled with species suitability models (e.g., Iverson et al. 2008a, 2008b), indicate that the suitable habitats for eastern North American tree species will shift northward in the coming decades.

These changes will occur within a context of forest ecosystems that have already been subjected to major anthropogenic disturbances within the past two centuries and that continue to suffer from significant additional stressors today. The harvesting and fires of the late 1800s and early 1900s dramatically changed the species composition of Pennsylvania's forests, greatly reducing the extent of once common species such as white pine, hemlock and beech and increasing the dominance of oaks (Whitney 1990, Brose et al. 2001). Chestnut blight and other exotic diseases including Dutch elm disease and beech bark disease, and, exotic insects, such as the hemlock wooly adelgid, the gypsy moth, and the emerald ash borer have been and/or are currently stressors to the forest (Liebhold et al. 1995; Gottschalk 2007). Native plants compete with nonnative plants, including trees such as ailanthus and Norway maple, shrubs such as bush honeysuckle, multiflora rose, Japanese knotweed, and privet, and herbaceous plants such as Japanese stiltgrass and mile-a-minute weed (Webster et al. 2006). Finally, atmospheric deposition has substantially altered the soil chemistry of at least some of the state's forest soils, and some species, particularly sugar maple, have been shown to be very sensitive to these changes (Horsley et al. 2000, 2008, Driscoll et al. 2001, Fenn et al. 2006).

The state's forests also face other significant stressors, including forest loss and fragmentation due to development (Riitters et al. 2002, Lister et al. 2005), parcelization into increasingly difficult-to-manage small ownership blocks(Alig 2006), unsustainable harvesting practices and regeneration problems (McWilliams et al. 2005, 2007). So, climate change can be viewed as just one more stressor within this increasingly challenging forest management context. Adapting to a changed climate will be

complicated by many of these problems, and a changing climate will likely exacerbate others.

Increased Susceptibility to Disturbances

Trees adapt to both the climate where they are found and the disturbance regime under which they have evolved. Disturbance regimes, in turn, depend on both the climate and the structure and composition of the forest ecosystem. Pennsylvania's trees are likely to experience a significantly changed climate within their lifetimes with little ability to adapt to those changes. As a result, Pennsylvania's forests will become increasingly stressed as the climate changes. This stress will likely create conditions that may foster increased rates of disturbance, including higher mortality rates, increased fuel loads, and greater susceptibility to insect and disease attacks (Dale et al. 2001). Unlike trees, disturbance regimes can change relatively rapidly in response to changing climatic conditions. Increased availability of stressed trees, combined with warmer and possibly wetter conditions will likely favor higher rates of insect and disease outbreaks. Increased fire risk and larger fires have already been attributed to climate change in the western US (Westerling et al. 2006), but not in the more humid eastern US. Warmer weather, prolonged periods of drought and increased quantities of dead wood could, however, create conditions where forest fires could be more common in Pennsylvania. Increased total rainfall and potential CO_2 fertilization effects could create higher fuel loads, which during periods of drought could result in greater susceptibility to fire (Dale et al. 2001).

Some insects and diseases will likely benefit from climate change, just as some tree species will benefit. Insect populations have the potential to respond dramatically to climate change. Because they are cold-blooded, they are particularly sensitive to changing temperatures. Additionally, they typically are mobile, they have the capacity to rapidly increase their populations, and, because of their relatively short generations, they have the potential to adapt genetically to changing environments (Logan et al. 2003). Bark beetles in the western US have benefited from longer growing seasons, resulting in outbreaks that have killed millions of acres of spruce and pine. In the east, it is believed that the spread of the hemlock wooly adelgid has been slowed by cold winter temperatures, so climate change may allow the insect to spread farther and more rapidly than what has been observed to date (Paradis et al. 2008). Furthermore, climate change will promote expansion of invasive species into more remote high-elevation areas which currently tend to have fewer problems with invasives (Pauchard et al. 2009).

Invasive plant species may also benefit from climate change. Ziska (2009) studied the growth response of six invasive weed species, including kudzu and Canada thistle, to increased atmospheric CO_2 concentrations and found that their growth rates increased more than three times faster than similar CO_2-induced growth increases for other plants. Smith et al. (2000) also observed that elevated CO_2 levels benefited an invasive, exotic grass more than native plants in a western North American ecosystem.

Changing Productivity

Climate change will most likely lead to an overall increase in the net primary productivity (NPP), and hence growth rates, of the Earth's ecosystems. In fact, Nemani et al. (2003) estimated that global NPP increased by 6% just between 1982 and 1999. This was due to a host of factors related to climate change, including longer growing seasons, increased temperatures, increased rainfall, reduced cloud cover, and CO_2 fertilization. Experimental studies of these effects include free-air CO_2 enrichment (FACE) studies, open-top chamber (OTC) and growth chamber (GC) studies (Luo et al. 2006). Luo et al. (2006) combined the results of over 104 published papers and concluded that average carbon pools in shoots, roots and whole plants increased by 22.4 %, 31.6% and 23%, respectively, under higher CO_2 concentrations. Woodward (2002) also provides a useful review of CO_2 fertilization studies. At least three FACE studies (Calfapietra et al. 2003, Herrick and Thomas 2001, DeLucia et al. 1999), which most closely replicate likely natural conditions of trees growing in natural conditions, found increased growth rates of trees under elevated atmospheric CO_2 concentrations. These increases are often short-lived, however, as in some cases the CO_2-enhanced increase in plant growth rates becomes limited by other factors, such as soil fertility (Körner 1993, Oren et al. 2001). At one relatively infertile site reported by Oren et al. (2001) increased CO_2 levels had no effect on growth. However, when nitrogen fertilizer was added to the infertile site in combination with elevated atmospheric CO_2 concentrations substantial improvements in growth rates were observed.

Increased net growth rates may not be realized for some time, since trees that are no longer well adapted to the climate where they are growing will likely become stressed and suffer higher mortality rates. Furthermore, changes in species composition in response to climate change can also result in both increases and decreases in growth rates (Chiang et al. 2008).

Impacts on biodiversity and ecosystems

There is little doubt that climate change is already affecting ecosystems. Parmesan and Yohe (2003) considered changes in the ranges and timing of key springtime events for over 1,700 species and found average range shifts of 6.1 km per decade toward the poles and that spring events are occurring on average 2.3 days per decade earlier. Similarly, Root et al. (2003) considered 143 studies of biological changes driven by climate change and found that more than 80% of the species studied exhibited shifts in their ranges, timings of events, morphologies, behaviors and genetic frequencies were consistent with those predicted by climate change models.

Nevertheless, there are a lot of uncertainties about how ecosystems will be affected by climate change in the future. Several studies (Schwartz 1992, Berry et al. 2002, Hannah et al. 2002, Midgley et al. 2002, Peterson et al. 2002, Thomas et al. 2004) suggest that climate change could drive a large number of species to extinction. This depends on several factors: 1) how broad the current range of the species is, 2) how narrow the habitat requirements of the species are, 3) the mobility of the species, and 4) the adaptability of other species that the species is dependant on (Peters and Darling 1985, Schwartz et al. 2006). Plants tend to be less mobile than animals, and plants with the

most narrow habitat requirements are the most likely to suffer high extinction rates as a result of climate change. Birds and insects tend to be the most mobile, but if their habitats are not wide-ranging or do not migrate with the changing climate they could also become extinct. Many popular wildlife species such as deer are mobile generalists and are relatively unlikely to go extinct. Because there are so many interacting factors, it is difficult to make predictions for individual species. Models are an important tool not only for predicting the general risk of extinctions for an area but for quantifying the uncertainty. For example, Malcolm et al. (2006) generate predictions of extinction rates for 25 biodiversity hotspots under several GCMs and under two global vegetation models, with different assumptions about migration rates, biome specificity, species' habitat specificity, and species-area relationships. Their projections range from no extinctions to losses of up to 75% of the species in the biome.

Given all of the above, it is very possible that climate impacts on Pennsylvania's forest ecosystems will be substantial in the 21st century due to likely significant shifts in the species composition and character of Pennsylvania's forests: Pennsylvania's eight most common species are projected to decline in the coming century, and disturbance rates from insects and diseases and from fire are likely to increase. These shifts are likely to be accompanied by a shift from natural to cultivated forests as many of the species that are currently present in the state find the habitat here increasingly less suitable and natural regeneration becomes increasingly more difficult and less desirable. A shift from natural to planted forest communities will likely lead to simplified forest plant and animal communities (Carnum et al. 2006). Wildlife populations will need to migrate across an increasingly fragmented landscape in order to find more suitable habitat. Furthermore, bioreserves created to protect particular communities of species will no longer support those communities (Peters and Darling 1985).

Economic Impacts

The economic implications of climate change could be either positive or negative. In looking at the economic impacts of climate change on the forest products sector, it is useful to consider the perspectives of three different groups of people: 1) forest landowners, 2) forest products manufacturers (including loggers), and 3) consumers of forest products. Each of these groups will be affected differently by climate change. The main potential impacts from climate change that will affect Pennsylvania's forest products sector are 1)increased mortality due to stresses on trees that are not well adapted to changed climatic conditions and increased disturbance rates, 2) increased forest productivity due primarily to warmer temperatures, longer growing seasons, increased rainfall, and CO_2 fertilization effects, resulting in 3) a need for substantial investments in forest protection and regeneration, and 4) increased demand for forest biomass for energy production.

While the US and Canada remain the largest producers of pulp and paper in the world, for the past 20+ years, the global paper market has seen a shift out of Canada, the US and Europe (primarily Scandinavia) to Asian and Latin American countries such as China, Brazil, Indonesia, Russia, Malaysia and Chile. With faster potential forest growth rates, rapidly expanding areas in plantations, fewer environmental restrictions, favorable

exchange rates, and low-cost labor, these countries production costs are considerably lower than US and European producers' costs. As a result, some 72 pulp and paper mills were closed in the US between 1997 and 2002 (AFPA 2002). Pennsylvania has experienced a similar trend, losing roughly half of its pulp and paper capacity over the past 20 years. These trends are not likely to be reversed in the coming decades.

Pennsylvania's niche in global forest products markets has been the production of high quality hardwood lumber and veneer. The state's current favorable position in these markets is the result of the high-quality cherry, maple and oak available. This same-age resource began to reach maturity in the 1980s and has continued to grow and mature for the past 20 years. The long-term sustainability of this resource is far from assured. It is threatened by a host of problems identified throughout in this report, including unsustainable harvest practices, regeneration problems, invasive pests and pathogens, and climate change. In the short term this resource is likely to continue to be harvested and utilized. Increased mortality rates due to either the primary effects of a changing climate or the secondary effects of increased disturbance rates may accelerate this harvest, but unless the mortality occurs in a sudden event such as a hurricane, a severe drought, or a major pest outbreak, forest products manufacturers will not likely be negatively affected and may even benefit from accelerated harvesting opportunities. Similarly, forest products consumers are not likely to be negatively affected; they may even benefit from lower forest product prices. Forest landowners, on the other hand, may see lower prices from selling salvaged dying or dead timber.

What happens in the long run depends on whether these stands are actively and appropriately regenerated after the current generation of forests is harvested. Without this regeneration, the state could end up with millions of acres of poorly stocked forests with low-value species that are not well adapted to the changing climate. Such forests will not produce high-value products or ecosystem services, and there will be very little incentive to keep these acres in forest. Even if landowners and forest managers are careful to regenerate currently desirable species on these lands, these species may turn out to be poorly adapted to future climatic conditions. If species and genotypes can be identified that will thrive under future climatic conditions, and if the investments are made to establish these species, then future growth rates on those sites may exceed current growth rates, benefiting forest landowners, the forest products industry, and forest products consumers. This would require a major shift in silvicultural thinking in the state, as it would, in many cases, entail a shift from natural regeneration to artificial regeneration, i.e., plantations. This is a significant challenge we must begin to address today if we want to have healthy forests and a healthy forest products industry in the state several decades from now.

Increased demand for woody biomass could potentially be helpful in achieving a more desirable future for the forests of Pennsylvania. Woody biomass markets are an opportunity for forest landowners, as they would provide a market for low value species and trees that are today mostly a liability for landowners, as they often cost more to harvest than what they are worth. Having a market for this so-called "low-use" wood makes a larger variety of silvicultural management options financially viable.

Unfortunately, the future outlook for one of Pennsylvania's culturally important non-timber forest products, maple syrup, looks bleak. Consumers of maple syrup will most likely continue to find the product from remaining producers in regions north of Pennsylvania.

Role of Forests in Mitigating Climate Change

Forests can play a role in mitigating the factors causing climate change. Forests – and their soils – represent one of the largest terrestrial pools of carbon, and they actively sequester carbon from the atmosphere. However, at current growth rates, the carbon sequestered by Pennsylvania's forests each year equals only one twentieth of the carbon emissions from burning fossil fuels in the state (PA DCNR 2008a). Even if growth rates could be doubled, which is unlikely, sequestration by forests would only offset one tenth of our emissions. It is possible to significantly increase the rate at which carbon is sequestered by the forests of Pennsylvania, but not without very large investments in forest management, and not without fundamentally changing their character, from the naturally-regenerated forests to planted forests.

On the other hand, forest clearing results in losses from the pool of carbon stored in the forests and their soils. Depending on what happens to the wood from cleared forest land and depending on the land use that replaces forest, much of the carbon stored in this pool will be emitted to the atmosphere. Thus, preventing the loss of forests can be an effective way to reduce carbon emissions. Globally, forest clearing has been the second most important source of carbon emissions to the atmosphere, after burning of fossil fuels (IPCC 2007). In the eastern US, and in Pennsylvania in particular, the pool of carbon in forests has increased over the past century. This trend may be reversed if forestland is increasingly cleared for development in light of declining growth rates and increasing harvest levels as the forest matures (McWilliams et al. 2007). The most effective policy to ensure the continued contribution of Pennsylvania's forests to mitigating climate change is for them to remain forests.

In general, it is possible to dramatically increase forest growth rates, and hence carbon sequestration rates, but this typically requires a shift from natural forests to intensively managed plantations, which would generally involve planting conifers. Pennsylvania's climate and soils are not well-suited to this type of forestry, which is why such plantations do not currently exist in the state. Rather, Pennsylvania's forests have been managed for the state's native oaks and northern hardwoods, which are relatively slow growing, but produce high-quality, high value wood products, albeit over long rotations. They are not particularly responsive to silvicultural treatments to increase their growth rates, and the practice of silviculture in the state has focused more on increasing the quality of wood grown through improvement thinnings and, more recently, on addressing the challenges of regenerating the forest with ecologically and economically desirable tree species. Where good silviculture has been practiced, the opportunities for increasing sequestration rates are relatively limited.

Because roughly 70 percent of Pennsylvania's forestland is privately owned (McWilliams et al. 2007), and because Pennsylvania's private forest landowners do not have a strong tradition of seeking professional forestry assistance when making management decisions, much of Pennsylvania's forestland has been poorly managed (as more fully discussed in chapter 4C) using practices such as diameter limit cutting that leaves typically slower growing, genetically inferior, and economically less valuable trees. Repeated application of this harvesting approach eventually leaves the landowner with few financially viable silvicultural options. Growth rates could be significantly increased in these forests, but often only by clearing the existing forest and starting again with planted trees. This management option is expensive and will not provide financial or significant carbon sequestration benefits for a decade or more. Nevertheless, because of the other ecological and social benefits provided by healthy forests, this could be a worthwhile investment from society's perspective.

Pennsylvania has tens of thousands of acres of what are termed "marginal lands" that are not currently forested or have trees but at very low stocking levels. These include marginal farmland, land that is idle because of lack of management by the current owner, and reclaimed mine lands. Trees could be planted in these areas, again at some expense, and they would eventually sequester significant amounts of carbon, but not for the first decade or so. There likely are more cost-effective ways to sequester carbon, with more immediate effects, than afforestation efforts on these lands. Urban and suburban environments offer another important opportunity for increased carbon sequestration by trees that will also save on energy consumption by reducing cooling costs, absorb other pollutants, increase property values, calm traffic, and improve the aesthetics of urban and suburban environments. Because of these substantial co-benefits, planting urban and suburban trees is likely a cost-effective approach to sequestering carbon, but, again, compared to the total carbon emissions of our society, the amount of carbon that urban trees can sequester is relatively small.

Mortality caused by native and non-native diseases and pests also significantly reduces the carbon sequestration rates of Pennsylvania's forests. As discussed above, climate change is likely to exacerbate these problems. Investments to mitigate these forest health problems can help to ensure that the state's forests continue to sequester carbon at their highest potential.

There may be market opportunities to use wood from Pennsylvania's forests to produce biofuels that can be used in the place of fossil fuels, reducing net carbon emissions as the carbon released by burning is offset by the carbon that is sequestered by the trees when the wood is grown. Wood can be burned directly, co-fired with coal, or converted to biofuels, such as cellulosic ethanol and other advanced biofuels. Woody biomass has important advantages over other sources of biomass as it does not directly compete with food production, although this non-compete presumes that significant areas of land are not shifted out of agriculture into woody biomass production. Woody biomass is available in large quantities in Pennsylvania (PAHDC 2008) and the infrastructure for harvesting it and transporting it already exists to some degree. Markets for woody biomass could have the additional benefit of improving forest management by providing

a way for landowners to economically dispose of low-value wood that cannot currently be harvested economically. This would make treatments such as improvement thinings more economically viable and reduce incentives to only harvest the high-value trees and leave low-value trees to dominate the future forest. While conversion of wood to biofuels such as ethanol is feasible, it is not currently commercially viable. Substantial investments in research on conversion technologies can lead to commercialization of the technology within the next few years. At least one commercial scale biofuels facility that will use wood is currently being built in Michigan, albeit with substantial federal and state subsidies (Clark 2007).

A significant challenge with increasing the use of wood biomass for energy is the cost and logistics of harvesting and transporting large amounts of wood to a wood-burning facility or a biofuels refinery. Because the harvesting and transportation costs are a significant part of the cost of producing energy from woody biomass, the most efficient opportunities may well be small-scale uses such as heating or combined heat and power generation for homes, schools, hospitals, or even communities. Another potential problem is that removing too much biomass during harvesting could negatively affect forest soils through compaction or exporting too many nutrients. These problems can be minimized by putting into place guidelines on how biomass harvests should be done (e.g., PA DCNR 2008b).Finally, forests can be used to mitigate climate change by providing building materials that provide a long-term storage pool of carbon and that require less carbon emissions to manufacture than alternative building materials such as steel, concrete, brick and aluminum (Lippke et al. 2004).

Adaptation Strategies

The impact of climate change on forests can be mitigated by efforts to reduce carbon and other greenhouse gas emissions to the atmosphere, but Pennsylvania's climate is likely to change in the coming decades and the state's forest ecosystems are going to be affected by these changes. Since the specific nature of these changes is uncertain, foresters will have to take an adaptive approach to addressing these impacts, by investing more in managing for healthy, resilient forests with a high degree of biodiversity. Key steps to fostering healthy forests in the state include:

- Aggressively combat invasive species to eliminate them where possible or at least reduce their spread.
- Continue and increase research to address the state's forest regeneration problem.
- Maintain deer populations at a level that is commensurate with the forest's ability to provide forage for a healthy deer population.
- Educate and encourage forest landowners to use harvest practices that maintain the genetic quality and diversity of the forest resource.
- Minimize forest loss and maintain or increase the connectivity of the forest land base.
- Reduce air pollution and atmospheric deposition of pollutants.

Recognize potential climate-change induced impacts when planning forest management activities. To accomplish this, forest managers and policy makers should:

- Support research to better predict climate change impacts on forests.
- Monitor the health and productivity of the forest resource to better detect the impacts of climate change.
- Grow more southern species in state nurseries and obtain seed and other reproductive material from more southern sources.
- When planting, favor seed sources from southern locations over seed from more northerly locations.
- Educate forest managers and policy makers on what is known about climate change and its likely impact on Pennsylvania's forests so they can better account for climate change impacts in management decisions.
- Support research to better understand how to adapt Pennsylvania's forests under a changing climate.

Summary

Forests once covered more than 90 percent of Pennsylvania's land area, and even today they are the state's dominant land use, covering some 58 percent of the state (McWilliams et al. 2007). Pennsylvania's forests contribute much to the state, from forest products and places for recreation to ecosystem services such as providing wildlife habitat and clean water. These ecosystems have been dramatically changed in the past 200 years by extensive clearcutting between 1880 and 1920, fires that burned as much as one million acres a year in the early part of the 20th century, heavy deer browsing for much of the past 70 years, fragmentation, pollution, and invasive non-native plants, insects and diseases. As a result, the state's forests today are very different from the forests the early European settlers found several centuries ago. And many of these problems continue to stress the state's forests. Climate change will likely cause many additional changes in Pennsylvania's forests. First, the state will become increasingly unsuitable for many of the trees species that are now present, especially those generally associated with northern hardwood ecosystems.

Northern species such as paper birch, quaking aspen, bigtooth aspen, and yellow birch are projected to be extirpated in the state under high emissions scenarios, and greatly reduced, if not eliminated, even under the low emissions scenarios (Iverson et al. 2008a). Other species, including American beech, black cherry, striped maple, eastern hemlock, red maple, sugar maple, eastern white pine, sweet birch, white ash, and American basswood, are projected to find increasingly less suitable habitat in the state and will likely decline in numbers. In general, the state is projected to become increasingly hospitable for more southern species such as oaks and hickories, although the state's two most common oaks, northern red oak and chestnut oak, are projected to decline under the high-emissions scenarios. The state will also become increasingly suitable for some species that are currently rare or not present in the state, such as loblolly and shortleaf pines, common persimmon and red mulberry, although it is not clear how these species will come to the state without human intervention.

The warming climate will cause susceptible species to become increasingly stressed, and their mortality rates will increase and their regeneration success will decline, resulting in declining populations in the state of those species. The increasing stress due to climate change will also make some species more susceptible to a host of other stressors, including atmospheric deposition and both native and non-native insects and diseases. Tree mortality could rise due to these secondary impacts, and it may be difficult to attribute these changes directly to a changing climate. Tree mortality could also increase if climate change increases the frequency of severe storms, and fires may become more common as temperatures rise. Some studies suggest that the longer growing season, warmer temperatures, possibly higher rainfall, and a phenomenon termed "CO_2 fertilization" will increase overall forest growth rates in the state. However, these effects will likely be offset by increased mortality rates, at least until the climate stabilizes and the mix of tree species in the state is once again in a more stable equilibrium with the state's climate.

The state's forest products industry will need to adjust to the changing resource, but humans and their activities tend to be more adaptable than ecosystems. The industry could benefit from planting faster-growing species and from salvaging dying stands of trees. On the other hand, if mortality is dramatic and sudden, as might occur with an extended drought or a major storm such as a hurricane, the industry might not be able to utilize all of the dead wood. Substantial investments in artificial regeneration may be needed if large areas of forests begin to die back due to climate-related stress.

Forests can contribute to the mitigation of climate change by sequestering carbon. While it may be difficult to substantially increase the growth rates of Pennsylvania hardwoods, additional carbon can be sequestered and stored in the state's forests by increasing stocking levels or reducing stocking reductions, especially those due to poor management practices such as diameter limit cutting. Marginal lands, such as abandoned mine lands, can be reforested, but, again, the best opportunities may lie in preventing forest loss, rather than increasing the number of forested acres. Since 70 percent of Pennsylvania's forests are privately owned, often in small, family-owned parcels, it will be necessary to engage private forest landowners if significant changes are to be made in how Pennsylvania's forests are managed. Forests can also be a significant source of biomass for either direct burning or conversion to biofuels. Biomass is the only currently viable alternative to fossil fuels for producing liquid fuels, and biomass production from forests does not directly compete with food production.

There is little doubt that Pennsylvania's forest ecosystems are going to be affected by climate change in the coming decades. However, there is much the state can do to mitigate and adapt to these changes. They include:

- Invest more in managing for healthy, resilient forests with a high degree of biodiversity.
- Monitor the health and productivity of the forest resource to identify and detect the effects of climate change.
- Support research to better predict the impacts of climate change on the state's forests

- Recognize potential climate-change induced impacts when planning forest management activities.

Most of these strategies will provide benefits regardless of how dramatically the state's climate changes.

References

Aber, J., R.P. Neison, S. Mcnulty, J.M. Lenihan, D. Bachelet, and R.J. Drapek. 2001. Forest processes and global environmental change: Predicting the effects of individual and multiple stressors. *Bioscience* 51(9):735–751.

Abrams, Marc D. 1998. The red maple paradox. *Bioscience* 48:355-364. Alig, Ralph J. 2006. Land-base changes in the United States: long-term assessments of forest land condition. In: *Proceedings of the Sixth Annual Forest Inventory and Analysis Symposium*; 2004 September 21-24; Denver, CO. Gen. Tech. Rep. WO-70. Washington, DC: U.S. Department of Agriculture Forest Service. 126 p.

Berry, P. M., T. R. Dawson, and R. A. Harrison. 2002. Modelling potential impacts of climate change on the bioclimatic envelope of species in Britain and Ireland. *Global Ecology and Biogeography* 11:453-462.

Bosworth, Dale, Richard Birdsey, Linda Joyce, and Constance Millar. 2008. Climate change and the nation's forests: challenges and opportunities. *Journal of Forestry* 106(June):214-221.

Breshears, D.D., N.S. Cobb., P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer. 2005. Regional vegetation die-off in response to global-change-type drought. *Proc. Natl. Acad. Sci.* 102(42):15144 –15148.

Brose, Patrick, Thomas Schuler, David Van Lear, and John Berst. 2001. Bringing fire back: The changing regimes of the Appalachian mixed-oak forests. *Journal of Forestry* 99(11): 30-35.

Campbell, John L, Lindsey E Rustad, Elizabeth W Boyer, Sheila F Christopher, Charles T Driscoll, Ivan J Fernandez, Peter M Groffman, Daniel Houle, Jana Kiekbusch, Alison H Magill, Myron J Mitchell, Scott V Ollinger. 2009. Consequences of climate change for biogeochemical cycling in forests of northeastern North America. *Canadian Journal of Forest Research* 39(2): 264-?.

Carnum, Jean-Michael, John Parrotta, Ekehard Brokerhoff, Michel Arbez, Herve Jactel, Antoine Kremer, David Lamb, Kevin O'Hara, and Bradley Walters. 2006. Planted forests and biodiversity. *Journal of Forestry* 104(2): 65-77.

Calfapietra, C., B. Gielen, A. N. J. Galema, M. Lukac, P. D. Angelis, M. C. Moscatelli, R. Ceulemans, and G. S. Mugnozza. 2003. Free-air CO2 enrichment (FACE) enhances biomass production in a short-rotation poplar plantation. Tree Physiology 23:805–814.

Chiang, Jyh-Min, L.R. Iverson, A. Prasad, and K.J. Brown. 2008. Effects of climate change and shifts in forest composition on forest net primary production. *Journal of Integrative Plant Biology* 50:1426–1439.

Clark, Giles. 2007. Mascoma to build first commercial wood to ethanol plant. *Biofuel Review* http://www.biofuelreview.com/content/view/1112/ Published Wednesday, 25 July 2007. Accessed April, 2009.

Dale, Virginia H., Linda A. Joyce, Steve McNulty, Ronald P. Neilson, Matthew P. Ayres, Michael D. Flannigan, Paul J. Hanson, Lloyd C. Irland, Ariel E. Lugo, Chris J. Peterson, Daniel Simberloff, Frederick J. Swanson, Brian J. Stocks, and B. Michael Wotton. 2001. Climate change and forest disturbances. *BioScience* 51:723-734.

Davis, M. B. 1969. Climatic changes in southern Connecticut recorded by pollen deposition at Rogers Lake. *Ecology* 50:409–422.

Delcourt, P.A. and Delcourt, H.A. 1981. Vegetation maps for eastern North America:40,000 yr BP to the present. In: Romans, R.C., ed. *Geobotany II*. New York: Plenum Press: 123-165.

DeLucia EH, et al. 1999. Net primary production of a forest ecosystem with experimental CO_2 enrichment. *Science* 284: 1177–1179.

Driscoll, C. T., G. B. Lawrence, A. J. Bulger, T. J. Butler, C. S. Cronan, G. Eagar, K. F. Lambert, G. E. Likens, J. L. Stoddard, and K. C. Weathers. 2001. Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects, and management strategies. *BioScience* 51:180–198.

Easterling, M. M., D. R. DeWalle, L. R. Iverson, A. M. Prasad, A. Z. Rose, A. R. Buda, and Y. Cao. 2000. The potential impacts of climate change and variability on forests and forestry in the Mid-Atlantic Region. *Climate Research* 14:195-206.

Fenn, M. E., T. G. Huntington, S. B. McLaughlin, C. Eager, A. Gomez, and R. B. Cook. 2006. Status of soil acidification in North America. *Journal of Forest Science* 52:3-13.

Gottschalk, Kurt W., ed. 2007. *Proceedings, 18th U.S. Department of Agriculture Interagency Research Forum on Gypsy Moth and Other Invasive Species 2007*; 2007 January 9-12; Annapolis, MD. Gen. Tech. Rep. NRS-P-28. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 84.

Hannah, L., G. F. Midgley, and D. Millar. 2002. Climate-change-induced conservation strategies. *Global Ecology and Biogeography* 11:485-495.

Hansen, A. J., V. Dale, C Flather, R. P. Neilson, P. Bartlein, L. Iverson, and D. Currie. 2001. Global change in forests: interactions among biodiversity, climate, and land use. *BioScience* 51(9):765-779.

Herrick, J. D., and R.B. Thomas. 2001 No photosynthetic down-regulation in sweetgum trees (Liquidambar styraciflua L.) after three years of CO2 enrichment at the Duke Forest FACE experiment. Plant, Cell and Environment, 24, 53–64.

Higgins, P. A. T., and J. Harte. 2006. Biophysical and biogeochemical responses to climate change depend on dispersal and migration. *Bioscience* 56:407–417.

Horsley, S. B., R. P. Long, S. W. Bailey, R. A. Hallett, and T. J. Hall. 2000. Factors associated with the decline disease of sugar maple on the Allegheny Plateau. *Canadian Journal of Forest Research* 30:1365–1378.

Horsley, Stephen B., Scott W .Bailey, Todd E. Ristau, Robert P. Long, Richard A. Hallett. 2008. Linking environmental gradients, species composition, and vegetation indicators of sugar maple health in the northeastern United States. *Canadian Journal of Forest Research* 38(7):1761-?.

Houston, David R., and James T. O'Brien 1983. *Beech Bark Disease.* U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station**.** Forest Insect and Disease Leaflet 75. Accessed online at http://www.na.fs.fed.us/spfo/pubs/fidls/beechbark/fidl-beech.htm, March, 2009.

International Panel on Climate Change (IPCC). 2007. *Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

Irland, Lloyd C., Darius Adams, Ralph Alig, Carter J. Betz, Chi-Chung Chen, Mark Hutchins, Bruce A. McCarl, Ken Skog, and Brent Sohngen. 2001. Assessing socioeconomic impacts of climate change on US forests, wood product markets, and forest recreation. *Bioscience* 51(9):753-764.

Iverson, L.R., Prasad, A.M., 1998. Predicting abundance of 80 tree species following climate change in the eastern United States. *Ecol. Monogr.* 68:465–485.

Iverson, L. R. and A. M. Prasad. 2001. Potential changes in tree species richness and forest community types following climate change. *Ecosystems* 4:186-199.

Iverson, L. R. and A. M. Prasad. 2002. Potential redistribution of tree species habitat under five climate change scenarios in the eastern US. *Forest Ecology and Management* 155(1-3):205-222.

Iverson, L. R. and A. Prasad. 2003. Using FIA data to assess current and potential future tree species importance values in the Eastern United States. Pages 171-172 in R. E. McRoberts, G. A. Reams, P. C. Van Deusen, and J. W. Moser, eds. *Proceedings of the Third Annual Forest Inventory and Analysis Symposium*. North Central Research Station, Forest Service U.S. Department of Agriculture, St. Paul, MN.

Iverson, L.R., Prasad, A.M., Hale, B.J., Sutherland, E.K., 1999a. *An atlas of current and potential future distributions of common trees of the eastern United States.* General Technical Report NE-265, Northeastern Research Station, USDA Forest Service, Radnor, PA.

Iverson, L.R., Prasad, A.M., Schwartz, M.W., 1999b. Modeling potential future individual tree-species distributions in the Eastern United States under a climate change scenario a case study with Pinus virginiana. *Ecol. Modell.* 115:77–93.

Iverson, L.R., Prasad, A.M., Liaw, A., 2004a. New machine learning tools for predictive vegetation mapping after climate change: Bagging and Random Forest perform better than regression tree analysis. In: Smithers, R. (Ed.), *Proceedings, UK-International Association for Landscape Ecology*, Cirencester, UK, pp. 317–320.

Iverson, Louis R.; Schwartz, M.W.; Prasad, Anantha M. 2004b. How fast and far might tree species migrate in the eastern United States due to climate change? *Global Ecology and Biogeography* 13: 209-219.

Iverson, Louis R; Prasad, Anantha M.; Schwartz, Mark W. 2005. Predicting potential changes in suitable habitat and distribution by 2100 for tree species of the eastern United States. *J. Agric. Meteorol.* 61(1): 29-37.

Iverson, L.R., Ollinger, S., Goodale, C., Rodenhouse, N., Lambert, D., Matthews, S., McFarland, K., Paradis, A., Elkington, J., Kraft, C., and Prasad, A. 2007. Forests. Chapter 4. Pages 47-61 in: Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions.* Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

Iverson, Louis, Anantha Prasad, and Stephen Matthews. 2008a. Modeling potential climate change impacts on the trees of the northeastern United States. *Mitig Adapt Strat Glob Change* 13:487-516.

Iverson, Louis, Anantha Prasad, Stephen Matthews, and Matthew Peters. 2008b. Estimating potential habitat for 134 eastern US tree species under six climate scenarios. *Forest Ecology and Management* 254: 390–406.

Jacobson, Michael G, and James C Finley. Various years. *Timber Market Report*. Pennsylvania State University School of Forest Resources (PSU SFR) Cooperative Extension. Available online at http://www.sfr.cas.psu.edu/TMR/TMR.htm. Accessed March 2009.

Johnson, P. S., S. R. Shifley, and R. Rogers. 2002. *The Ecology and Silviculture of Oaks.* CABI Publishing, New York, NY.

Liebhold, Andrew M., William L. MacDonald, Dale Bergdahl, and Victor C. Mastro. 1995. Invasion by exotic forest pests: A threat to forest ecosystems. *Forest Science Monograph* 30. 49 p.

Lister, Andrew, Rachel Riemann, Tonya Lister, and Will McWilliams. 2005. Northeastern regional forest fragmentation assessment: rationale, methods, and comparisons with other studies. In: *Proceedings of the Fifth Annual Forest Inventory and Analysis Symposium*; 2003 November 18-20; New Orleans, LA. Gen. Tech. Rep. WO-69.Washington, DC: U.S. Department of Agriculture Forest Service. 222p.

Loehle, Craig, and David LeBlanc. 1996. Model-based assessments of climate change effects on forests: a critical review. *Ecological Modelling* 90:1-31. Logan, Jesse A., James A. Powell. In press. Ecological consequences of climate change altered forest insect disturbance regimes. In F. H. Wagner. *Climate Change in Western North America: Evidence and Environmental Effects*. Available online at www.usu.edu/beetle/documents/Logan-Powell2005.pdf; last accessed Mar. 2009.

Logan, Jesse A. Logan, Jacques Regniere, James A. Powell. 2003. Assessing the impacts of global warming on forest pest dynamics. *Frontiers in Ecology and the Environment*1(3):130-137.

Malcolm, Jay, Canran Liu, Ronald Neilson, Lara Hansen and Lee Hannah. 2006. Global warming and extinction of endemic species from biodiversity hotspots. *Conservation Biology* 20(2): 538-548.

McCarl, Bruce A., Darius M. Adams, Ralph J. Alig, Diana Burton, and Chi-Chung Chen. 2000. Effects of global climate change on the US forest sector: response functions derived from a dynamic resource and market simulator. *Clim Res* 15:195-205.

McClure, Mark S., Scott M. Salom, and Kathleen S. Shields. 2001. *Hemlock Wooly Adelgid.* U.S. Department of Agriculture, Forest Service. FHTET-2001-03. 14 p. Available online http://www.forestpests.org/acrobat/fhtet-2001-03.pdf, accessed March 2009.

McCullough, Deborah G. 2009. Putting the pieces together: can we solve the emerald ash borer management puzzle? In: McManus, Katherine A; Gottschalk, Kurt W., eds. Proceedings. *19th U.S. Department Of Agriculture Interagency Research Forum on Invasive Species 2008*; 2008 January 8-11; Annapolis, MD. Gen. Tech. Rep. NRS-P-36. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 46-48.

McWilliams, William, Todd Bowersox, Patrick Brose, Daniel Devlin, James Finley, Kurt Gottschalk, Steve Horsley, Susan King, Brian LaPoint, Tonya Lister, Larry McCormick, Gary Miller, Charles Scott, Harry Steele, Kim Steiner, Susan Stout, James Westfall, and Robert White. 2005. Measuring tree seedlings and associated understory vegetation in Pennsylvania's forests. In: McRoberts, Ronald E.; Reams, Gregory A.; Van Deusen, Paul C.; McWilliams, William H.; Cieszewski, Chris J., eds. *Proceedings of the Fourth Annual Forest Inventory and Analysis Symposium*; Gen. Tech. Rep. NC-252. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 21-26.

McWilliams, William H.; Cassell, Seth P.; Alerich, Carol L.; Butler, Brett J.; Hoppus, Michael L.; Horsley, Stephen B.; Lister, Andrew J.; Lister, Tonya W.; Morin, Randall S.; Perry, Charles H.; Westfall, James A.; Wharton, Eric H;. Woodall, Christopher W. 2007. *Pennsylvania's Forest, 2004.* Resour. Bull. NRS-20. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 86 p.

Midgley, G. F., L. Hannah, D. Millar, M. C. Rutherford, and L. W. Powrie. 2002. Assessing the vulnerability of species richness to anthropogenic climate change in a biodiversity hotspot. *Global Ecology and Biogeography* 11:455-451.

Nemani, R.R., C.D. Keeling., H. Hashimoto, W.M. Jolly, S.C. Piper, C.J. Tucker, R.B. Myneni, and S.W. Running. 2003. Climate driven increases in global terrestrial net primary production from 1982 to 1999. *Science* 300:1560 –1563.

Oren, R., D. S. Ellsworth, K. H. Johnsen, N. Phillips, B. E. Ewers, C. Maler, K. V. R. Schäfer, H. McCarthy, G. Hendrey, S. G. McNulty, *et al.* 2001. Soil fertility limits carbon sequestration by forest ecosystems in a CO_2-enriched atmosphere. *Nature* 411:469-472.

Parmesan, Camille, and Hector Galbraith. 2004. *Observed Impacts of Global Climate Change in the US.* Pew Center on Global Climate Change, Arlington, VA. www.pewclimate.org. 55 p.

Paradis, Annie, Joe Elkinton, Katharine Hayhoe, and John Buonaccorsi. 2008. Role of winter temperature and climate change and future range expansion of the hemlock wooly adelgid (*Adelges tsugae*) in eastern North America. *Mitig Adapt Strat Glob Change* 13:541-554.

Parmesan, C., and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421:37– 42.

Pauchard, Aníbal; Kueffer, Christoph; Dietz, Hansjörg; Daehler, Curtis C.; Alexander, Jake; Edwards, Peter J.; Arévalo, José Ramón; Cavieres, Lohengrin A.; Guisan, Antoine; Haider, Sylvia; Jakobs, Gabi; McDougall, Keith; Millar, Constance I.; Naylor, Bridgett J.; Parks, Catherine G.; Rew, Lisa J.; Seipel, Tim 2009. Ain't no mountain high enough: plant invasions reaching new elevations. *Frontiers in Ecology and the Environment* 2009(7). http://www.treesearch.fs.fed.us/pubs/31764

Pennsylvania Forest Products Association (PFPA). 2004. *The Timber and Forest Products Industry: Vital to Pennsylvania's Economy*. Pennsylvania Forest Products Association http://www.hlma.org

Pennsylvania Department of Conservation and Natural Resources (PA DCNR). 2008a. *Report of the Carbon Management Advisory Committee.* Department of Conservation and Natural Resources, Harrisburg, PA. http://www.dcnr.state.pa.us/info/carbon/documents/final-report-050708.pdf

Pennsylvania Department of Conservation and Natural Resources (PA DCNR). 2008b. *Guidance on Harvesting Woody Biomass for Energy in Pennsylvania.* Pennsylvania Department of Conservation and Natural Resources, Harrisburg, PA. http://www.dcnr.state.pa.us/info/carbon/documents/final-report-050708.pdf

Pennsylvania Hardwood Development Council (PA HDC). 2008. Report of the Blue Ribbon Task Force on the Low Use Wood Resource. Pennsylvania Hardwood Development Council. Harrisburg, PA. http://www.agriculture.state.pa.us/agriculture/lib/agriculture/hardwoodsfiles/low_use_wood_energy_report_08.pdf

Peters, Robert L., and Joan D. S. Darling. 1985. The greenhouse effect and nature reserves. Bioscience 35(11):707-717.

Peterson, A. T., M. A. Ortega-Huerta, J. Bartley, V. Sanchez-Cordero, J. Soberon, R. H. Buddemeier, and D. R. B. Stockwell. 2002. Future projections for Mexican faunas under global climate change scenarios. *Nature* 416:626-629.

Prasad, A. M., L. R. Iverson, and A. Liaw. 2006. Newer classification and regression tree techniques: bagging and random forests for ecological prediction. *Ecosystems* 9:181-199.

Riitters, Kurt H., James D. Wickham, Robert V. O'Neill, K. Bruce Jones, Elizabeth R.Smith, John W. Coulston, Timothy G. Wade, and Jonathan H. Smith. 2002. Fragmentation of continental United States forests. *Ecosystems* 5:815-822.

Schmidtling, Ronald. 2007. Genetic variation in the southern pines: evolution, migration, and adaptation following the Pleistocene. In: Kabrick, John M.; Dey, Daniel C.; Gwaze, David, eds. *Shortleaf Pine Restoration and Ecology in the Ozarks: Proceedings of a Symposium*; 2006 November 7-9; Springfield, MO. Gen. Tech. Rep. NRS-P-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 28-32.

Schwartz, Mark W. 1992. Potential effects of global climate change on the biodiversity of plants. *Forestry Chronicle* 68: 462-471.

Schwartz, Mark W.; Iverson, Louis R.; Prasad, Anantha M.; Matthews, Stephen N.; O'Connor, Raymond J. 2006. Predicting extinctions as a result of climate change. *Ecology* 87(7): 1611-1615.

Shugart, Herman, Roger Sedjo, and Brent Sohngen. 2003. *Forests and Global Climate Change: Potential Impacts on US Forest Resources.* Pew Center on Global Climate Change. Arlington, VA. www.pewclimate.org. 52 p.

Smith, Stanley D., Travis E. Huxman, Stephen F. Zitzer, Therese N. Charlet, David C. Housman, James S. Coleman, Lynn K. Fenstermaker, Jeffrey R. Seemann and Robert S. Nowak. 2000. Elevated CO2 increases productivity and invasive species success in an arid ecosystem. *Nature* 408:79-82.

Sohngen, B. and R. Mendelsohn. 1998. Valuing the market impact of large scale ecological change: The effect of climate change on U.S. timber. *Am. Econ. Rev.* 88(4):689–710.

Soja, Amber J.**,** Nadezda M. Tchebakova, Nancy H.F. French, Michael D. Flannigan, Herman H. Shugart, Brian J. Stocks, Anatoly I. Sukhinin, E.I. Parfenova, F. Stuart Chapin III, Paul W. Stackhouse Jr. 2007. Climate-induced boreal forest change: Predictions versus current observations. *Global and Planetary Change* 56(3-4):274-296.

Thomas, Chris D., Alison Cameron, Rhys E. Green, Michel Bakkenes, Linda J. Beaumont, Yvonne C. Collingham, Barend F. N. Erasmus, Marinez Ferreira de Siqueira, Alan Grainger, Lee Hannah, Lesley Hughes, Brian Huntley, Albert S. van Jaarsveld, Guy F. Midgley, Lera Miles, Miguel A. Ortega-Huerta, A. Townsend Peterson, Oliver L. Phillips and Stephen E. Williams. 2004. Extinction risk from climate change. *Nature* 427:145-148.

Union of Concerned Scientists. 2008. *Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State*. Union of Concerned Scientists, Cambridge, MA. 62 pp.

Van Mantgem, Phillip J.; Stephenson, Nathan L.; Byrne, John C.; Daniels, Lori D.; Franklin, Jerry F.; Fulé, Peter Z.; Harmon, Mark E.; Larson, Andrew J.; Smith, Jeremy M.; Taylor, Alan H.; Veblen, Thomas T. 2009. Widespread increase of tree mortality rates in the western United States. *Science* 323(5913):521-524.

Webb, T., III; Bartlein, P.J.; Kutzbach, J.E. 1987. Climatic changes in eastern North America during the past 18,000 years; comparisons of pollen data with model results. *Geology of North America Vol. K-3, North America and Adjacent Oceans during the Last Deglaciation.* Geological Society of America: 447-462.

Webster, Christopher R., Michael A. Jenkins, and Shibu Jose. 2006. Woody invaders and the challenges they pose to forest ecosystems in the eastern United States. *Journal of Forestry* 104(7): 366-374.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increases western U.S. forest wildfire activity. *Sciencexpress* (July 6, 2006). Available online at www.sciencexpress.org ; last accessed November 2007.

Whitney, G. G. 1990. The history and status of the hemlock-hardwood forests of the Allegheny Plateau. *Journal of Ecology* 78:443-458.

Woodall, C.W., C.M. Oswalt, J.A. Westfall, C.H. Perry, M.D. Nelson, and A.O. Finley. 2009. An indicator of tree migration in forests of the eastern United States. *Forest Ecology and Management* 257: 1434–1444.

Woodward, F. I. 2002. Potential impacts of global elevated CO_2 concentrations on plants. *Curr. Opin. Plant Biol.* 5, 207–211.

Ziska, L.H. 2003. Evaluation of the growth response of six invasive species to past, present and future carbon dioxide concentrations. *J. Exp. Bot.* 54:395– 404.

Chapter 4E

Issues, Threats and Opportunities - Communicating Natural Resource Values

Introduction

Public education and outreach has always been a strong component of the Bureau of Forestry's mission. Our agency's enabling, legislation mandates the bureau to "develop forestry and knowledge of forestry" throughout the Commonwealth. Our expanded mission further states that we will accomplish this by "advising and assisting other government agencies, communities, landowners, forest industry and the general public in the wise stewardship and utilization of forest resources." Fulfilling this role is vital in advancing forest conservation throughout the Commonwealth today and well into the future.

Importance of Communications

Effective public communication strategies are especially vital to natural resource agencies, where conservation efforts are closely tied to promoting "stewardship" or care of the resource to individuals and communities. We want private forest landowners to follow best management practices on their property. We want people to be careful with fire. We encourage people to plant trees along their streets and the streams that run through their land. Even broader conservation strategies that go beyond individual action, however, require a citizenry that appreciates and understands the benefits that forest resources provide to the community. Conservation funding, forest land acquisitions, community forestry programs, forest friendly land use planning efforts all require a constituency that actively promotes and supports forest conservation.

The future success of many of our forest conservation efforts and programs, both on and off state forest land, in many ways hinges on our ability to engage the public, especially youth, with forest resources and inspire them to action. There is considerable concern and mounting evidence that people are increasingly disconnected and insulated from the natural world. This subject has been the source of books, newspaper articles and conferences. Experiences of resource professionals point to a public that does not necessarily draw direct linkages between certain values and benefits and the forest's role in providing them. Kayakers may appreciate and enjoy clean rivers and streams but may not have an awareness of the forest's role in keeping watersheds healthy. An

environmentally conscious citizen who decides to drive a fuel-efficient vehicle to reduce their carbon footprint may not value healthy forests and their role in mitigating climate change. While awareness alone doesn't necessarily lead to a public committed to the forest resource, it is an important step in leading people to act as citizens, landowners, and other stakeholders in supporting forest conservation efforts.

Engaging the Broad Citizenry in Forest Conservation

Many natural resource professionals express the concern that the general public does not have an awareness of the role the forests play in providing a multitude of values to society, from clean air, clean water to a variety of wood products. While this can easily be seen as a lack of education of the public, it also perhaps represents an inability of natural resource professionals to meaningfully connect with people and the values they hold and relate them to forest conservation and management. What follows are some of the primary challenges and opportunities in communicating natural resource values to a broad audience.

Challenges:

- Understanding people's values and how they relate to the forest. (This is key to framing forest conservation issues in a way that relates to their values.)
- Lack of coordinated and consistent messaging about forest resources from a statewide, regional and national perspective.
- Lack of social marketing tools (beyond Smokey Bear) to encourage people to take forest conservation measures, and not just landowners.
- Perception that foresters and forestry agencies are chiefly concerned with timber management and wood products.
- Funding/resources for market research, focus groups, and the development of communications tools.

Opportunities:

- Interpretive efforts on state forest land that seek to engage people with the forest resource while communicating conservation messages.
- Taking advantage of recreational interest on state forest land to promote state forest land, the value of forests and "stewardship" in general. (For

example, using a guided "bird watching" hike to discuss the value of habitat and the various forest management practices that can be used to maintain or enhance it.)

- Capitalizing on current events and the focus on being "green" and relating them to forests. Energy conservation, global climate change, carbon footprints, local food/resource use, for example.
- Using community forestry (planting and tending the urban forest) as a means of reaching a large and diverse audience with broader forest conservation and stewardship messages.
- Utilizing electronic social media, such as Facebook and Twitter, to reach out to new audiences.
- Bolstering information about forest resources on the web that relate to a broad audience.

Children and Nature

Attitudes are more difficult to modify as people age, so it is critical that youth have meaningful experiences in the outdoors. Besides the potential loss of future outdoor stewards, child advocates also express concern for the physical and mental well-being of children who haven't had adequate opportunities to play in nature. The time is right to focus outdoor recreation planning for kids and families. Through the work of Richard Louv (Last child in the Woods; Saving Our Children from Nature Deficit Disorder, 2005), USDA Forest Service's "More Kids in the Woods" and other programs, a movement to reconnect children to nature is in full swing.

Challenges:

- Survey work shows people consistently cite lack of time as their major obstacle to outdoor recreation.
- A general fear of nature is shown to be holding back many would-be participants in outdoor recreation.
- Concern about crime impedes outdoor play in more urban areas.
- Diminishing outdoor recreational opportunities are cited as another source of the widening disconnect.

Opportunities:

- Use of Conservation Education activities as a tool to help engage youth with nature and the outdoors.
- Promote the wide range of outdoor recreational opportunities available to families on state forest lands.

Enhancing Federal Programs through Communications and Outreach

Each major federal program area has distinct communications needs and challenges. In the absence of a regulatory structure or significant cost-sharing funds, communications and outreach efforts become important tools to promote and encourage conservation practices. What follows encapsulates some of the primary communications issues, challenges and opportunities that relate to specific programs.

Private Forestland (Stewardship)

Challenges:

- The need to communicate forest conditions on a regional basis to help answer the question "Why are private forest lands important and why should I be concerned?"
- The ability to understand the needs of and reach audiences in the land-use context to further forest conservation in land use planning. (County commissioners, land-use planners, township officials, private forest landowners, real estate agents, etc.)
- Increasing number of landowners coupled with shrinking staff and resources makes it necessary to reach larger audiences in more effective ways.
- The need to communicate to forest landowners in ways that relates to their values and reasons for owning their land.

Opportunities:

- Providing high quality technical assistance to forest landowners through the web.

- Reaching more forest landowners more effectively with technical assistance and stewardship messages through group communications (Woodland Owner Associations, conservation groups, workshops, etc.)
- Further developing peer-to-peer models, such as PA Forest Stewards, in providing technical assistance to landowners.
- Continued training for staff in land-use planning and communicating forest values in the land-use context.
- Provide educational opportunities to broad audiences regarding the value of the private forest resource and practices to conserve them (e.g., land-use planners, local government officials, private forest landowners, industry and agricultural groups, local watershed groups, general citizenry, etc.)

Urban & Community Forestry

Challenges:

- Need to communicate the full suite of values trees provide to help people see funding for urban trees as an investment.
- The need for comprehensive web resources for tree care and maintenance.

Opportunities:

- Continue to promote and develop and fund community tree care trainings, such as Tree Tenders.
- Development of effective marketing tools to promote tree planting and aftercare.

Conservation Education

Challenges:

- Lack of general forest conservation educational material with broad conservation messages for various age groups.
- Lack of overall coordinated approach to forest conservation education in Pennsylvania.

Opportunities:

- Development of a statewide forest conservation education plan to guide program development.
- Enhance partnerships among the Pennsylvania Department of Education and the Bureau of State Parks.
- Develop age-specific forest conservation messages.

Forest Health

Challenges:

- Establish/maintain credibility with the public and hunters regarding deer management.
- Reaching the public with prevention messages related to the spread of invasive species.
- Increasing threats from new introductions of invasive species can lead to an increased need for additional resources

Opportunities:

- Utilize educational and training opportunities to increase awareness of forest health issues, invasive species, and other damage causing agents.
- Continue to enhance public relations and outreach efforts relating to deer management.
- Increase coordination with the Pennsylvania Invasive Species Council regarding the "Don't Move Firewood" Campaign and outreach program.
- Provide forest health technical assistance to broader audiences.
- Continue to train and assist Gypsy Moth County Coordinators and other cooperators for participation in the gypsy moth suppression program.
- Continue to conduct Forest Health Updates for foresters and other professional staff, and at Woodland Owners Association meetings.

Fire

Challenges:

- One of the most challenging but critical issues eastern wildland fire managers face is that of public awareness. Consistent, accurate and timely messaging must be delivered to the public so that they are able to make informed decisions about their impact on the wildfire situation in Pennsylvania
- Increased activity in the prescribed fire arena increases our need to engage in smoke management planning and to keep the public informed of our objectives and activities.

Opportunities:

- Continue to develop the wildfire prevention messages through Smokey Bear and other prevention outlets.
- Develop additional methods of providing timely information and warnings to the public regarding fire weather and the potential for wildfire starts. Utilize NWS products and contacts, local community contacts, fire danger signs and Red Flag Watches/Warnings.
- Ensure communities at risk from wildfire are aware of their condition and assist them in finding ways to modify their situation

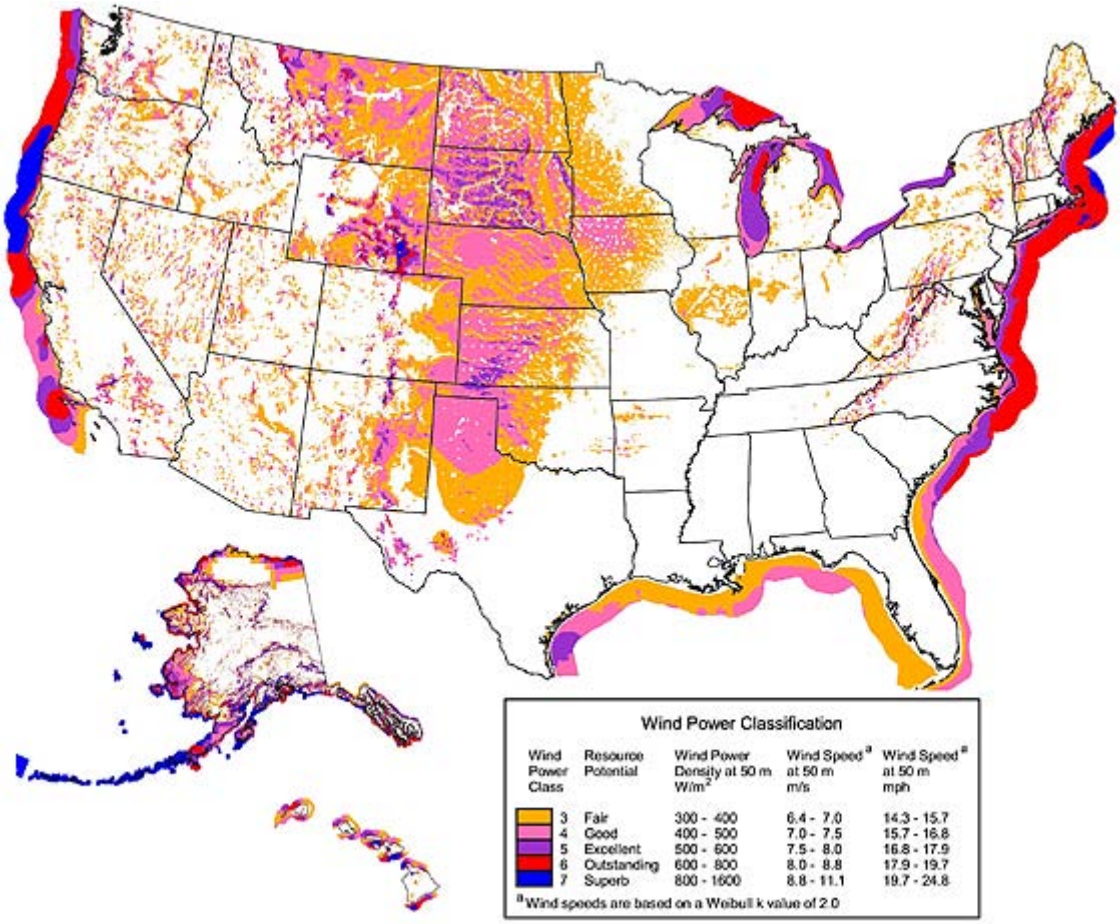
Chapter 4F

Issues, Threats and Opportunities - Energy Development

Introduction
There are four sections to the Energy Development chapter. Those sections are in order of appearance: 1) Wind Energy, 2) Biomass, 3) Rights-of-Way, and 4) Marcellus Shale.

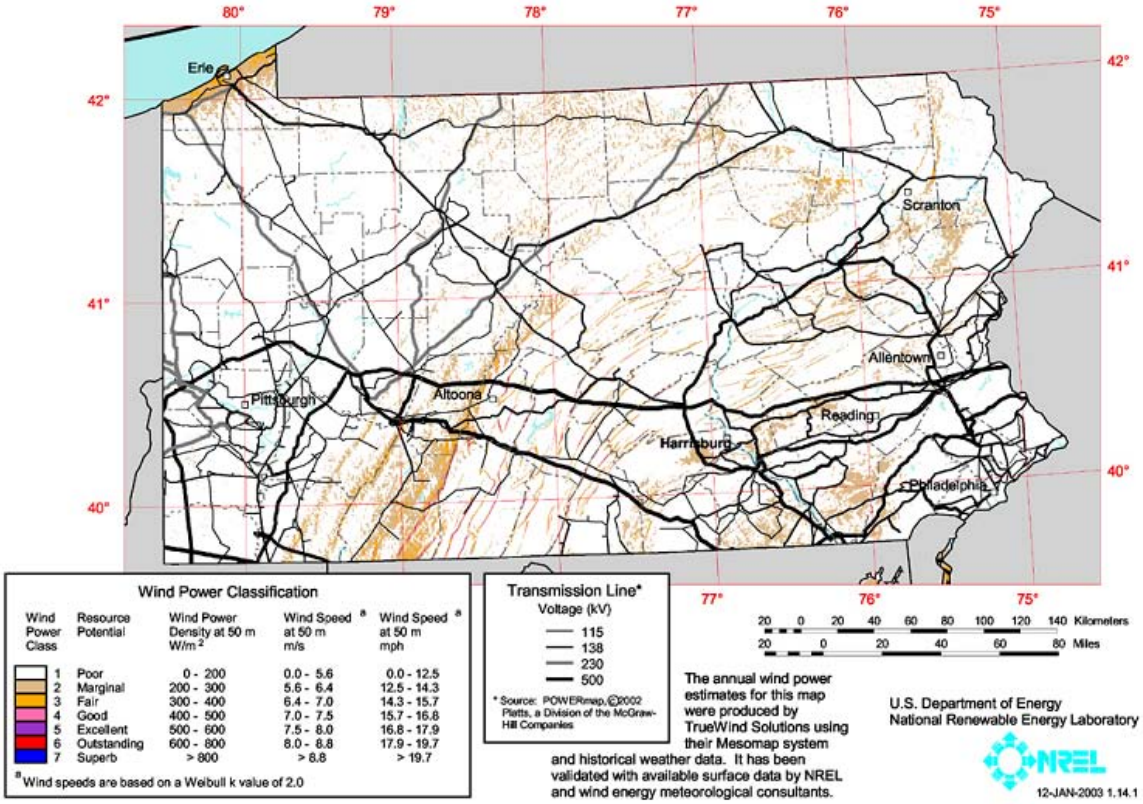
Wind Energy
Wind energy is a safe, clean, and renewable energy source, but also has limitations because it can disrupt recreational opportunities, impact wildlife (especially birds), and cause habitat fragmentation. Harvesting wind does not deplete any finite resources. Unlike energy produced from fossil or nuclear fuels, wind energy generation has no pollutants and constantly renews itself. Wind energy is produced from wind-driven turbines that convert kinetic energy in the wind into mechanical power. The wind turns the blades on turbines, which spins a shaft that connects to a generator making electricity. Using a 1.5 megawatt (million watt) wind turbine in a class 3 wind region is estimated to eliminate 12.5 tons of Nitrous Oxide, 36.8 tons of Sulfur Dioxide, and 4,845 tons of Carbon Dioxide annually. This would be equivalent to taking 970 cars off the road (11,400,000 driving miles/year) or planting 540,000 full grown trees (Conservation Consultants Inc. 2009).

Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the Earth's surface, and the rotation of the Earth. Wind flow patterns are modified by the Earth's terrain, bodies of water, and vegetation. The figure below is a map depicting wind potential across the nation. Pennsylvania has good-to-excellent wind resources that are consistent with utility-scale production. Pennsylvania is ranked 22nd in the nation in terms of potential wind power capacity, and ranked 15th in the nation for existing wind power capacity (American Wind Energy Assn 2009).



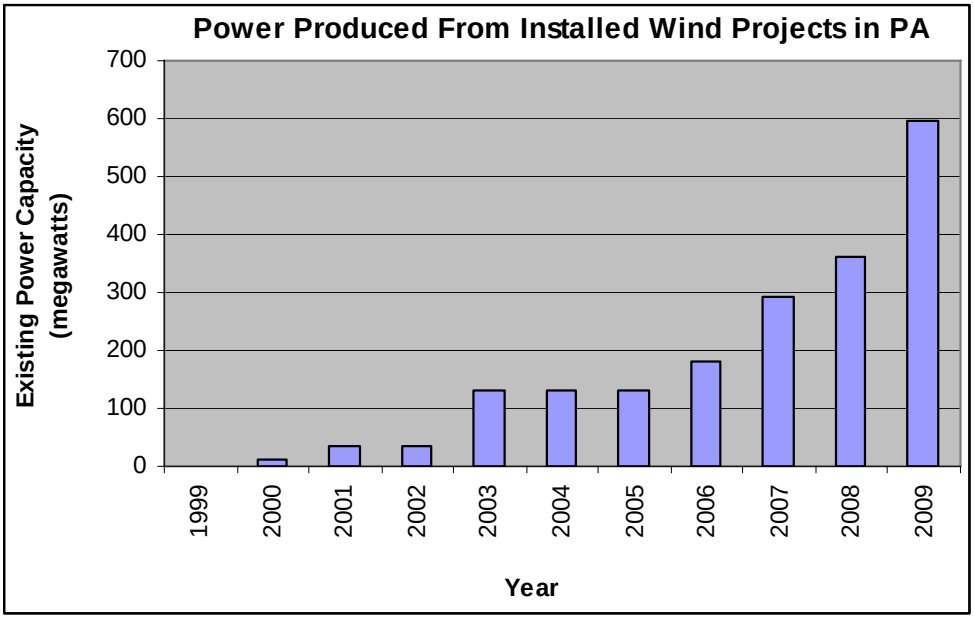
Map of wind power potential across the U.S., Source: U.S. Dept. of Energy

The figure below depicts a map of Pennsylvania's wind power potential and existing transmission line infrastructure. The two largest concentrations of high wind resource areas in Pennsylvania are found along the Allegheny Front (Southwestern PA) and near the Lake Erie shoreline.



Potential wind power in Pennsylvania and major transmission lines. Source: U.S. Dept. of Energy

In 2004, Pennsylvania's Governor signed into law the Alternative Energy Portfolio Standards Act or Act 213 (Pennsylvania General Assembly 2009) which requires that 18% of the electricity sold to retail customers in Pennsylvania come from renewable and advanced energy sources within 15 years. Wind power will compete for a substantial share of this alternative energy market, and has become a growing industry in Pennsylvania. The figure below shows the existing power (megawatts) of wind power in Pennsylvania since 1999.



Pennsylvania existing wind power (megawatts) capacity since 1999. Source: U.S. Dept. of Energy

Although there are many benefits to wind energy, there are also some limitations. Wind turbines have the potential to impact raptor, songbird, and bat populations, especially if constructed along migratory routes. Forest fragmentation and habitat disruption could result from the infrastructure (e.g., roads, transmission lines, pad sites, etc) needed for wind development. Wind turbines are large and when constructed along ridge tops, they have the potential to disrupt scenic views and aesthetics and cause noise when in operation. Lighting on wind turbines can be bird attractants and sometimes conflict with other land uses, such as stargazing in dark night skies.

To assist wind energy development in an environmentally responsible manner, the Governor convened The Pennsylvania Wind and Wildlife Collaborative to develop a set of Pennsylvania-specific principles, policies, best management practices, guidelines, and tools that can be used to assess risk to habitat and wildlife from wind power development, and to mitigate for the impact of that development. This collaborative has been led by the Pennsylvania Department of Conservation and Natural Resources and includes collaborative participants from Federal and Commonwealth Agencies/Offices, Nongovernmental Agencies, and the Wind Industry. More information about the collaborative can be found at http://www.dcnr.state.pa.us/wind/index.aspx. (PA DCNR 2009)

The Pennsylvania Game Commission has developed a voluntary wind energy cooperation agreement to further assist wind energy development on game lands in an environmentally responsible manner and with best regard to the conservation of the Commonwealth's wildlife resources. This effort seeks to support renewable energy initiatives (e.g., wind development) while assessing how best to avoid, minimize, and/or

mitigate adverse impacts to wildlife resources. More information on this voluntary program can be found at http://www.pgc.state.pa.us. (PA Game Commission 2009)

Current legislation does not authorize wind development on Pennsylvania's state forests. Authorization is not currently being sought, but may be pursued in the future. To prepare for future wind development potential on state forestland, a set of wind energy siting criteria has been proactively developed describing inappropriate sites (e.g., wild & natural areas, scenic areas, etc) and remaining sites that could potentially be nominated for wind energy development.

In summary, wind energy is a clean, safe, and renewable energy source. Some portions of Pennsylvania have potential for utility-scale wind energy development, and wind energy development has increased in the state in recent years. However, wind energy is not appropriate everywhere and many efforts are underway to develop best management practices, monitor efforts, and assess potential impacts.

References

American Wind Energy Assn. U.S. Wind Energy Projects – Pennsylvania. http://www.awea.org/projects/Projects.aspx?s=Pennsylvania. November 2, 2009.

Conservation Consultants Inc. About Wind Energy. http://www.pawindmap.org/htm/learnEnviron.htm. November 2, 2009

U.S. Dept. of Energy (1). United States 50 m Wind Resource Map. http://www.windpoweringamerica.gov/wind_installed_capacity.asp. November 2, 2009.

U.S. Dept. of Energy (2). Pennsylvania Wind Resource Map. http://www.windpoweringamerica.gov/maps_template.asp?stateab=pa. November 2, 2009.

U.S. Dept. of Energy (3). Installed U.S. Wind Capacity and Wind Project Locations. http://www.windpoweringamerica.gov/wind_installed_capacity.asp. November 2, 2009.

Pennsylvania General Assembly. Regular Session 2003-2004, Senate Bill 1030. http://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?syear=2003&sind=0&body=S&type=B&BN=1030. November 2, 2009.

PA DCNR. Wind and Wildlife Collaborative. http://www.dcnr.state.pa.us/wind/index.aspx. November 2, 2009.

PA Game Commission. Wind Energy Program. http://www.pgc.state.pa.us. November 2, 2009.

Biomass

The following draws from the Introduction to "Guidance on Harvesting Woody Biomass for Energy in Pennsylvania – DCNR 2008) link to entire document - http://www.dcnr.state.pa.us/PA_Biomass_guidance_final.pdf

As policymakers look for a way to reduce the carbon emissions from fossil fuels and meet growing energy demands with alternative energy sources, there has been an escalating interest in Pennsylvania's forests – "Penn's Woods" - as raw material for the emerging bioenergy market. Investors and policymakers are looking at woody biomass as potential feedstock for everything from large-scale cellulosic biofuel plants to local wood-to-energy installations to heat school buildings.

Pennsylvania is both a forest-rich state and a leader in sustainably managing its forest resources. It was the first state to certify its 2.1 million acres of state forestland through the internationally recognized Forest Stewardship Council protocol. Several of the state's largest privately owned hardwoods forests are also certified. With the most diverse, most valuable temperate hardwood forest in North America, Pennsylvania has a stewardship responsibility to conserve its forest resources for multiple users and for current and future generations.

"Sustainability" can be an ambiguous term in the context of biomass because it has at least two definitions. When energy entrepreneurs speak of "sustainability," they are referring to the need for a reliable supply of cellulosic materials to fuel their bioenergy production operations. When foresters and conservationists speak of "sustainable" resources, they want to ensure that any existing and new uses of Pennsylvania's forests preserve its full range of benefits and functions, and its capacity to regenerate a healthy future forest. DCNR's 2008 Guidance on Harvesting Woody Biomass for Energy in Pennsylvania attempts to address both supply and conservation concerns.

DCNR undertook this guidance to help frame the issues surrounding the emerging biofuel industry, including existing markets, inventory, supply, demand, best practices, sustainable forest management, potential impacts, and opportunities. The guidance addresses biomass harvesting on both state and private forestlands. The two are treated distinctly because DCNR manages its state forestlands directly while providing management guidance for privately owned forestlands.

The guidance was written with two audiences in mind. The first half is a policy overview of issues, trends, concerns and opportunities designed for policymakers, potential investors and general audiences. The second half, written for forest products industry stakeholders and non-industrial forestland owners, summarizes existing harvest practices on state-owned forestlands and best management practices on private forestlands. While the guidance primarily addresses intact forestlands, it offers, where applicable, guidance for short-term rotational biofuel crops that are likely to convert open fields, Conservation Reserve Enhancement Program lands, poorly reclaimed or abandoned mine lands and others within a landscape mosaic of forested lands and agricultural fields.

Summary of major report recommendations:
Harvesting woody biomass from Pennsylvania's forests could help meet the demand for alternative sources of energy and reduce greenhouse gas (GHG) emissions, but should not compromise other important forest functions and values – including protecting water quality, critical natural areas and communities, biodiversity, recreational opportunities, and wildlife habitat.

Private forestland owners should follow accepted best management practices for timber harvests when implementing biomass harvesting on their lands, and involve resource professionals who can provide technical expertise.

Small-scale biofuel operations (requiring under 2,000 tons of biomass/year) such as the "Fuels for Schools and Beyond" program are more economically viable for Pennsylvania than large-scale operations that require larger volumes of feedstock (300,000 tons or more) annually and entail higher transportation costs.

The forest floor, including roots, stumps and below-ground biomass, should always be off-limits to biomass harvesting. This material provides too many irreplaceable functions to sustaining a healthy forest, including nutrients essential for tree growth and maintaining biodiversity.

Agroforestry operations should never replace existing natural forest. The state forest system in Pennsylvania has 98% of its land base in natural forest and thus would be offlimits to biomass plantations. Abandoned or poorly reclaimed mine sites on state forest land could be appropriate sites for plantation biofuel crops. Private lands will offer more potential for plantation biomass production but should not convert forestland or highly erodable lands.

A range of 15-30% of pre-harvest biomass – depending on soil type, forest composition and other factors – should always be left on site to buffer against nutrient depletion, erosion, loss of wildlife habitat and other factors. This would translate, for example, into leaving one out of every 3 to 6 harvested trees per acre on the forest floor.

Whole-tree harvesting may offer the potential to improve forest regeneration, aesthetics, and reduce fire hazards, but should be done with extreme care to avoid damage to the remaining forest during harvesting.

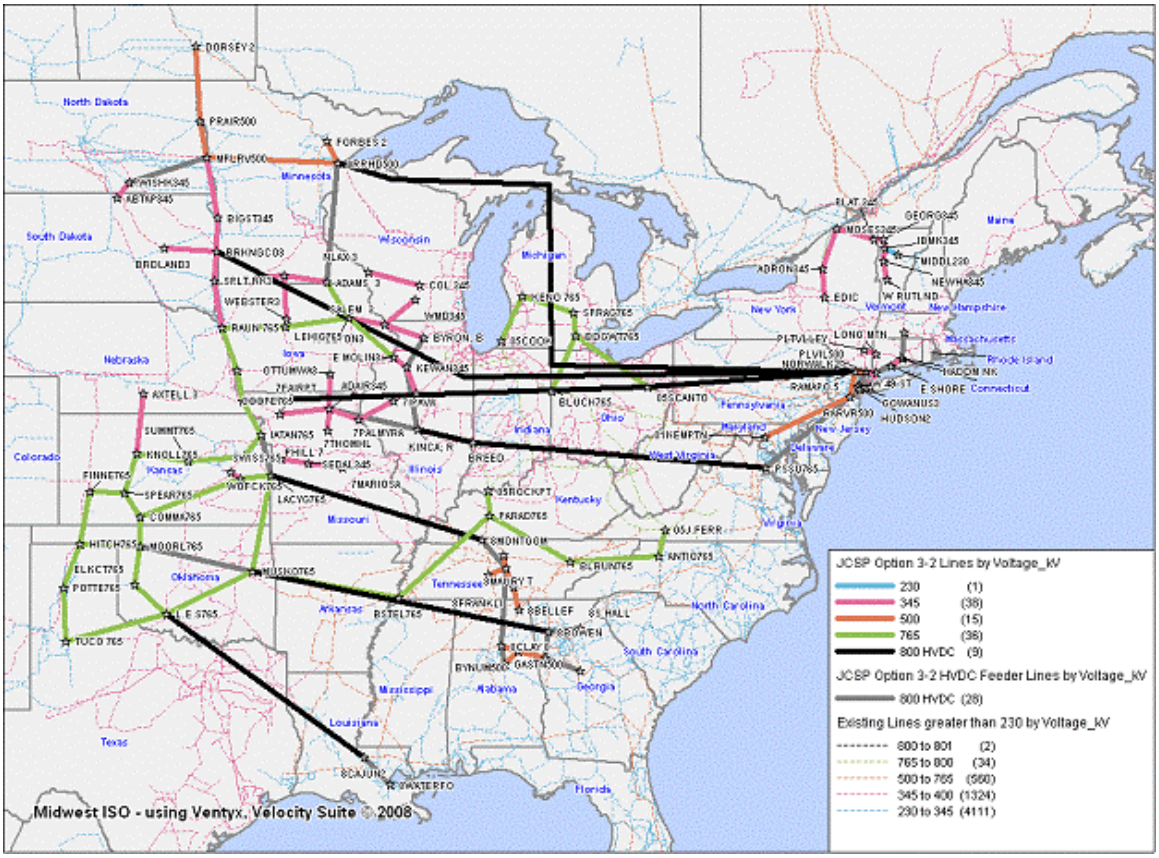
Studying Pennsylvania's existing forest products procurement stream and forest land ownership patterns and preferences should be a prerequisite before initiating biomass energy operations to ensure that sustainable quantities of biomass exist to support them.

The best opportunities for biomass harvest in Pennsylvania may be natural-event driven. Disturbance from fire, wind, ice storms, insect damage and other events can create harvest opportunities that complement good silvicultural management. Biomass harvest should always include and advance practices that lead to healthy forest regeneration.

Rights of Way

Introduction

Rights of way have crisscrossed Pennsylvania for more than a century. Many were developed as the national power grid was assembled in the early 1900s, and bring electricity via transmission towers and lines into Pennsylvania and from Pennsylvania-generated electricity sources to in-state and out-of-state locations. Rights of way (ROWs) have also been developed in the state for gas lines, water lines, sewer lines, and more recently, buried cable lines. Over the past two years, the number of ROW requests in the state have accelerated as natural gas drilling technology has made recovery of natural gas from the Marcellus shale more available. Efforts to modernize and expand capacity of National Interstate Electric Transmission Corridors (NIETC), including the Mid-Atlantic NIETC that crosses Pennsylvania, have added pressure for new or expanded ROWs to accommodate projected increased energy demands, particularly along the eastern seaboard where Pennsylvania connects power plants in the Midwest to concentrations of users in New York and New Jersey.



Major electric transmission lines through Pennsylvania and the Eastern U.S.

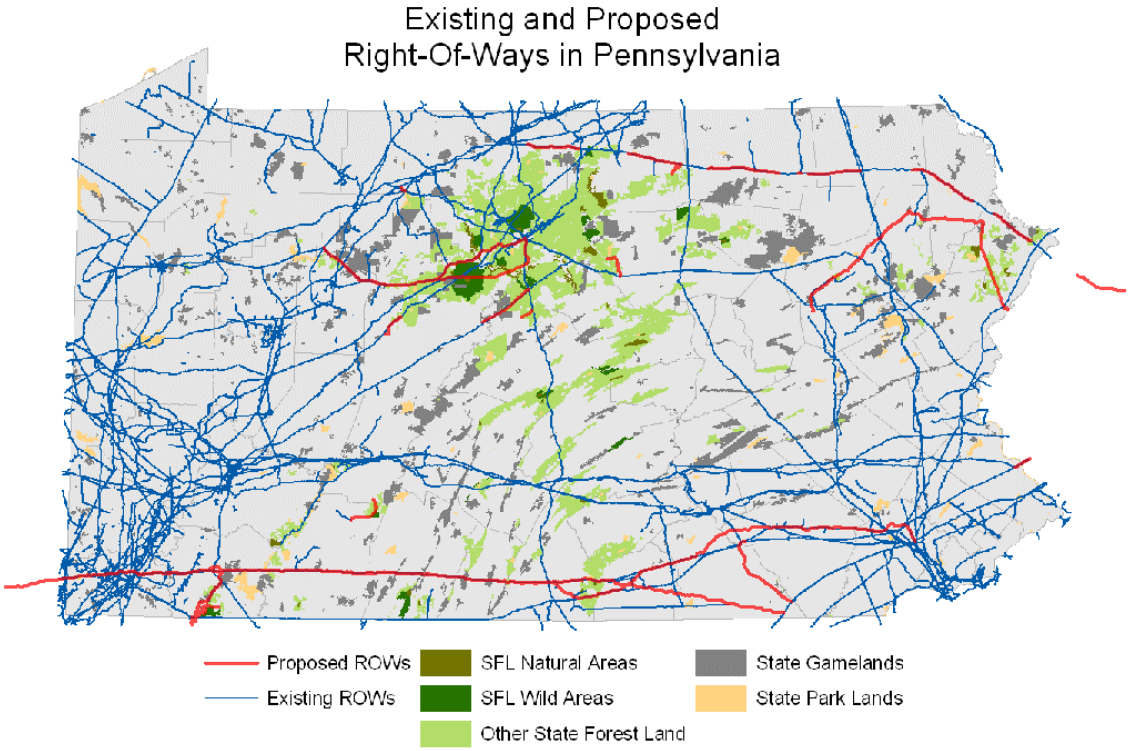
Recent efforts by land-conservation advocacy groups and others have made the once routine process of obtaining ROW permission more controversial, as groups have begun

to question the need for long-distance transmission and expanded corridor widths and tower heights. Environmental advocates are also focusing on the fragmentation impacts of new ROW routes that target undeveloped lands. State forestland contains many ROWs. One of the first – and now largest – terminals for natural gas in the nation was located in the middle of the Sproul State Forest at Leidy in the 1950s, and is highly visible on the state pipeline route map above.

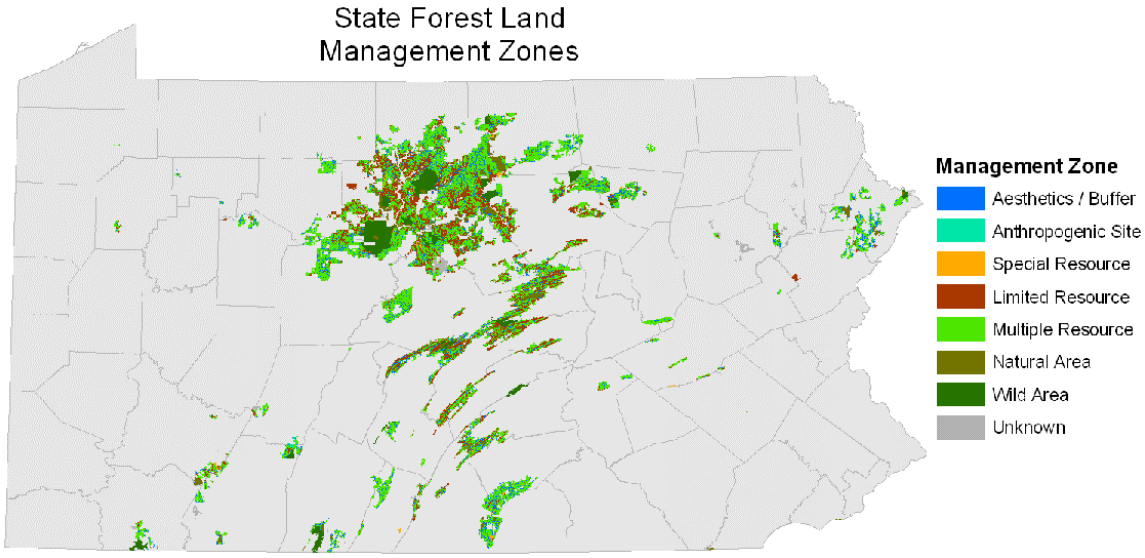
State Forests and ROWs

In the past, ROW requests were relatively infrequent and the low volume of requests were such that district and central office personnel were readily able to handle them. the Bureau of Forestry was able to easily evaluate requests on a case by case basis. Evaluation included a thorough review of the request and the ability to apply stewardship and sound land management principals to state forest lands. In 2009, DCNR developed a new set of policies and practices regarding the permitting and implementation of ROWs on state forest and park lands in response to an escalation in the number of requests it began experiencing in 2008. The surge included requests specific to new or expanded electric lines, electric lines to support wind farms, fiber optic lines, and new or expanded natural gas lines. Currently, and for the foreseeable future, the most numerous requests appear to be for natural gas lines.

These new policies address the application process itself, provide new siting criteria, update the fee structure, and offer guidance to help limit invasive plant species along ROWs and other related practices. DCNR's Bureau of Forestry also convened a regular internal review committee to assemble better data and GIS maps, and to develop a pro-active approach to let industry know which zones of the forest and other DCNR lands were more appropriate for ROWs. This included an all-day stakeholder meeting for industry representatives, environmental groups, and other stakeholders and a substantial public comment effort. As a result, DCNR is now better positioned to handle the increased volume in ROW requests and to communicate its preferences and policies to potential applicants.



Some of the objectives in revising the ROW request process and procedures were to make the process clear to all, modernize processes and procedures, ensure an appropriate level of review, sound stewardship (reducing/managing forest fragmentation and protecting special concern areas such as Wild and Natural Areas, State Parks, and high-use recreational areas), and improve project turn around time while maintaining quality customer service to the applicant.



While the need to revise the ROW request process was largely driven by the increased volume requests for natural gas; however, the Bureau uses the same or very similar processes and procedures for all utility ROW requests.

Guidelines

The new guidelines apply to state forestland and to Pennsylvania's 117 state parks. In general, the guidance recommends that applicants avoid state park lands altogether, and considers pipelines incompatible with the primarily recreational mission of state parks. State forests, on the other hand, have multiple purposes, one of which is to develop state oil and gas resources.

The guidelines are divided into three primary sections; description of special protection areas, guidance on route planning, and guidance on design and construction.

Special Protection Areas:

- Right-of-way development within Wild Areas, Natural Areas, and State Parks is predominately incompatible with management objectives.
- Corridors should avoid exemplary geologic formations, sensitive habitats, and known occurrences for rare, threatened, or endangered flora and fauna species.
- Impacts to water resources including wetlands and vernal pools should be avoided.

Route Planning:

- A clear need for the right-of-way should be established and alternative routes should be investigated and included in the proposal as well as a justification for why the preferred route was chosen.
- Proposals should minimize further forest fragmentation by paralleling existing rights-of-way and roads.
- Routes should work within topographical constraints to minimize aesthetic impacts.
- Proposed corridors should consider potential recreational impacts and existing DCNR operations.

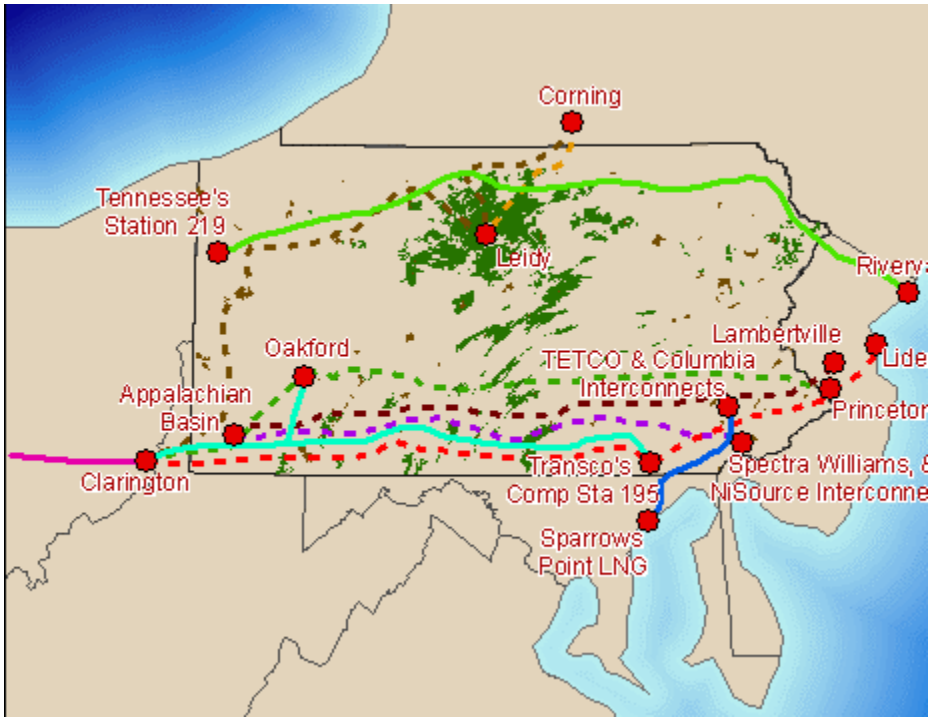
Design and Construction:

- Companies with existing rights-of-way should work within that right-of-way to increase available capacity versus requesting additional acreage to site additional infrastructure.
- Corridor widths should be minimized to include only the width necessary to ensure safe and adequate working conditions.
- Companies with adjacent right-of-way interests should work cooperatively in the management of the corridor and the siting of necessary infrastructure.

ROW Application Process

The diagram below shows the basic application and review process. The process makes two important distinctions in project types. Projects are either considered "major" or not, depending upon size. In general, a "major" project is as large or larger than a township,

county, or state and requires a more lengthy and involved review. ROW projects that remain within state boundaries are within the jurisdiction of the Pennsylvania Utilities Commission, but those that cross state boundaries come under the jurisdiction of the Federal Energy Regulatory Commission and must adhere to federal guidelines and standards. DCNR currently recognizes two different types of state forest land ROW agreements: license for mainline transmission pipeline or large ROW, and license for marketing and/or gathering pipeline or small ROW. More complete information about how to apply for a ROW can be found on the Bureau of Forestry's ROW website at http://www.dcnr.state.pa.us/forestry/ROW/Process/How%20To%20Apply%20for%20a%20Right%20of%20Way%20on%20State%20Forest%20Lands.pdf.



Interstate/FERC-licensed existing and proposed gas pipeline routes in PA.

Annual Rental Rate Update

One of the major revisions in the Department's update of its ROW policies and practices was to bring its rental rates for ROWs in line with adjacent states and current market prices. For decades, these rates had remained well below the market average. The figure below shows the updated rates. Interestingly, these increases have not been met with an outcry from industry, which recognized the effort as a correction of out-of-date practices rather than a punitive or unreasonable increase. A list of the Commonwealth's revised free structure can be found on its ROW website at http://www.dcnr.state.pa.us/forestry/ROW/Agreement/Proposed%20DCNR%20ROW%20Fees.pdf.

Issues:

1. Certification

The increase in ROW requests and ROW development pose a serious challenge to DCNR to maintain its annual certification. DCNR has been recognized for its commitment to sustainable forest management as one of the largest landowners in the United States to be certified as "well managed" according to the principles of the Forest Stewardship Council. The State Forests first became certified by this independent, third-party system in 1998. The Department's environmental review process and guidance are designed to help ensure that it does not lose its certification due to ROW impacts.

2. Fragmentation

A ROW represents a long-term change in land use that can limit or prevent other uses (such as recreational access) and can have a variety of impacts on habitat. Linear corridors dramatically increase edge habitat within the forest. While this can benefit several species of flora and fauna, it decreases critical habitat for interior forest-dependant species, increases competition for limited resources, and fuels the potential for introducing undesirable invasive species and diseases.

3. Invasives

ROW projects across lands managed by DCNR have the potential to disturb sizable acreage. Careful and well-planned revegetation efforts following ROW construction can help restore wildlife habitat, suppress soil erosion and improve aesthetics. DCNR's2009 ROW revegetation plan addresses these issues and provide guidance.

There are four vegetative components to be planted as part of the revegetation plan: native and non native mix of grasses and legumes mix in the disturbed pipeline ROW, clumps of shrubs within the pipeline and work area, a native mix of grasses and herbs, and a non-native legume mix.

The native and non native grass mix is the main component of the revegetation plan and can be used for cover and stabilization in the disturbed ROW. The plan delineates what species of cover crop will be planted and when, and how the application should be handled. It addresses application of lime, fertilizer, grass species to be planted, and amounts per acre based on site slope.

The plan also addresses revegetation of temporary work areas, with species recommendations of shrubs and trees; revegetation of access points, and minimum standards for survival rates. It also addresses reestablishment of food plots, and how to keep equipment from bringing in invasive plants to the site. Only weed free seed, dirt, gravel, and mulch can be used on the state forest land section of the ROW.

In addition, the plan directs how basking areas and habitat for the Timber Rattlesnake and the Allegheny Woodrat will be created where appropriate throughout the pipeline corridor whenever materials are available.

4. Mineral Rights Ownership

ROWs may not be required for pipelines or transmission corridors on State Forest or State Park lands when the requester has the ability to use the surface for such purposes as a result of the requester's subsurface ownership or rights through other existing agreements. The Commonwealth owns all rights and interests (both surface and subsurface) on approximately 77% of State Forest and State Park lands. On the remaining 23% (approximately 550,000 acres), the Commonwealth only owns the rights and interests in the surface. The owners of the subsurface rights on these lands have the ability to make certain use of the surface.

When subsurface owners are interested in using the surface for pipelines to transport their subsurface resources (e.g., oil or gas), they may not need a right-of-way agreement depending on the nature of the pipeline and the rights provided by deed when the subsurface was severed from the surface ownership. Subsurface owners interested in constructing pipelines or otherwise establishing transmission corridors should provide DCNR with a description of the proposed project and copies of the documents (deeds, leases, etc.) describing the subsurface owner's rights regarding use of the surface. If DCNR agrees that the subsurface owner has the right to use the surface as proposed, a right-of-way agreement would not be required. DCNR strongly urges subsurface owners to enter into a voluntary agreement with DCNR, however, to ensure that the subsurface owner's use of the surface proceeds in a manner that both the subsurface owner and DCNR agree protects the state forest or state park land.

On approximately 370,000 acres of state forest land for which the Commonwealth owns the subsurface oil and gas rights, DCNR has entered into leases with private companies for the development of the oil and gas resources or for natural gas storage. As of June 2010, the DCNR Bureau of Forestry identified 140 active leases across the state.]

Results/Discussion

The recent surge in request for ROW development or expansion on state forest land and park land is not likely to abate any time soon. Drivers of the increase include electricity demand and expansion of gas exploration in the Marcellus shale. A shift to alternative, renewable energy resources like windpower and solar power will create new demand for ROWs as developers seek to transmit energy generated on mountaintops and other remote locations to the grid.

DCNR has taken pro-active steps to signal to industry how it will handle ROW requests and where it prefers ROW development to occur, and has created guidance on invasives and other impacts to lessen overall ROW damage to state forests and parks. The increase in rental fees is not likely to have any impact on demand for ROWs, but will help increase mitigation funds that can address future impacts. Improved communication of the steps DCNR has already taken should help create a climate of transparency around

ROWs and signal both to industry and to the public who enjoy state lands for recreational uses that the Department is doing all it can to maintain these public spaces for multiple uses and minimize impacts.

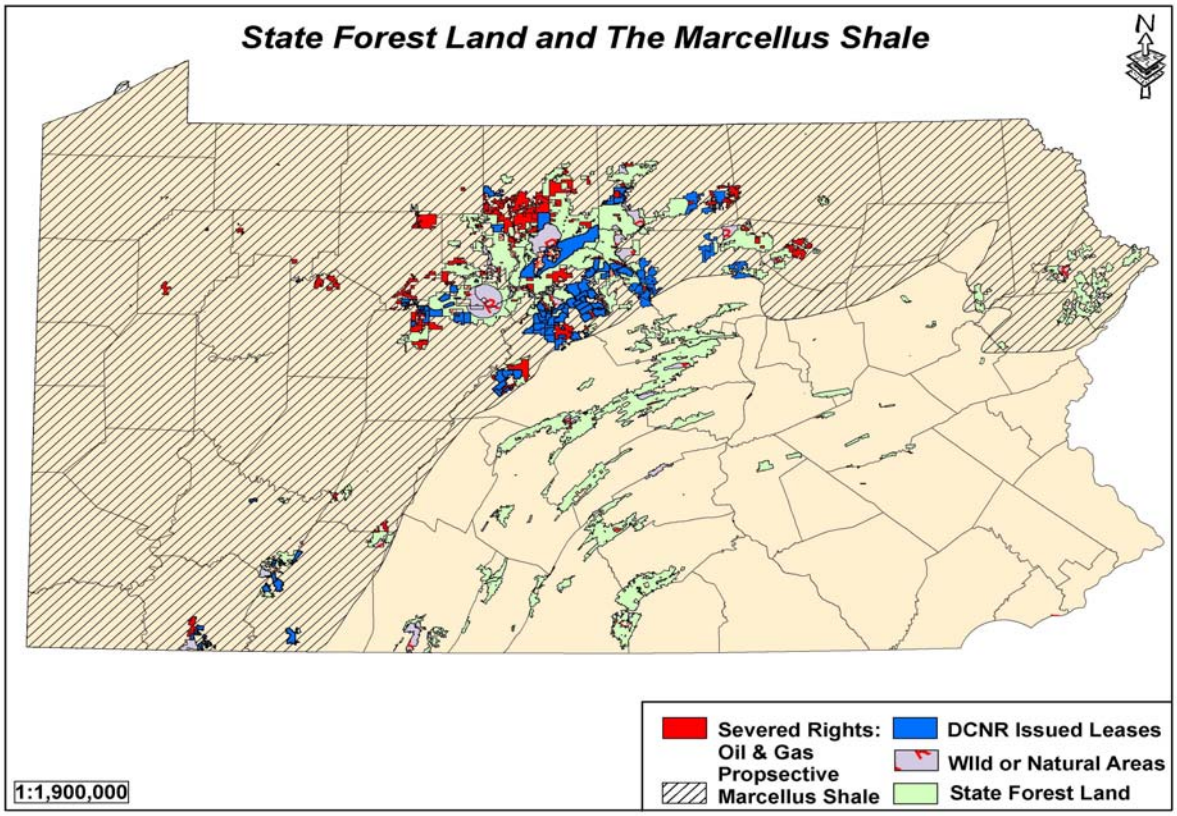
Resources/Framing for Potential Solutions:

- Continue to do careful permitting and environmental review.
- Improve communication to industry and the public.
- Encourage dialogue at public forums like EMAC to mediate conflicts.
- Monitor impacts and document concerns via an agency database.
- Work with permitting agencies like DEP to address noncompliance where it happens.

Marcellus Shale

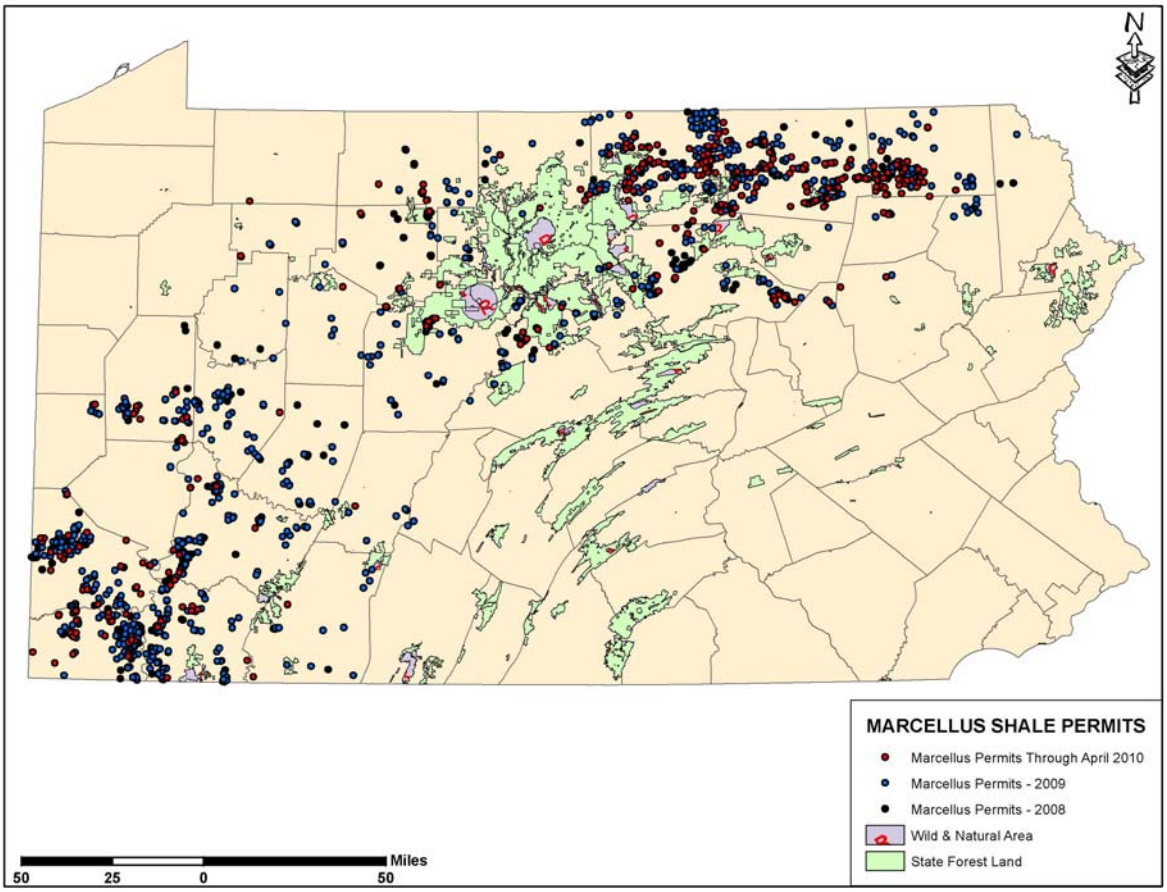
The Marcellus Shale is a rock deposit which lies as much as 8,000 feet below the surface of two-thirds of Pennsylvania. It may contain nearly 170 trillion cubic feet of natural gas that was previously thought too difficult and too expensive to access, as it must be released from between the impermeable layers of shale. Advances in drilling technology, along with high but fluctuating gas prices, have made natural gas production from shale deposits more economically viable and thus more desirable for both industry and landowners. The resulting interest and growth in natural gas production is generating interesting opportunities and challenges for Pennsylvania.

While much of the data and characterization of Marcellus Shale development presented in this chapter are based on activities occurring on state forest land, the Bureau of Forestry views this as a significant issue potentially affecting all forests and communities in the Marcellus region.



More than 350,000 oil and gas wells have been drilled throughout Pennsylvania since the first commercial well was developed in 1859. DCNR has sustainably leased state forest lands for natural gas extraction for more than 60 years. At the end of 2009 DCNR was actively managing Commonwealth issued oil and gas leases across about 370,000 acres state forest lands owned fee-simple by DCNR (surface and subsurface rights held). There are an additional 290,000 acres of state forest lands where only surface rights are held by

DCNR and the subsurface rights are currently leased to or owned by the oil and gas industry. At the close of 2009, approximately 750 gas wells were in production on about 660,000 acres of DCNR land.



With private lands, other public lands, and the 660,000 acres of state forest land available for gas development, there is ample opportunity in the Marcellus Shale. A significant portion of this acreage is currently being tested for development potential, although future development is significantly dependent upon economic conditions. Site-specific management and oversight of all exploration and development activities will be required to ensure the protection and preservation of the scenic and ecological integrity of forested lands.

Environmental Concerns

Oil and gas projects have been regulated since 1956 under state laws including the Clean Streams Law, Dam Safety and Encroachments Act, Solid Waste Management Act, Water Resources Planning Act, and the Worker and Community Right to Know Act.

The Department of Environmental Protection is responsible for reviewing and issuing drilling permits, inspecting drilling operations and responding to complaints about water quality problems, including activities on DCNR lands. DEP inspectors conduct routine

and unannounced inspections of drilling sites and wells statewide. Other agencies directly responsible for monitoring the effects of drilling on water quality and aquatic life include the Pennsylvania Fish and Boat Commission, the Susquehanna and Delaware River basin commissions, the U.S. Fish and Wildlife Service and Pennsylvania's county conservation districts.

Pennsylvania's forests are important refuges for many bird, mammal and aquatic wildlife and plant species. Several state forest wild or natural areas exist within the Marcellus Shale range, with a total of approximately 180,000 acres zoned as such and protected from development and human activity. Surface disturbances are prohibited in both wild and natural areas.

Aerial photo of a gas well site. © iStockphoto / Edward Todd.

Fragmentation of once continuous forest tracts by gas development and related access on and adjacent to state forests land is a great concern. Almost any development activity in a natural forest will have impacts to wildlife and plant populations. Multi-well pad horizontal drilling has created the potential to reduce the number of necessary well pads, access roads, pipeline corridors, compression facilities, processing plants and other associated infrastructure required for natural gas development and production. But, this infrastructure will still require proper management and will have a large impact on the forest system.

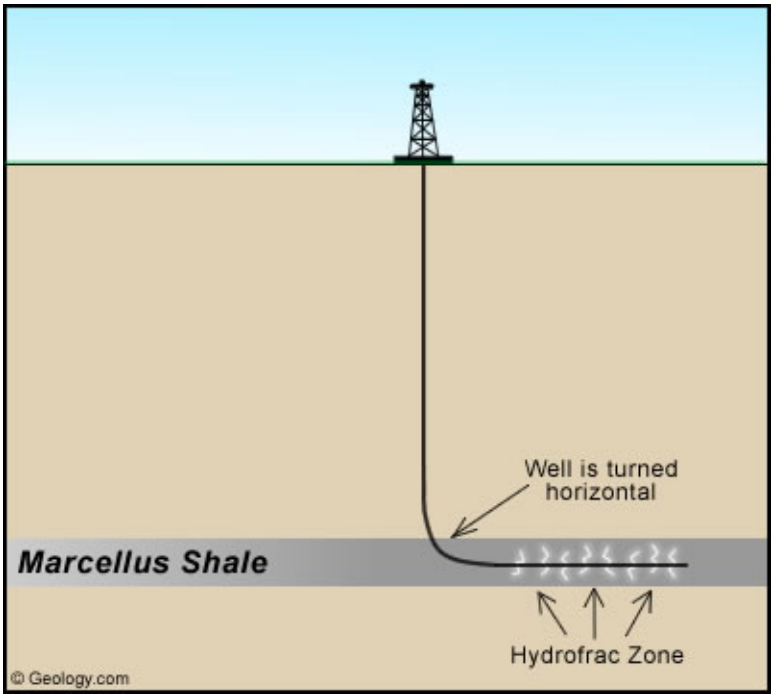
Road building and heavy-equipment landings, clearings for drilling pads, on-site water storage and treatment facilities, and other necessary infrastructure will eliminate important wildlife habitat, create pollution and noise disturbance to wildlife, and may alter the composition of wildlife and plant species over time. Such clearings also create opportunities for the introduction and spread of invasive plant species.

While some species benefit from an increase in 'edge' forest, even small clearings necessary for gas exploration and production fragment the forest and eliminate interior forest, which is important habitat for many migratory bird species (among other wildlife).

Permit reviews in Pennsylvania do assess whether a site is known habitat for rare and/or endangered species; however, many declining species of birds would not be protected and would stand to lose important migratory habitat.

The aesthetic value of the forest and forest-dependent wildlife provides indirect benefits to Pennsylvania. Tourism is the Commonwealth's second most economically significant industry sector, following agriculture. Some 3.9 million wildlife watchers and 1.5 million anglers and hunters take to Pennsylvania's woods and streams each year. Spending associated with wildlife watching alone in Pennsylvania in 2006 amounted to $1.4 billion in retail sales, over $2.6 billion for lodging, transportation, equipment and supplies, and generated $880 million in salaries, wages and business owners' income.

Pennsylvania's state forest system was created in part to serve as watershed protection for pristine surface waters of the Commonwealth. The hydraulic fracturing (water pressure used to create cracks in the rock) required for economic natural gas recovery from the Marcellus Shale uses large amounts of water. A typical well may consume one million gallons of water per completion stage and take multiple stages to complete.



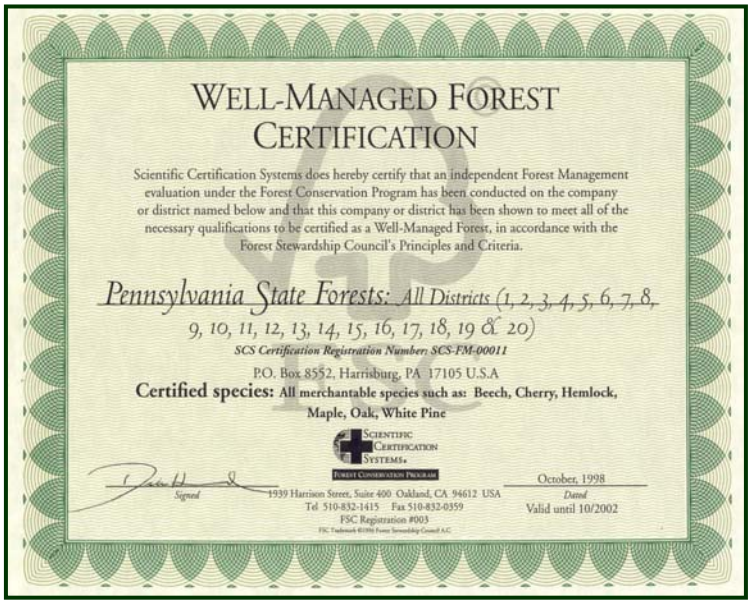
Particular water concerns revolve around:

- locating sources of water to withdraw for well construction without negatively impacting local water supplies,
- protecting small streams and watersheds from degradation caused by movement of heavy equipment and site construction, and
- treatment or disposal of the contaminated water recovered from the hydraulic fracturing process.

Industry-driven research is moving toward improved water supply and wastewater treatment systems which recycle and reuse the water that returns to the surface once it has been used in hydraulic fracturing. This contaminated water can go through repeated recycling processes to be used in fracturing again (minimizing the total amount of water withdrawn and the total amount of contaminated water produced by the operation). Water can be treated and recycled or treated and discharged (normally to a publicly owned

treatment facility for additional treatment). Water withdrawal and disposal of used and treated waste waters presents significant concerns, though research is optimistic and growing. A better understanding of the effects of these processes is needed.

Improper disposal (including spillage) of contaminated industrial waters may pollute larger waterways and subsurface waters with a potentially wide impact. As privately-owned parcels adjacent to state forests are developed, DCNR will be approached for access for water withdrawals.


WELL-MANAGED FOREST CERTIFICATION

Scientific Certification Systems does hereby certify that an independent Forest Management evaluation under the Forest Conservation Program has been conducted on the company or district named below and that this company or district has been shown to meet all of the necessary qualifications to be certified as a Well-Managed Forest, in accordance with the Forest Stewardship Council's Principles and Criteria.

Pennsylvania State Forests: All Districts (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 & 20)

SCS Certification Registration Number: SCS-FM-00011

P.O. Box 8552, Harrisburg, PA 17105 U.S.A

Certified species: All merchantable species such as: Beech, Cherry, Hemlock, Maple, Oak, White Pine

SCIENTIFIC CERTIFICATION SYSTEMS

FOREST CONSERVATION PROGRAM

Signed

1939 Harrison Street, Suite 400 Oakland, CA 94612 USA
Tel 510-832-1415 Fax 510-832-0359
FSC Registration #003

October, 1998
Dated
Valid until 10/2002

DCNR is committed to maintaining its third-party forest certification of state forest lands, which could be lost if too much forest is converted to another land use. DCNR has been recognized for its commitment to sustainable forest management as one of the largest landowners in the United States whose forests are certified as "well-managed" according to the principles of the Forest Stewardship Council. DCNR also has a legislative mandate to manage Pennsylvania's state forests for multiple uses: clean water, clean air, recreation, wildlife, timber and mineral development, and for the enjoyment of all generations now and in the future.

Opening extensive new state forest acreage for gas production may threaten publicly held forest resources beyond sustainable limits. Careful consideration of all environmental issues, along with much research, planning and monitoring, will be of the utmost importance in future exploration and development of the Marcellus Shale natural gas reserves on state forest lands and across the Commonwealth.

Social Considerations

DCNR supports the sound utilization of oil and gas resources by methods that ensure the sustainability of the forest system and also in ways that are responsive to society's changing energy demands. From both an economic development and an energy independence standpoint, the prospects of the Marcellus Shale hold great promise for the Commonwealth and its communities, and the positive benefits obtained from Marcellus Shale development and natural gas production could last for many decades.

Even with proper regulation and oversight, such industrial development is often accompanied by social costs. Studies have found that "communities are often

overwhelmed by rapid population influxes associated with the energy development and that energy development often provides a number of unique opportunities and challenges to communities and local governments." (NERCRD Rural Development Paper No. 43)

Community issues range from housing needs and population/cultural change, to pressure on emergency preparedness and revenue distribution, to greatly increased costs of road maintenance. Communities are being asked to adapt to the positive and negative impacts caused by rapid growth of the area as industry booms; they must also be prepared for the changes that will inevitably occur when the industry slows or halts just as rapidly as it grew. This boom and bust experience is of concern to many communities for which industrial growth resulting from Marcellus Shale gas production is prospect.

The communities of the Commonwealth will benefit from careful planning for both industry growth and decline. Planning must be long term, as it is important to consider the short-term needs for the community, but it is also important to plan for future possibilities. It will be important to monitor and understand social changes and environmental impacts and develop and disseminate best practices.

Financial Considerations

Historically, a major factor in generating acceptance of gas leasing by many state forest users and environmental groups is that the revenue from the gas sales has been used for conservation investment such as additional land acquisitions and recreational projects. Recently, income from royalties and lease sales has been used to help balance the state government budget.

State budget negotiations for FY 2010-2011 have included discussion of a proposed moratorium on additional leasing of state forest lands, and proposals to introduce a tax on all natural gas extraction in the Commonwealth (more commonly known as a severance tax).

Summary

The mission of DCNR's Bureau of Forestry includes providing resources and values to society – one of which is the environmentally sound extraction of mineral resources. DCNR recognizes that many Pennsylvanians are concerned about rising energy costs, reliable and clean energy sources, and the range of concerns associated with energy production and independence. Staying true to its mission – and working with other agencies, industry and landowners – DCNR can help to carefully address these concerns and can help to ensure the sustainable management of Pennsylvania's natural resources.

References

Frantz, Joseph, Jochen, Valerie. October 2005. Shale Gas White Paper. *Schlumberger Marketing Communications.*

Jacquet, Jeffrey. January 2009. Energy Boomtowns & Natural Gas: Implications for Marcellus Shale Local Governments & Rural Communities. *NERCD Rural Development Paper No. 43.*

PA DCNR. Oil and Gas on State Forest Lands (web page). April 2008.
http://www.dcnr.state.pa.us/forestry/oil_gas.aspx

PA DEP. Marcellus Shale Page. January 2010.
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/new_forms/marcellus/marcellus.htm

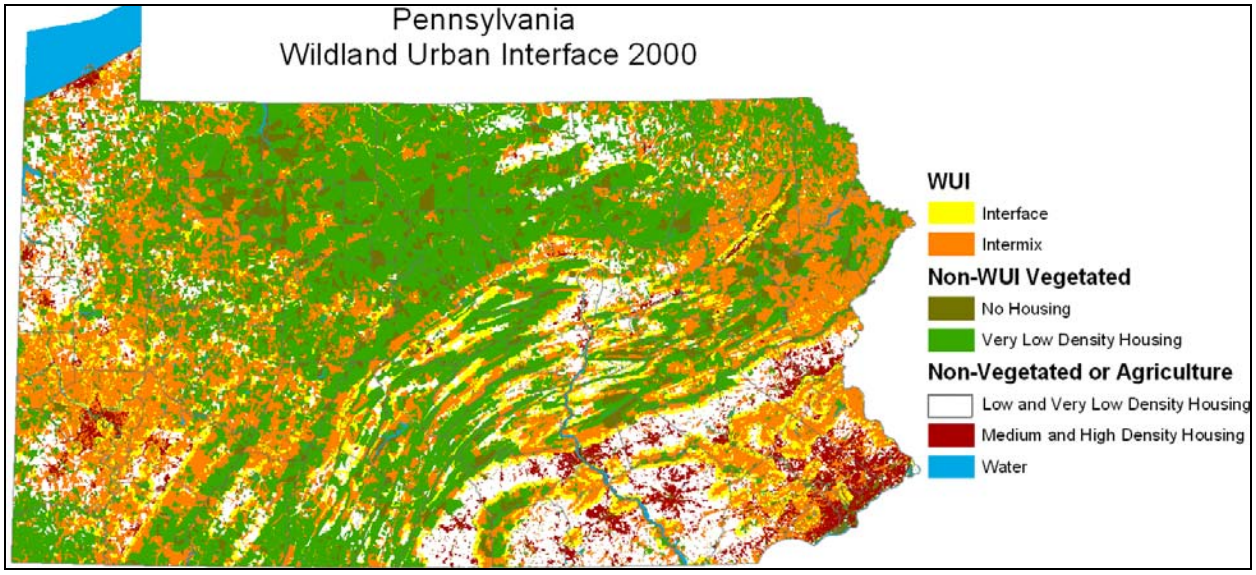
Soeder, Daniel, William Kappel. May 2009. Water Resources and Natural Gas Production from the Marcellus Shale. *USGS Fact Sheet 2009-3032*.

Chapter 4G

Issues, Threats, and Opportunities - Wildfire and Public Safety

Setting the Stage

The Commonwealth of Pennsylvania, "Penn's Woods," has nearly 17 million acres of forested land and 7 million rural acres of crop and grasslands. Ten million residents call the Commonwealth home with many living in urban and suburban areas, and a smaller number living in rural mountain communities or in single homes in remote mountainous areas characterized as Wildland/Urban Interface or Intermix. Data developed by the University of Wisconsin Silvis Lab and the USFS indicates that more than 17% of the state's residents live in Pennsylvania's Wildland/Urban interface. An informal wildfire risk assessment was conducted in 2002 identifying more than 250 municipalities at risk. This assessment continues to be updated.



Location Map of Wildland/Urban Interface Areas in Pennsylvania

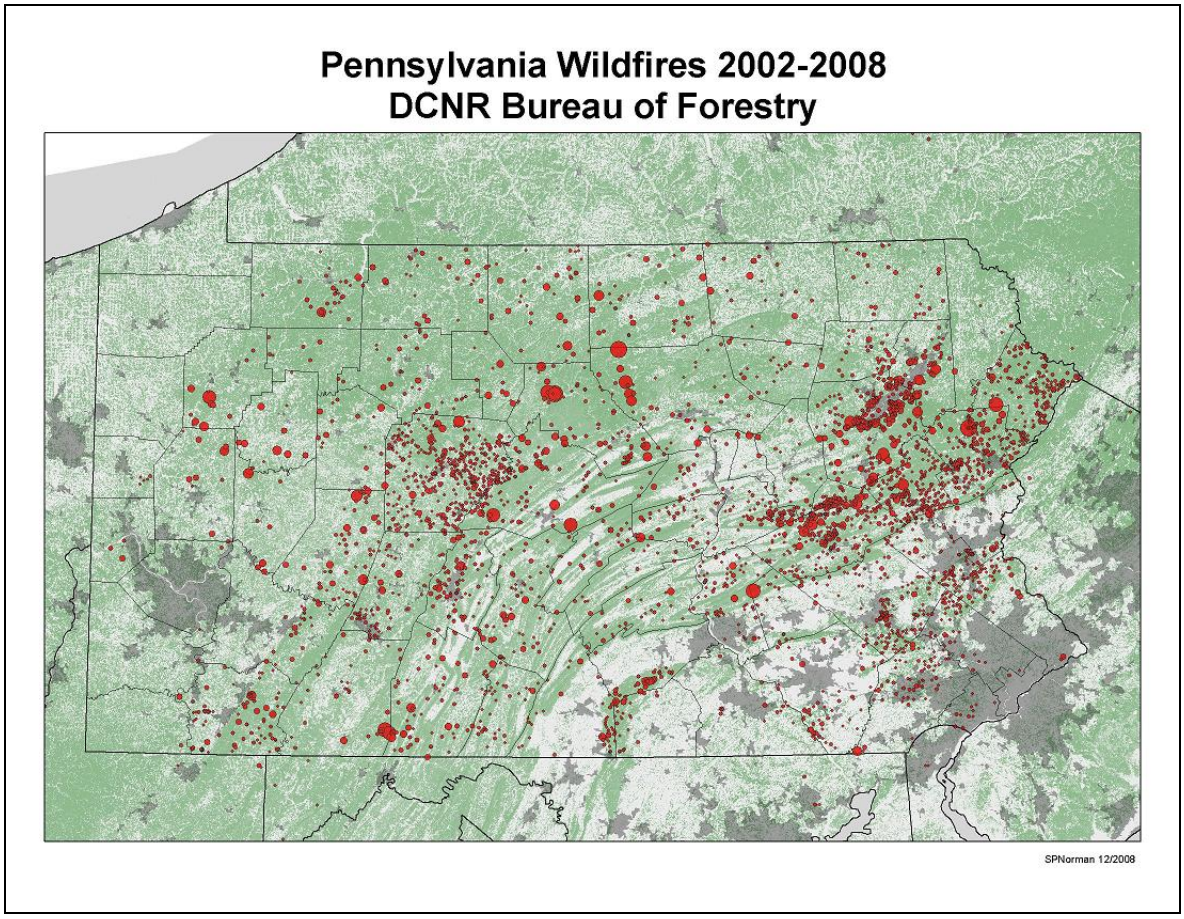
A primary role of government is to help ensure the safety of its citizens. Since its creation in 1895, the Bureau of Forestry has been tasked with protecting all of the Commonwealth's wildlands from wildfire, but the Bureau of Forestry and the United States Forest Service increasingly find our primary mission becoming the protection of lives and property from damage by wildfire. As public demands increase, our ability to provide the services they expect is decreasing in terms of manpower and funding. These

are significant challenges that we will be facing at least for the next several years. Coordinated training and unified command with our volunteer fire companies is essential to address these issues now and in the future.

Act of May 4, 1927, P.L. 737 defines wildland as: *"The terms "woodlot." "forest," or "wildland," in this section, are intended to include woods, farmer's woodlots, marshes, brush barrens, brush lands, and wild, unseated, uncultivated land."*

A wildfire in Pennsylvania is defined as: *"any fire burning on, or which threatens to spread fire to woods, woodlots, marshes, brush barrens, brush lands, or any wild, unseated, uncultivated lands in the commonwealth."*

Much of Penn's Woods is mountainous terrain. Oak hardwood forests are dominant in much of the state. However, scrub oak, mountain laurel understory, and scattered conifer plantations add local complexity to the Bureau's wildland fire protection scenario.

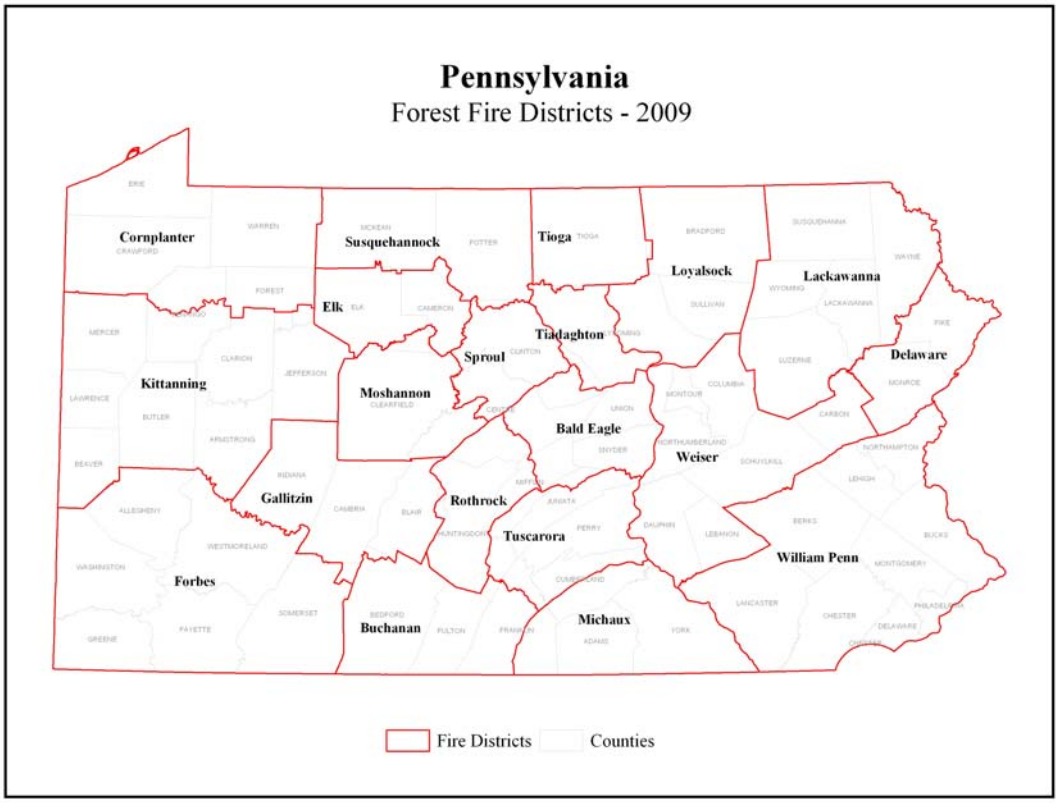


Map of Wildfire Origins in Pennsylvania 2002-2008

More than 2,000 rural fire companies are chartered to respond to fires in the Commonwealth's 1,500 townships and municipalities. Although all of these resources are an asset, simply dealing with this large number of entities is a challenge when it comes to providing equipment and training and in facilitating joint responses to local wildland fires utilizing *Unified Command* principles.

The Bureau maintains a strong commitment to promoting fire prevention as its first line of defense. In 1929 a system of forest fire wardens was created through legislation granting authority and responsibility through a Chief Forest Fire Warden to a network of local wardens statewide. In addition to fire prevention, they are charged with and authorized to develop local crews of trained wildland firefighters and to respond to wildfires in the Commonwealth regardless of land ownership, public or private. Today, nearly 2,000 fire wardens are on call across the Commonwealth.

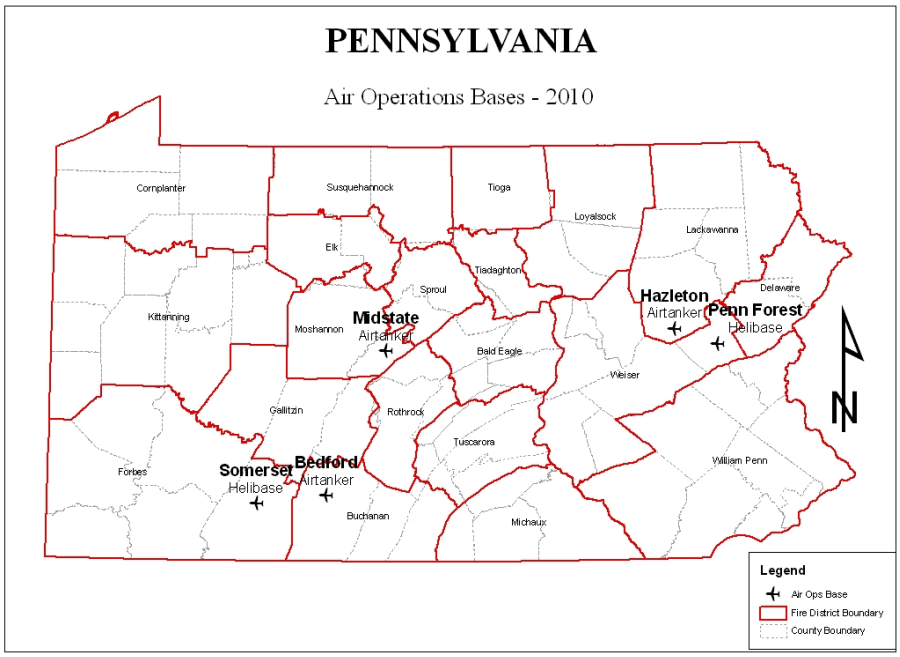
Bureau strategy has been to respond to the challenge of delivering wildland fire protection on the statewide scale through twenty forest districts dividing the Commonwealth. A District Forester serves as the District Forest Fire Warden in each district. They are responsible for ensuring that all aspects of fire protection in their district are attended to including prevention, pre-suppression, training, detection, suppression, investigation, billing and claim recovery.



Map of Pennsylvania Forest Fire Districts

Along with the twenty district offices, nine forest fire control stations and forty-six forest maintenance headquarters function as fire tool and equipment caches and serve as a dispersed network of dispatch points for firefighters. The Division of Forest Fire Protection maintains a statewide fire cache that is used to distribute wildland fire materials, tools and equipment for both in-state and out-of-state incidents.

The Bureau operates three single engine air tanker bases, two alternate fixed-wing bases and three helibases. All are activated seasonally utilizing contracted aircraft. In addition to suppression aircraft, the Bureau also contracts with private aircraft vendors across the state for single engine aircraft for detection, tactical decision-making and mapping.



Map of Air Operations Bases in Pennsylvania

The Bureau owns forty-six fire towers across the Commonwealth. They remain an important asset for discovering and locating wildfires. Although structurally sound, most are aging and require a significant amount of maintenance and upkeep. Twelve are recognized as "Historic Lookouts". In light of recent budget constraints, they provide an important back-up to our aerial reconnaissance effort.

Description of Issue

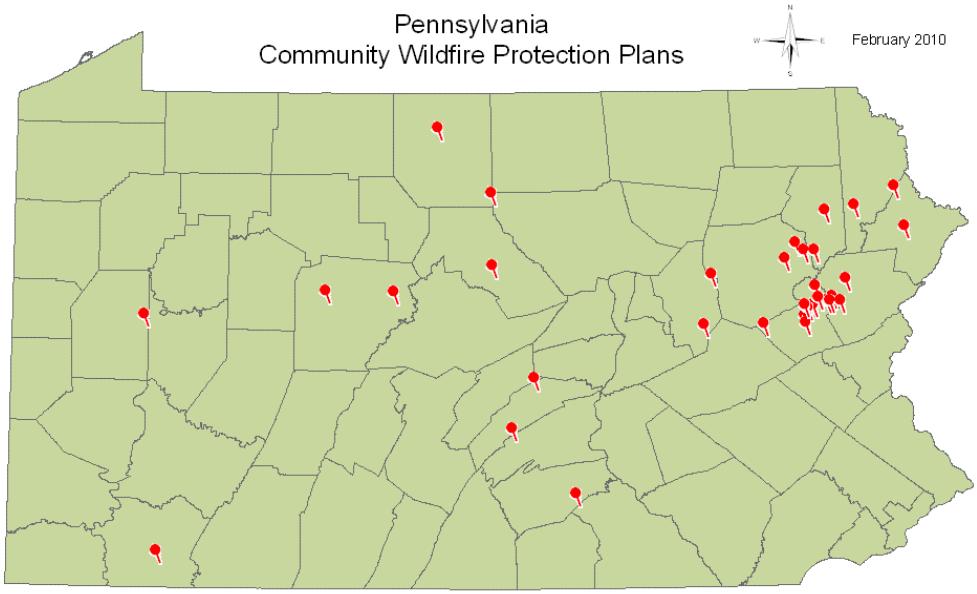
Once primarily a rural issue, the spread of residential development into forested areas has made wildfire a statewide threat. In recent years, wildfires have threatened hundreds of homes. Three aspects of this changing situation are: changing land use, coordination of resources and public awareness.

Land Use Changes

As a Commonwealth, decisions about development are generally made at the township or municipality level. As a result, communities have expanded into previously undeveloped or "wildland" areas at a record pace. The Pocono region in northeast PA stands out as an example. Attracted by forests, streams and wildlife, large seasonal or bedroom communities have developed there with commuters traveling to and from New Jersey and New York City.

Over the last few decades, expansion of these *Wildland/Urban Interface* (WUI) areas—where homes and other human development meet or intermingle with undeveloped land—has significantly impacted all emergency response and disaster management activities. In many areas, community expansion has outpaced local infrastructure, stretching capabilities of fire, police, and other local emergency services. The WUI creates an environment where fire can move readily between structural and vegetative fuels, increasing the likelihood that wildfires will threaten homes and people.

The primary task is to prevent wildfires before they start, but failing that, the imperative becomes making those communities at risk aware of their condition and assisting them to modify their situation. This is a daunting task in Pennsylvania. To address this issue the Bureau of Forestry has developed a Firewise Task Force. The Firewise Task Force has representation from Pennsylvania Fire Commissioner's Office, Pennsylvania Emergency management Agency, Pennsylvania State University, and the Bureau of Forestry. The Task Force developed the Pennsylvania Firewise Communities Program and acts as an advisory committee to address wildland fire issues within the WUI. The Pennsylvania Firewise Communities Program was first introduced in the Pocono Region of the state targeting "gated communities". In 2003 the Firewise Task Force initiated an attempt to develop one Firewise Community in each of the twenty Forest Districts. Sixteen of the twenty districts successfully developed Firewise Communities. Today there are 33 communities that have Community Wildfire Protection Plans (CWPPs). A map and table list of CWPPs is shown below.



Community Wildifre Protection Plans (CWPPs) in Pennsylvania.

Community Wildfire Protection Plans (CWPPs) by County and Township.

Community Name	County	Township
Pine Township	Armstrong	Sugarcreek
Lake Harmony Home Owners Assn	Carbon	Kidder
Julian Woods	Carbon	Packer
Penn Forest Estates	Carbon	Penn Forest
Bear Creek Lakes	Carbon	Penn Forest
Penn Forest Streams	Carbon	Penn Forest
Pleasant Valley West	Carbon	Penn Forest
Hickory Run Forest	Carbon	Penn Forest
Mount Pocahontas	Carbon	Penn Forest
Valley View Estaes	Carbon	Penn Forest
Towamensing Trails	Carbon	Penn Forest
West Branch Susquehanna River (Corridor Community Development)	Clearfield	Cooper
Bear Run Property Association	Clearfield	Pike
White Rock	Clinton	Bald Eagle
Hemlock Springs	Columbia	Briar Creek
Deer Lake Community	Fayette	Wharton
Juniata Forest	Juniata	Fayette
Windsor Hill	Lackawanna	Roaring Brook
Thornhurst Country Club Estates	Lackawanna	Thornhurst
Laurelbrook Estates	Luzerne	Bear creek
Meadow Run (Mtn. Lake Park)	Luzerne	Bear creek
Lake Aleeda (Property Owners Association)	Luzerne	Bear creek
Black Forest Village	Lycoming	Brown
Sierra View Development	Monroe	Chestnuthill

Emerald Lakes	Monroe	Tobyhanna
Indian Mountain Lakes	Monroe	Tunkhannock
Heritage Hills	Perry	Northeast Madison
Hemlock Farms	Pike	Blooming Grove
Forkstone Mountain Property Owners Association	Pike	Lackawaxen
Green Forest Association	Potter	Sweden
Roaring Creek	Schuylkill	Union
Roag Wood Sewer & Water	Wayne	Salem
White Rock Acres	York	Carroll

Recently the Bureau of Forestry has changed their target for Firewise Communities away from gated communities to municipalities to provide opportunities for needed mitigation projects outside of gated communities. The existing plans have been a valuable tool for assisting local communities with wildfire safety and for communicating a wildfire prevention message. Future efforts to expand the CWPP program are planned to target entire townships instead of individual communities, but many challenges currently exist. Cultural norms and local systems of government in the Commonwealth have severely limited township-wide progress to date. The main strategy for overcoming these challenges will focus on local engagement and public education efforts.

Coordination of Resources

As a nation, we thrive on competition. Competition drives us to improve performance and efficiency, often fostering new ideas and paradigms. The wildfire community has benefited greatly and been challenged by competition over the years. Competition for time and resources often leads to shortages in manpower and equipment, leaving rural volunteer fire companies increasingly unable or unprepared to respond to calls. Active memberships are dwindling, and increased demands for training and liability are cited as the main issues.

In previous decades the Bureau was able to maintain a workforce and infrastructure to provide statewide wildfire protection. Budget constraints have changed the picture dramatically triggering layoffs, unfilled positions and loss of veteran staff to retirement without replacement and an increased demand on our federal dollars for things like basic maintenance of buildings and equipment. The Division of Forest Fire Protection is committed to maintaining at least one full-time fire position in each Forest District and to maintaining current staffing levels in the Division of Forest Fire Protection. State and local agencies are not alone in this situation. Federal resources are more frequently overwhelmed, often tapping into state partners for assistance.

An important challenge that must be addressed is the coordination of resources as we respond together to incidents. In Pennsylvania, Bureau of Forestry employees, volunteer forest fire wardens and rural volunteer fire companies are the major players in the mix. Again, because of the nature of our Commonwealth structure, approaching the issues must effectively begin at the local level.

The Bureau has always placed training high on the list of priorities. In recent years an emphasis has been placed on sharing instructors and inviting students from all members

of the fire protection and emergency management community. All-hazard response is now addressed in everyone's protocol.

The Federal Excess Personal Property Program (FEPP) and the DOD Firefighter Property (FFP) programs have proven to be extremely valuable in providing much needed equipment to rural fire companies statewide. Limited community funds are mostly devoted to structural fire protection. The equipment that FEPP and FFP programs provide helps municipalities to meet wildfire protection needs as well. Volunteer Fire Assistance (VFA) cost-share grants have also been critical in directing funds to wildland equipment and training.

In 2006, the Bureau of Forestry began the development of interagency incident management teams (IMTs) primarily to increase its capacity to deal with large or complex wildfires. This program has focused on building and maintaining partnerships with other state emergency management agencies; dealing with all-hazard situations, credentialing, training and responding to wildfire incidents. Currently these teams are being drawn into all-hazard situations. Issues related to authority and support must be addressed by both the Bureau of Forestry and other Commonwealth agencies.

The Bureau continues to be a major player in training and mobilizing resources to national wildfires and other disasters. Maintaining the capacity to train and equip its personnel to meet national standards is increasingly difficult. A critical issue is the need for support in delivering national and compact level trainings for both students and instructors.

Prescribed fire is a tool that has been added to the Bureau's toolbox recently through legislation. The Bureau has been charged with the lead in developing prescribed fire standards, with the expectation that it can and will provide equipment, personnel, training and leadership within the prescribed fire arena. As the demand for prescribed fire increases, so does the demand for plan reviews and tracking of prescribed fire activity across the Commonwealth.
DCNR as an agency is on the threshold of transitioning to a new 800 MHz / Augmented VHF radio system. The use and maintenance of that system will be for multiple agencies and multiple program areas, not just for fire use.

Wildfire incidents will continue to threaten wildlands and the people who live, work and play there. Citizens have greater than ever expectations for swift, sophisticated and coordinated responses to wildfire emergencies. The challenge is to perform by sharing often limited resources in a way that improve performance rather than obstructing it.

Public Awareness
One of the most challenging but critical issues eastern wildland fire managers face is that of public awareness. The nature of the public media business dictates a need to compete with national and sometimes global media events when bringing significant stories to the audience. Wildfires that reach the threshold of national media attention are relatively infrequent here in Pennsylvania.

Although local incidents can grab local media attention, these stories do not have the widespread or sustained impact associated with large fires in western states. That coupled with the timing of eastern fires, typically during spring and fall, often raises issues of credibility. Media efforts are stepped up in March and April long before the perceived risk of fire comes onto the public's radar or TV screen.

Pennsylvania recently has been able to establish a network of Remote Automated Weather Stations (RAWS) across the Commonwealth providing current information on fuels and weather conditions. There is an obvious need to get the information generated by these stations into the hands and minds of those who need it. Technology and desire to facilitate a solution exist, but time, funding and other priorities stand in the way.

Another variable of the awareness challenge is the timeliness and accuracy of information about wildfire occurrence. Because wildfire response is a joint effort in the Commonwealth, local rural fire companies and Bureau of Forestry suppression forces are often not totally aware of each others activity. At least two fire reporting systems exist with information gaps and overlap a routine occurrence. Although reporting isn't necessarily critical in controlling a given fire, it is extremely valuable when planning for and positioning resources. Increased activity in the prescribed fire arena also increases the need to engage in smoke management planning and to keep the public informed of program objectives and activities.

Conclusion

The Pennsylvania Bureau of Forestry is tasked with a large and expanding mission. More than 17% of the state's residents live at risk in Pennsylvania's wildland-urban interface. The Bureau is charged with protecting all of the Commonwealth's wildlands from wildfire. Every aspect of delivering fire protection is becoming more complex and expensive. Public expectations have expanded from protecting natural resources and now include the expectation to protect life and property. . We continue to build our capacity on the wildland fire side of the equation but demand for all-hazard emergency response continues to grow. To meet these needs the Pennsylvania Bureau of Forestry must continue to implement and develop programs with an emphasis on:

- Science-based risk and trend analysis to guide development of effective programs and initiatives.
- Prevention, risk reduction/mitigation, rapid response, and other cost-effective, proactive efforts focused on addressing identified causal factors.
- Building and maintaining strong support for our statewide network of Volunteer Forest Fire Wardens.
- Coordinated state and community-level programs with a broad cross-section of cooperating parties particularly our 2,000 Rural Volunteer Fire Companies.
- Integrated projects whose results impact multiple priorities
- Public outreach, education, and training

- Development of response resources and coordinated response efforts by promoting Community Wildfire Protection Plans to assist local communities with wildfire safety.
- Automated and publicly available information on wildfire risk.

The public safety challenges facing the Pennsylvania Bureau of Forestry are significant. The primary causal factors cannot be eliminated. Effectively identifying and mitigating risks requires continuous, high-level situational awareness coupled with large, ongoing, proactive initiatives in prevention, mitigation, preparedness, capacity building, and rapid response.

Chapter 4H

Issues, Threats and Opportunities - Plant and Wildlife Habitat

Introduction

Pennsylvania functions as a 'keystone state' for critical forms of biodiversity for both the Mid-Atlantic and Midwest, harboring northern, southern, and easternmost outlier populations and subspecies for numerous plants and animals. It forms the northernmost part of the range for southern species such as shortleaf and Virginia pine (*Pinus enchinata* and *Pinus virginiana*), and animals such as the southern leopard frog (*Rana sphenocephala*) and the eastern fox squirrel (*Sciurus niger*). Northern species that terminate the southern end of their range in the state include a number of rare aquatic plant species such as seven-angled pipewort (*Eriocaulon aquaticum*), bur-reed (*Sparganium angustifolium*), water milfoil (*Myriophyllum tenellum*), and water lobelia (*Lobelia dortmanna*) in the states glacial lakes. The endangered massasagua rattlesnake (*Sistrurus catenatus*) and remnant prairie grass communities including the rare side-oats gramma (*Bouteloua curtipendula*) represent easternmost biotic forms of species and communities whose ranges lie westward.

Pennsylvania also contains significant populations of numerous species whose wide habitat ranges but fragmented and sparsely distributed populations make them critical conservation priorities from a genetic diversity standpoint. Just a few examples of species with critical core populations in the state include the Allegheny woodrat (*Neotoma magister*), henslow's sparrow (*Ammodramus henslowii)*, snowshoe hare (*Lepus americanus*), and plants such as tamarack and red spruce trees (*Larix laricina* and *Picea rubens*), and the yellow lady slipper orchid (*Cypripedium parviflorum*). Pennsylvania also serves as a critical migratory and northern nesting site bottleneck between the great lakes and the eastern seaboard for species like the Louisiana waterthrush (*Seiurus motacilla)* and the golden-winged and cerulean warblers (*Vermivora chrysoptera* and *Dendroica cerulea),* making the maintenance of migratory corridors and connectivity between feeding and nesting sites for a diverse assemblage of species a critical conservation concern in the state.

Pennsylvania's historical legacy as a leader in natural resource conservation is closely linked with the high use-values its population places on plant and wildlife habitats. Citizens engage in a wide range of social and recreational uses of natural landscapes for pursuits such as hunting and trapping, fishing, birdwatching, mushroom gathering, berry

picking, and planting and collecting forest medicinal herbs such as ginseng and goldenseal, and the forest products industry represents a critical component of the state's economy while also impacting forest habitat values. Sustaining and enhancing the unique opportunities that Pennsylvania's natural diversity provides citizens and visitors alike is an important component of its ecological keystone role, but a critical challenge in coming years is to recognize and begin to adapt to inevitable changes to the make up of Pennsylvania's forest cover and the habitat types that it will likely support.

The Shifting Mosaic of Pennsylvania's Forest Habitats

The ranges of tree species in eastern North America have generally shifted northward as the climate has warmed over the past 14,000+ years since the last ice age (Davis 1969, Delcourt and Delcourt 1981, Webb et al. 1987, Schmidtling 2007). Historically, the ranges of different species have shifted differentially, resulting in changing forest community compositions over time. Climate change is expected to continue to shift the ranges of tree species generally northward so trees in habitats that become increasingly unsuitable for them will be stressed and therefore more susceptible to other stressors including atmospheric deposition and both native and non-native insects and diseases. Thus stressed, mortality rates will increase, regeneration success will decline, and species populations will decline. Tree mortality due to secondary impacts may be difficult to attribute the changes directly to a changing climate. Tree mortality could also increase if climate change increases the frequency of droughts and severe storms. As the habitat becomes less suitable for one suite of species, the habitat will become more suitable for others. Some species will likely disappear from Pennsylvania's forests entirely. Some of those species are already present in Pennsylvania, and their numbers will likely increase as they experience greater regeneration success and survival. While it is likely that the climate of the state will become suitable for some species not currently found in the state, it is less clear how rapidly – or even whether – those species will migrate to the state without active human intervention (Higgins and Harte 2006) Species migration will also be hindered by the fragmented nature of modern landscapes.

The ecosystem services that forests provide, such as slowing flood waters, maintaining groundwater recharge, reducing erosion, and filtering water, are threatened by the effects of climate change on forests. As regional warming increases, high elevation ecosystems and species that require lower temperatures and specific forest systems will see available habitat shrink, and may eventually become locally extinct if they are unable to migrate. Some current forest types such as spruce-fir, hemlock, mountain ash, sugar maple, and butternut are likely to disappear from the Bay watershed altogether. Limited by slow dispersal rates and habitat fragmentation that cuts off migration corridors, many tree species will not be able to naturally migrate into areas providing newly suitable habitat. In addition, with increasing temperatures come changes in the timing of recurring natural phenomena like budding, flowering, pollination and breeding which may have significant effects on the ability of plant species to regenerate. These effects compound to create stressed forests that are more susceptible to invasions by insects, disease, and invasive plant species. These factors further result in canopy and footprint fragmentation,

disruption of mobility corridors for ground dwelling species, and increased exposure of leaf litter layers with potential for associated release of greenhouse gases.

Researchers at the USDA Forest Service's Northern Research Station have developed models to project shifts in the potential suitable habitat for various tree species under different climate change scenarios (Iverson and Prassad 1998, 2001, 2002, 2003, Iverson et al. 1999a, 1999b, 2004a, 2004b, 2005, 2007, 2008a, 2008b, Prassad et al. 2006). Maps of Pennsylvania showing the modeled suitable habitat for 36 species under current climatic conditions and under projected climatic conditions 100 years from now under four climate change scenarios are shown in Appendices 4D-1 and 4D-2. How and whether species will be able to migrate to regions where they are not currently found is an open question. While the projections are a long time off by human time-scales, most tree species live for at least 100 years, so trees that are established now could experience these changed conditions within their lifetimes.

Scientific Name	Common Name	ClimIndx	ModRelv	Current	HadHiDif	PCMLoDif	GCMIAvgHiDif	GCMIAvgLoDif
Betula papyrifera	paper birch	Medium	High	0.08	-0.08	-0.08	-0.08	-0.08
Populus tremuloides	quaking aspen	High	High	0.04	-0.04	-0.10	-0.04	-0.03
Populus grandidentata	bigtooth aspen	High	High	1.17	-1.17	-0.48	-1.17	-0.82
Betula alleghaniensis	yellow birch	High	High	0.00	-0.01	-0.48	-0.00	-0.01
Fagus grandifolia	American beech	Low	High	5.32	-4.19	-2.54	-3.97	-2.97
Prunus serotina	black cherry	Medium	High	9.97	-8.08	-2.95	-9.09	-5.34
Acer pensylvanicum	striped maple	Medium	High	1.20	-0.99	-0.43	-0.93	-0.64
Tsuga Canadensis	eastern hemlock	High	High	2.82	-1.87	-0.93	-1.87	-1.37
Acer rubrum	red maple	Medium	High	14.69	-10.73	-2.00	-10.24	-4.97
Acer saccharum	sugar maple	Low	High	6.63	-5.42	-1.10	-4.10	-1.40
Pinus strobus	eastern white pine	Medium	High	1.98	-1.41	-0.28	-1.34	-0.43
Betula lenta	sweet birch	Medium	High	3.79	-2.43	-0.45	-2.39	-1.32
Fraxinus Americana	white ash	Medium	High	6.17	-3.94	-1.10	-3.67	-1.95
Tilia Americana	American basswood	Low	Medium	0.79	-0.43	-0.06	-0.44	-0.17
Quercus rubra	northern red oak	Medium	High	5.02	-1.60	-0.56	-1.20	-1.02
Quercus prinus	chestnut oak	Medium	High	4.81	-2.12	0.58	-1.99	-0.24
Liriodendron tulipifera	yellow-poplar	Medium	High	2.21	-1.06	0.99	-0.92	0.30
Sassafras albidum	sassafras	High	High	2.46	-0.48	1.07	-0.65	0.91
Carya glabra	pignut hickory	Medium	High	1.37	0.31	0.79	0.44	0.95
Nyssa sylvatica	blackgum	Medium	High	1.77	1.04	0.98	0.99	0.97
Juglans nigra	black walnut	Medium	Medium	0.72	0.01	0.55	0.36	0.70
Quercus alba	white oak	Medium	High	3.57	1.99	1.42	2.94	2.47
Ulmus Americana	American elm	High	Medium	1.36	1.55	-0.06	1.65	0.49
Cornus florida	flowering dogwood	Low	High	1.95	1.03	1.65	1.57	2.24
Carya tomentosa	mockernut hickory	Medium	High	1.37	1.78	0.76	1.64	1.10
Quercus velutina	black oak	Low	High	2.37	3.82	1.16	4.72	2.51
Acer saccharinum	silver maple	Medium	Medium	0.28	1.05	-0.05	0.96	0.29
Juniperus virginiana	eastern redcedar	High	Medium	0.40	3.88	1.31	3.72	2.40
Pinus taeda	loblolly pine	Medium	High	0.01	4.08	0.12	1.78	0.28
Pinus echinata	shortleaf pine	Medium	High	0.01	6.83	0.31	5.18	1.16
Diospyros virginiana	common persimmon	Medium	Medium	0.01	2.91	0.44	2.90	1.09
Morus rubra	red mulberry	Medium	Low	0.00	2.64	0.02	1.96	0.30
Carya tenera	black hickory	Medium	High	0.00	4.12	0.26	3.84	1.08
Quercus marilandica	blackjack oak	Medium	Medium	0.00	4.51	0.28	3.83	0.97
Ulmus alata	winged elm	High	High	0.00	6.47	0.38	5.07	1.12
Quercus stellata	post oak	High	High	0.01	14.11	1.37	12.05	3.80

Modeled current and projected changes in area-weighted importance values for selected species in Pennsylvania

The table above summarizes the information from the species maps in Appendices 4D-1 and 4D-2 by showing the current modeled area-weighted importance values (not their actual values) for the 36 species and the projected changes in these importance values for each species 100 years from now under four climate change scenarios.

The species in the table have been sorted into six broad categories, ranging from those that are likely to be extirpated from the state under the warmer, high CO2 scenario to species that are currently rare or not found in the state that are projected to find good habitat under the high CO2 scenario. The species in the first category are paper birch, quaking aspen, bigtooth aspen, and yellow birch. All these species are currently more common in the northern part of the state or at higher elevations. Paper birch has the smallest amount of modeled suitable habitat under current conditions, and suitable habitat for this species is projected to disappear from the state even under the coolest scenario (assuming CO2 emission reduction). Quaking aspen currently has more modeled suitable habitat than paper birch, yet it, too, is largely projected to be extirpated from the state, except under the coolest scenario. Bigtooth aspen is currently modeled to have suitable habitat in most of the state, and its habitat is projected to become limited to the more northern and higher parts of the state under the low-emissions scenarios. The suitable habitat for yellow birch is currently limited primarily to the northern and higher parts of the state. As the climate is projected to warm, its suitable habitat is projected to shrink, but even under the warmest scenarios it is projected to maintain a toehold in the state in the Pocono's region.

The importance values of the species in the next category – American beech, black cherry, striped maple and eastern hemlock – are projected to decline substantially (30-56%) under the cooler scenarios and dramatically (66-91%) under the warmer scenarios. This group includes three of the six most common species in Pennsylvania. American beech is the fourth most common species in the state (McWilliams et al 2007). The most suitable habitat for American beech is currently in the northern part of the state, but suitable habitat is modeled to exist throughout the state under current conditions. Under the cooler scenarios, beech habitat remains distributed throughout the state, but with lower importance values. Under the warmer scenarios, the species' habitat retreats to the more northern and higher parts of the state. This species is already experiencing heavy mortality in the northern and eastern parts of the state due to beech bark disease, a non native disease complex caused by a combination of an insect and a fungus (Houston and O'Brien 1983). Climate change may exacerbate this problem by increasing the stress on the species. Black cherry is the third most common species in Pennsylvania (McWilliams et al 2007), and it is found throughout the state. The best black cherry habitat is currently found in the western part of the state. Under the cooler scenarios, the best habitat for this species shifts to the northern and higher parts of the state. Even under the warmest scenarios, suitable habitat for the species is projected to be found throughout the state, but the species' area-weighted importance values are reduced by 66 to 91 percent. Black cherry is currently the most valuable commercial species in the state, and its loss would be a major blow to the state's hardwood lumber industry. Suitable habitat for striped maple is currently found in the central and northern highlands of the state. As the climate

warms, its suitable habitat is projected to shrink, but it is still projected to be found in a narrow north-south band in the central part of the state.

Like most of the other species in this second category, the most suitable habitat for eastern hemlock is currently found in the northern part of the state and areas with higher elevation. Currently the sixth most common species in Pennsylvania (McWilliams et al 2007), the importance values of the habitat for this species are projected to decline, but its range is not projected to shrink substantially, even under the high-emissions scenarios. However, this species is currently under attack in the southeastern half of the state from the hemlock wooly adelgid, an exotic insect that feeds on the trees, causing them to decline and die over several years (McClure et al. 2001). The range of the hemlock wooly adelgid continues to spread to the west and the north. Increased stress from climate change will likely make hemlocks more susceptible to attacks by the adelgid. Eastern hemlock is not a valuable timber species, but it has significant ecological and aesthetic value. Hemlocks often grow in the lower, wetter areas along streams, and their dense shade helps to maintain the colder stream temperatures that brook trout and other native fishes are adapted to. The species' dense foliage provides cover for a variety of wildlife species, including the black-throated warbler, the solitary vireo, and the northern goshawk, all of which are dependent on hemlock forest habitats. Hemlocks are also widely used as landscaping trees in urban and suburban environments.

The importance values of the species in the next category – red maple, sugar maple, eastern white pine, sweet birch, white ash, and American basswood – are projected to decline moderately (8-35%) under the cooler scenarios and substantially (54-82%) under the warmer scenarios. This group includes four of the seven most common species in the state. Red maple is currently the most common tree in Pennsylvania (McWilliams et al. 2007), and it is found throughout the state but is more prevalent in the higher, more northern areas. Red maple has been expanding its dominance in the state for the past several decades. Abrams (1998) describes the species as a "supergeneralist" that thrives in a wide variety of circumstances. He hypothesizes that until recently the species was limited primarily by frequent fires, often set by Native Americans and early European settlers. Red maple has dramatically expanded its habitat with the near-elimination of fire from Pennsylvania's forests in the 20th century. While still a relatively low value species, red maple stumpage prices have generally increased more than those of other species, and it is now a moderately valuable timber species (Jacobson and Finley various years). While red maple continues to increase in volume in the state, the number of red maple trees began to decline between 1989 and 2004 (McWilliams et al. 2007) with the declines happening entirely in the smallest diameter classes. This suggests that while mature red maple trees continue to grow and add volume, regeneration of this species is slowing. This would be consistent with the projections in the above table (modeled current and projected changes), which show red maple's area-weighted importance values declining by 14-34 percent under the low emissions projections and by 70-73 percent under the high-emissions projections.

Sugar maple is currently the fifth most common tree species in Pennsylvania (McWilliams et al. 2007). It is one of the most widely recognized trees in Pennsylvania's

forests, known for its attractive and valuable wood, the syrup made from its sap, and its stunning fall colors. Unfortunately, sugar maple has been declining throughout the northeastern US, particularly in northern Pennsylvania, since at least the mid 1980s (Horsley et al. 2000, 2008, Driscoll et al. 2001). This decline has been attributed to repeated defoliations by a variety of insects including the elm spanworm, drought, soil nutrient depletion attributed to atmospheric deposition, and climate change. Sugar maple is found throughout Pennsylvania, and its range is not projected to change significantly under the cooler scenarios, but the projected area-weighted importance values decrease by 17 to 20 percent. Under the warmer scenarios, however, much of the southern part of the state is projected to become unsuitable for this species, and its importance values are projected to decline by 62 to 82 percent.

Eastern white pine, the tallest tree species in eastern North America, was once one of the most common trees in northern Pennsylvania and even today is found in nearly all parts of the state. Heavy harvesting of the species for ships' masts and its other uses in the 18th and 19th centuries greatly reduced the species' abundance. Recently, the species has been making something of a comeback in the state, with increasing numbers in both large and small diameters (McWilliams et al. 2007). Under the projected climate change scenarios, however, the species' suitable habit is increasingly restricted to the northern and higher-elevation parts of the state and its projected area-weighted importance values decrease by 14 to 22 percent under the cooler scenarios and by 68 to 71 percent under the warmer scenarios.

Sweet birch, also commonly known as black birch, is currently the second most common species in Pennsylvania and the most rapidly increasing in abundance (McWilliams et al 2007). Sweet birch is not adapted to fire and, like red maple, has probably benefited from the success of fire exclusion since the early part of the 20th century. While sweet birch is used for lumber production it is not a high value species, as it seldom reaches a large size and has generally poor form. The habitat suitability projections suggest that the trend toward the increasing abundance of sweet birch in the state may be reversed by climate change, with the species' importance values projected to decrease by 12 to 35 percent under the cooler scenarios and by 63 to 64 percent under the warmer scenarios. Suitable habitat for the species shifts toward the northeastern part of the state.

White ash is currently the seventh most common tree species in Pennsylvania (McWilliams et al. 2007). While ash lumber is used for specialized purposes such as baseball bats and flooring, these uses and the stumpage prices for ash have declined in the past 20 years (Jacobson and Finley various years). Ash is a popular landscaping tree in urban and suburban settings. The habitat projections suggest that climate change will greatly reduce the suitability of the habitat in the state for this species, yet even under the warmer scenarios, the species could potentially be found in all parts of the state. However, a greater threat to the species, and other ash species as well, is the emerald ash borer, an exotic insect that has devastated ash populations in Michigan, Ohio, Indiana and Ontario (McCullough 2009). Experience in those states suggests that once the emerald ash borer becomes established virtually all the ash trees in the area are eventually killed. The insect was identified in the Pittsburgh area in 2005 and in central Pennsylvania in

early 2009. It is considered highly likely that it will eventually kill nearly all the ash trees in the state.

American basswood, the final species in this category, is currently widely distributed at relatively low densities in most parts of the state, except the southeastern and, to a lesser degree, the southwestern corners of the state, where it is not currently expected to find suitable habitat. As the climate is projected to warm, the species is projected to retreat to the north and the east and the higher elevations. Model projections for this species are less reliable, however.

The next category includes four species – northern red oak, chestnut oak, yellow-poplar, and sassafras – that are currently fairly widely distributed within the state and are projected to either be harmed only marginally or even benefit marginally in the state under the cooler, low-emissions scenarios, but will generally suffer moderate losses of habitat quality (importance values declining by 20 to 48 percent) under the hotter, high emissions scenarios. Northern red oak and chestnut oak are currently the eighth and ninth most common species in the state, respectively. In terms of biomass, northern red oak is the third most important species in the state and chestnut oak is the fifth. Both have experienced small declines in their numbers in the past two decades (McWilliams et al. 2007). Their decline is partly due to a general problem with regenerating oak species in the eastern US (Lorimer 1993). Northern red oak is projected to decline moderately under either the low-emissions scenarios (11-20%) or the high-emissions scenarios (24-32%). Chestnut oak is projected to stay about the same under the low-emissions scenarios (-5 to +12%) but decline under the high-emissions scenarios (41-44%).Yellow-poplar and sassafras are projected to gain (14-45%) under the low-emissions scenarios but decline (20-48%) under the high-emissions scenarios. The extreme northeastern part of the state does not have suitable habitat for either of these species when modeled under current conditions, and one can see the northward progression of suitable habitat as all of the state is modeled as suitable habitat, albeit at a low level of reliability, for these species under all of the future scenarios.

The six species in next category are projected to find moderately better habitat in the state under climate change. Three of the species – pignut hickory, black walnut, and flowering dogwood – benefit more (58-115%) under the low-emissions scenarios than they do under the high-emissions scenarios (1-81%). The other three species in the category – blackgum, white oak, and American elm – tend to gain moderately (-4 to +64%) under the low-emissions scenarios and do even better (56-121%) under the high-emissions scenarios. The best habitat for most of the species in this category shows a definite shift from the southern part of the state to the northern part of the state. Blackgum is currently the tenth most common species in the state (McWilliams et al. 2007). Blackgum is a medium-sized tree, and is not particularly valuable as a timber tree. It is currently distributed mostly in the southern part of the state. It is projected to benefit about the same amount (55-59%) under all scenarios, but the best habitat for the species is projected to shift further north under the higher-emissions scenarios.

Black walnut trees are highly prized for their attractive, dark-colored wood and their edible nuts. The species is not currently common in Pennsylvania, and is found mostly in the state's southwestern and southeastern corners. Black walnut is projected to gain more under the cooler scenarios, expanding its habitat to nearly all of the state. Under the warmer scenarios the species' habitat shifts out of the southwestern and southeastern parts of the state to the northern and central parts of the state, so although the importance values for the species are about the same under the high scenarios as under current modeled conditions, the species would be found in almost completely different parts of the state. This species also has a relatively low model reliability rating.

White oak is one of the more valuable timber species in the state (Jacobson and Finley various years). While it is only the 15th most common species in the state, it is the eighth most important by biomass volume (McWilliams et al. 2007). White oak is currently found mostly in the central part of the state and is relatively rare in the northern tier of counties. Its range is projected to expand under the low-emissions scenarios and shift to the north under the high-emissions scenarios.

American elm habitat is projected to improve somewhat under the low-emissions scenarios and more substantially under the high-emissions scenarios. However, this tree has already been decimated in the state by Dutch elm disease and is now suffering from a new non-native species, elm yellows. It is unlikely that this species will be common in Pennsylvania's forests in the future. Flowering dogwood is an understory tree, known for its spring flowers. It is currently found primarily in the southern part of the state. Favorable habitat for the species is projected to expand in the state under the low emissions scenarios and shift to the northern part of the state under the high emissions scenarios. However, the species has been heavily hit by an exotic fungal disease, dogwood anthracnose.

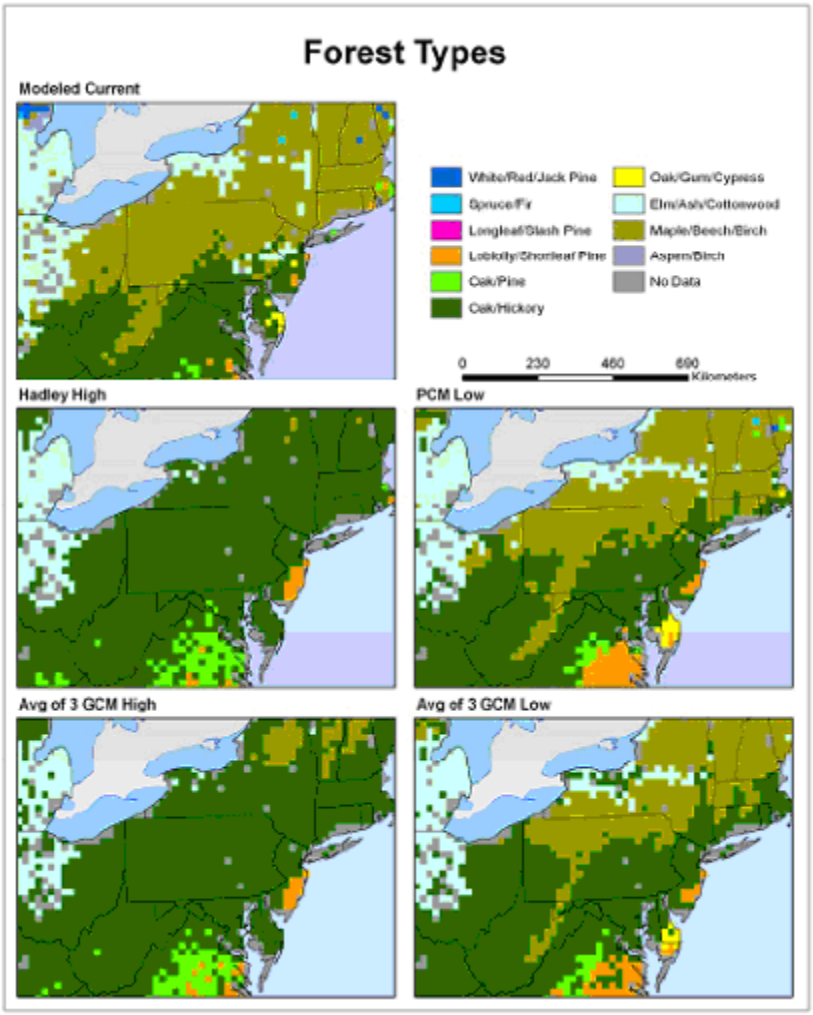
The next category includes four species that are expected to gain substantial habitat in the state under climate change. Two of the species – mockernut hickory and black oak – are currently somewhat common in southern Pennsylvania. The area-weighted importance values for these species are projected to improve in the state, by 53-116 percent under the low-emissions scenarios and by 140 to 280% under the high-emissions scenarios, and their habitats shift into the northern parts of the state. The other two species in this category – silver maple and eastern red cedar – are currently not common in Pennsylvania and are found mostly in the southeastern part of the state. The habitat for silver maple is not projected to change much under the cooler scenarios, but is projected to expand throughout the state under the warmer scenarios. Suitable habitat for red cedar is projected to expand considerably under the cooler scenarios and throughout the state under the warmer scenarios. Model reliability for these two species is relatively low.

The final category includes eight species – loblolly pine, shortleaf pine, common persimmon, red mulberry, black hickory, blackjack oak, winged elm, and post oak – that are currently rare in Pennsylvania, but that are projected to gain substantial habitat in Pennsylvania. Whether these species will thrive in the state as well as the model projects is less certain than for species in other categories in the table. The statistical model

reliability for three out of eight species in this category is either medium or low, and Peters et al. (2008) question the reliability of the projections for winged elm, black hickory and post oak, even though these species are given a high statistically-based model reliability rating. Shortleaf pine and loblolly pine are southern pine species with very little suitable habitat in the state under current conditions. Under the low-emissions scenarios, suitable habitat for shortleaf pine is projected to expand to most of the southern half of the state, with the exception of the Laurel Highlands region. Loblolly pine is projected to expand its range but remain mainly in the coastal plain of the southeastern portion of the state. Under the high-emissions scenarios, all of the state is projected to become suitable for shortleaf pine and importance values increase dramatically. Loblolly pine expands its range to all but the northern tier of counties and increases its importance values dramatically in the state's southeastern corner. Foresters have considerable experience managing these species in plantations, and rotations for these species are relatively short (2-4 decades), so it is quite plausible that these species could be widely established in the state by the end of the century.

Whether or not the remaining species in this category will become widely distributed in Pennsylvania is more speculative. Winged elm is susceptible to elm yellows disease, so it is not likely to be common in the state in the future. Post oak and black oak are likely to be more limited by soils than reflected in the models (Peters et al. 2008), and in general oaks and hickories are currently difficult to regenerate in much of the eastern US, including Pennsylvania, even when they are already present (Lorimer 1993). Persimmon and mulberry are not particularly valuable species for their lumber, so it is unlikely that large areas will be planted in those species.

In summary, the eight most common species in Pennsylvania – red maple, black birch, black cherry, beech, sugar maple, eastern hemlock, white ash and northern red oak – are all projected, to varying degrees, to lose habitat in the state under climate change. Most of these species are associated with the northern hardwood (maple-beech-birch) forest type, which is currently modeled as the dominant forest type in the state. Under the low-emissions scenarios, the area dominated by this forest type is projected to shrink, but it remains the dominant forest type in the state. Under the high-emissions scenarios, however, this forest type is projected to disappear from the state and even from much of New York and New England as well. Thus, it seems very likely that northern hardwood species will lose habitat and become less abundant in the state under climate change. The extent to which this will occur, however, is highly dependent on the level of emissions over the coming decades and the degree of climate change that occurs.



Current modeled forest type distribution in Pennsylvania and surrounding states and projected forest type shifts under four climate change scenarios (image provided by Louis Iverson and Matt Peterson).

Species that tend to gain habitat in the state are oaks, hickories and southern pines. Thus, the oak-hickory forest type that currently occurs primarily in the southern part of the state is projected to expand its area under the low-emissions scenarios and completely dominate the state under the high-emissions scenarios. Whether and how this will occur is less certain, however, given current difficulties establishing oaks and hickories throughout the eastern US (Lorimer 1993). Oak is typically established using natural regeneration techniques that rely on the presence of an existing seed source. The large tap root that helps give oak its ability to survive (and even thrive) with fire also makes it a relatively difficult species to establish in plantations (Johnson et al. 2002).Furthermore, oaks and hickories are generally managed on longer rotations (60-100 years), which make large investments in stand establishment unprofitable in most situations. Finally, oaks and hickories are fire-adapted species, and prescribed fire is difficult to apply in landscapes with high human populations (such as much of Pennsylvania). Southern pines are also projected to find increasingly suitable habitat in Pennsylvania. Southern pines are

commonly managed in plantations and their cultivation is relatively profitable, so it seems reasonable that large areas of the state – primarily in the south – could eventually be converted to pine plantations. Black walnut is another species that is projected to find improved habitat in Pennsylvania under climate change. Because of the high value of its wood, black walnut is cultivated in other parts of the country, and it may become feasible to profitably grow high-quality black walnut in Pennsylvania as the state's climate warms.

Critical Issues Impacting wild plant and animal species and their habitat.
For the purposes of this assessment, critical issues have been categorized to allow for more intuitive integration with program functions and funding flows administered specifically by the Bureau of Forestry within Department of Conservation and Natural Resources. The Bureau of Forestry sees tremendous opportunity in Farm Bill and other funding to address plant and wildlife habitat issues in concert with the other issues and strategies addressed in the assessment and other partners inside and outside the agency with critical roles to play in the state's conservation of biotic resources (i.e. Pennsylvania Natural Heritage Program, Pennsylvania Fish and Boat Commission, Pennsylvania Game Commission, etc.). In particular, DCNR is particularly interested in working with other state level partners to leverage available EQUIP, WHIP, and CREP funds to address shared environmental and habitat goals. For a fuller treatment of the issues facing wildlife habitats in Pennsylvania, please refer to the State Wildlife Action Plan (http://www.wildlifeactionplans.org/pdfs/action_plans/pa_action_plan.pdf). For additional information about the state's listed plant species and unique natural communities, please refer to the Pennsylvania Natural Heritage Program's website (http://www.naturalheritage.state.pa.us/).

1. Climate Change, Invasive species, and the Identification of Keystone Habitats

Invasive species have long been a threat to native wild plant and animal habitats. Allocating scarce resources to mitigate their impact on native species and habitats is a critical challenge for natural resource managers. Concern is also growing over how to sustain primary ecosystem functions such as nutrient, water, and carbon cycling while also sustaining as many native forms of biota and habitats as possible in the face of potential vegetation shifts due to global climate change. A potential approach is to identify existing keystone habitat types or species that are likely to represent "best bet" alternatives for sustaining ecosystem functions and native diversity within the face of continued invasive species threats and climate induced plant community change. (See also Chapter 4D: Climate Change)

2. Habitat loss and degradation due to fragmentation and conversion of native cover types.

By far one of the most critical impacts on wild plant and animal habitats is the loss of extent and connectivity of native plant communities due to increased use of the landscape to support residences, roads, energy infrastructure and other anthropocentric uses. These factors often have the most negative impacts on biodiversity where they are least noticeable; for example, when large, contiguous forest interior habitats are used to support gas wells, transmission lines, windmill farms, and other forms of infrastructure. These trends are all projected to increase in rural regions of the state experiencing Marcellus Shale drilling, wind development, and residential development, and have negative impacts on both early and late successional species and habitats. Species at risk from further fragmentation of large, forest interior areas include species like the already rapidly declining cerulean warbler (*Dendroica cerulea*) which is especially vulnerable to nest predation by the brown-headed cowbird (*Molothrus ater)* as the degree of habitat fragmentation around its nesting sites increases.

But habitat loss and degradation also threatens to locally extirpate remnant plant populations or habitat and cover types that are locally rare on many agricultural or suburbanizing landscapes across the state. Continued loss of plant and wildlife populations and connectivity of habitat patches for both specialist and generalist species on rural and suburbanizing landscapes not only further erodes the survival potential of local species at risk (for example, the bog turtle *(Glyptemys muhlenbergii)*, but often degrades the carrying capacity of the landscape to support human use interactions with nature, often turning popular and potentially economically valuable game species like the white-tailed deer (*Odocoileus virginianus)* into a municipal pest and public burden due to the loss of huntable cover patches due to land use change. (See also Chapter 4A: Land Use)

3. Lack of Regeneration and Understory "super competitors."

Numerous current theories attempt to explain prevailing conditions in Pennsylvania's forest habitats which include both a lack of abundance and diversity of advanced tree seedlings and shrubs, and an overabundance of a few, dominant understory species including hay scented fern, striped maple, and mountain laurel. Past and current selective browsing pressure by overabundant deer herds, acid deposition, and the disruption or suppression of historic fire regimes are all theories that have been posited as explanations of these understory conditions. Determining which model more efficiently predicts habitat recovery and diversity in different landscape contexts could go a long way toward understanding interrelationships between these three causal dynamics influencing plant and animal habitat, while continuing causal uncertainty often both hampers managers ability to efficiently allocate resources for habitat improvement or conservation and erodes public trust in conservation management decisions for both generalist and specialist species. As public land managers are called upon to implement more explicit management priorities for rare, specialist plant communities in order to sustain and enhance landscape level diversity, more

measured understanding of ecological drivers on individual landscapes and target community habitat needs will be needed.

4. Overstory Decline of Critical Tree Species

Many of the state's most important overstory tree species from an overall biological carrying capacity perspective are facing significant health threats. Examples include gypsy moth induced mortality in oak coupled with concurrent problems with oak regeneration, sugar maple decline, beech bark/nectria complex, hemlock wooly adelgid, and emerald ash borer, to name just a few. The impacts of decline of these tree species on wildlife are intuitive and direct in many cases. For instance, the loss of hemlock is a critical additional stressor to the already at risk northern flying squirrel which is highly dependent on mature, coniferous forests, or brook trout, which rely on the deep shade of hemlock cover to maintain favorable temperature regimes in many of the state's highest quality streams. Significant compositional shift away from the hard-mast producing oak and healthy beech forests represents a critical loss of carrying capacity for popular game species such as deer, bear, and wild turkey.

Though little is known about the impact overstory species declines will have on the diversity of other plants, given trends towards increasing competitiveness of relatively a-mychorrizal species such as red maple across much of the state, there is also some concern that current forest community compositional changes in overstory species fitness may also reflect decreasing diversity in the mycelial network with long-term implications for other plant associates as well. While indian pipes *(Monotropa uniflora)* might pose the most extreme example of plant species potentially at risk due to loss of mychorrizal host plant species in the overstory, the complex linkages between overstory tree species, underground mychorrizal diversity, and understory plant diversity makes forest compositional change and decline of keystone overstory species a critical issue from both a plant and wildlife habitat perspective. (See also Chapter 4B: Forest Health)

5. Degradation and Conversion of Wetland and Aquatic Habitats and Riparian Corridors.

Riparian and aquatic habitats are some of the state's richest in biodiversity. Healthy freshwater aquatic ecosystems also provide a high level of public ecosystem services in the form of clean water, flood control, and outdoor recreational opportunities. Addressing the causal factors leading to negative impacts on these habitat types is an extremely high priority in conservation planning.

Known causal factors negatively impacting riparian and aquatic habitats include:

- Acid mine drainage
- Atmospheric deposition of nutrients and pollution

- Groundwater infiltration of nutrients and pollution from anthropogenic activities on the landscape (i.e. agricultural production, lawn fertilization, extractive resource activities, etc.)
- Sedimentation loading from soil disturbance activities, including forest harvesting, road building or maintenance, and agriculture
- Increased areas of impervious surfaces resulting in increased storm water runoff and reduced infiltration
- Loss or degradation of floodplain and wetland habitats
- Lack of sufficient forest cover along lower order tributaries to support in-stream diversity levels and ecological functions
- Water withdrawals by utilities and agriculture that lower stream volumes and constrain buffering capacities of hydrologic and aquatic systems
- Unused dams that promote eutrophication and sever biological connectivity

Species most at risk range from those obviously dependent on high quality streams (eastern brook trout (*Salvelinus fontinalis*) and northern riffleshell mussel (*Epioblasma torulosa*)) and wetlands (e.g. disturbance sensitive amphibious species like the Jefferson salamander (*Ambystoma jeffersonianum*)) to less obvious associates such as the Louisiana waterthrush (*Seiurus motacilla*) which depends on riparian and wetland plant communities for migratory, feeding, and nesting habitats. But perhaps more critical even than the known rare or endangered species associated with these types of habitats is the loss of efficiency in nutrient uptake and processing provided by a diverse suite of invertebrates, algae, and bacteria. Loss of ecological functioning within these habitat types not only affects the carrying capacity and diversity of plant and wildlife species associated with them, but also the quality, quantity, and cost of fresh water resources available for human use. (See Water Section under Chapter 2: Benefits and Services)

6. Threat of endemic diseases in Rare, Threatened, Endangered, or Keystone Species

The relatively recent discovery of White Nose Syndrome in Pennsylvania's bat populations exemplifies how quickly critical and unforeseen factors can impact species already at risk. There is a need for emergency funding mechanisms that allow management agencies to conduct research and monitoring necessary to incorporate such unforeseen developments into conservation planning for keystone species at risk. Timely assessment of the additional risk factors posed by WNS to a species like the Indiana bat is critical in order to fine tune ongoing policy development around issues like wind energy.

Summary

Multiple issues impact plant and wildlife species and habitats based on Pennsylvania's context. DCNR works with partners on efforts leveraged to address them. See Appendix 4h for the State Wildlife Action Plan summaries which provide a matrix linking critical animal species with critical habitat types.

References

Abrams, Marc D. 1998. The red maple paradox. *Bioscience* 48:355-364. Alig, Ralph J. 2006. Land-base changes in the United States: long-term assessments of forest land condition. In: *Proceedings of the Sixth Annual Forest Inventory and Analysis Symposium*; 2004 September 21-24; Denver, CO. Gen. Tech. Rep. WO-70. Washington, DC: U.S. Department of Agriculture Forest Service. 126 p.

Davis, M. B. 1969. Climatic changes in southern Connecticut recorded by pollen deposition at Rogers Lake. *Ecology* 50:409–422.

Delcourt, P.A. and Delcourt, H.A. 1981. Vegetation maps for eastern North America:40,000 yr BP to the present. In: Romans, R.C., ed. *Geobotany II*. New York: Plenum Press: 123-165.

Driscoll, C. T., G. B. Lawrence, A. J. Bulger, T. J. Butler, C. S. Cronan, G. Eagar, K. F. Lambert, G. E. Likens, J. L. Stoddard, and K. C. Weathers. 2001. Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects, and management strategies. *BioScience* 51:180–198.

Higgins, P. A. T., and J. Harte. 2006. Biophysical and biogeochemical responses to climate change depend on dispersal and migration. *Bioscience* 56:407–417.

Horsley, Stephen B., Scott W .Bailey, Todd E. Ristau, Robert P. Long, Richard A. Hallett. 2008. Linking environmental gradients, species composition, and vegetation indicators of sugar maple health in the northeastern United States. *Canadian Journal of Forest Research* 38(7):1761-?.

Houston, David R., and James T. O'Brien 1983. *Beech Bark Disease.* U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station**.** Forest Insect and Disease Leaflet 75. Accessed online at http://www.na.fs.fed.us/spfo/pubs/fidls/beechbark/fidl-beech.htm, March, 2009.

Iverson, L.R., Prasad, A.M., 1998. Predicting abundance of 80 tree species following climate change in the eastern United States. *Ecol. Monogr.* 68:465–485.

Iverson, L. R. and A. M. Prasad. 2001. Potential changes in tree species richness and forest community types following climate change. *Ecosystems* 4:186-199.

Iverson, L. R. and A. M. Prasad. 2002. Potential redistribution of tree species habitat under five climate change scenarios in the eastern US. *Forest Ecology and Management* 155(1-3):205-222.

Iverson, L. R. and A. Prasad. 2003. Using FIA data to assess current and potential future tree species importance values in the Eastern United States. Pages 171-172 in R. E. McRoberts, G. A. Reams, P. C. Van Deusen, and J. W. Moser, eds. *Proceedings of the Third Annual Forest Inventory and Analysis Symposium*. North Central Research Station, Forest Service U.S. Department of Agriculture, St. Paul, MN.

Iverson, L.R., Prasad, A.M., Hale, B.J., Sutherland, E.K., 1999a. *An atlas of current and potential future distributions of common trees of the eastern United States.* General Technical Report NE-265, Northeastern Research Station, USDA Forest Service, Radnor, PA.

Iverson, L.R., Prasad, A.M., Schwartz, M.W., 1999b. Modeling potential future individual tree-species distributions in the Eastern United States under a climate change scenario a case study with Pinus virginiana. *Ecol. Modell.* 115:77–93.

Iverson, L.R., Prasad, A.M., Liaw, A., 2004a. New machine learning tools for predictive vegetation mapping after climate change: Bagging and Random Forest perform better than regression tree analysis. In: Smithers, R. (Ed.), *Proceedings, UK-International Association for Landscape Ecology*, Cirencester, UK, pp. 317–320.

Iverson, Louis R.; Schwartz, M.W.; Prasad, Anantha M. 2004b. How fast and far might tree species migrate in the eastern United States due to climate change? *Global Ecology and Biogeography* 13: 209-219.

Iverson, Louis R; Prasad, Anantha M.; Schwartz, Mark W. 2005. Predicting potential changes in suitable habitat and distribution by 2100 for tree species of the eastern United States. *J. Agric. Meteorol.* 61(1): 29-37.

Iverson, L.R., Ollinger, S., Goodale, C., Rodenhouse, N., Lambert, D., Matthews, S., McFarland, K., Paradis, A., Elkington, J., Kraft, C., and Prasad, A. 2007. Forests. Chapter 4. Pages 47-61 in: Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions.* Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).

Iverson, Louis, Anantha Prasad, and Stephen Matthews. 2008a. Modeling potential climate change impacts on the trees of the northeastern United States. *Mitig Adapt Strat Glob Change* 13:487-516.

Iverson, Louis, Anantha Prasad, Stephen Matthews, and Matthew Peters. 2008b. Estimating potential habitat for 134 eastern US tree species under six climate scenarios. *Forest Ecology and Management* 254: 390–406.

Jacobson, Michael G, and James C Finley. Various years. *Timber Market Report*. Pennsylvania State University School of Forest Resources (PSU SFR) Cooperative Extension. Available online at http://www.sfr.cas.psu.edu/TMR/TMR.htm. Accessed March 2009.

Johnson, P. S., S. R. Shifley, and R. Rogers. 2002. *The Ecology and Silviculture of Oaks.* CABI Publishing, New York, NY.

Lorimer, C. G. 1993. Causes of the oak regeneration problem. In Loftis, D. L. and C. E. McGee, editors. (eds.). Oak regeneration: serious problems, practical recommendations USDA Forest Service, Symposium Proceedings September 8–10, 1992. Knoxville, Tennessee. General Technical Report SE-84. pp. 14–39.Southeastern Forest Experiment Station. Asheville, NC, US.

McClure, Mark S., Scott M. Salom, and Kathleen S. Shields. 2001. *Hemlock Wooly Adelgid.* U.S. Department of Agriculture, Forest Service. FHTET-2001-03. 14 p. Available online http://www.forestpests.org/acrobat/fhtet-2001-03.pdf, accessed March 2009.

McCullough, Deborah G. 2009. Putting the pieces together: can we solve the emerald ash borer management puzzle? In: McManus, Katherine A; Gottschalk, Kurt W., eds. Proceedings. *19th U.S. Department Of Agriculture Interagency Research Forum on Invasive Species 2008*; 2008 January 8-11; Annapolis, MD. Gen. Tech. Rep. NRS-P-36. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 46-48.

McWilliams, William H.; Cassell, Seth P.; Alerich, Carol L.; Butler, Brett J.; Hoppus, Michael L.; Horsley, Stephen B.; Lister, Andrew J.; Lister, Tonya W.; Morin, Randall S.; Perry, Charles H.; Westfall, James A.; Wharton, Eric H;. Woodall, Christopher W. 2007. *Pennsylvania's Forest, 2004.* Resour. Bull. NRS-20. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 86 p.

Midgley, G. F., L. Hannah, D. Millar, M. C. Rutherford, and L. W. Powrie. 2002. Assessing the vulnerability of species richness to anthropogenic climate change in a biodiversity hotspot. *Global Ecology and Biogeography* 11:455-451.

Peters, Robert L., and Joan D. S. Darling. 1985. The greenhouse effect and nature reserves. Bioscience 35(11):707-717.

Prasad, A. M., L. R. Iverson, and A. Liaw. 2006. Newer classification and regression tree techniques: bagging and random forests for ecological prediction. *Ecosystems* 9:181-199.

Schmidtling, Ronald. 2007. Genetic variation in the southern pines: evolution, migration, and adaptation following the Pleistocene. In: Kabrick, John M.; Dey, Daniel C.; Gwaze, David, eds. *Shortleaf Pine Restoration and Ecology in the Ozarks: Proceedings of a Symposium*; 2006 November 7-9; Springfield, MO. Gen. Tech. Rep. NRS-P-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 28-32.

Webb, T., III; Bartlein, P.J.; Kutzbach, J.E. 1987. Climatic changes in eastern North America during the past 18,000 years; comparisons of pollen data with model results. *Geology of North America Vol. K-3, North America and Adjacent Oceans during the Last Deglaciation.* Geological Society of America: 447-462.

Chapter 5

Priority Landscape Areas

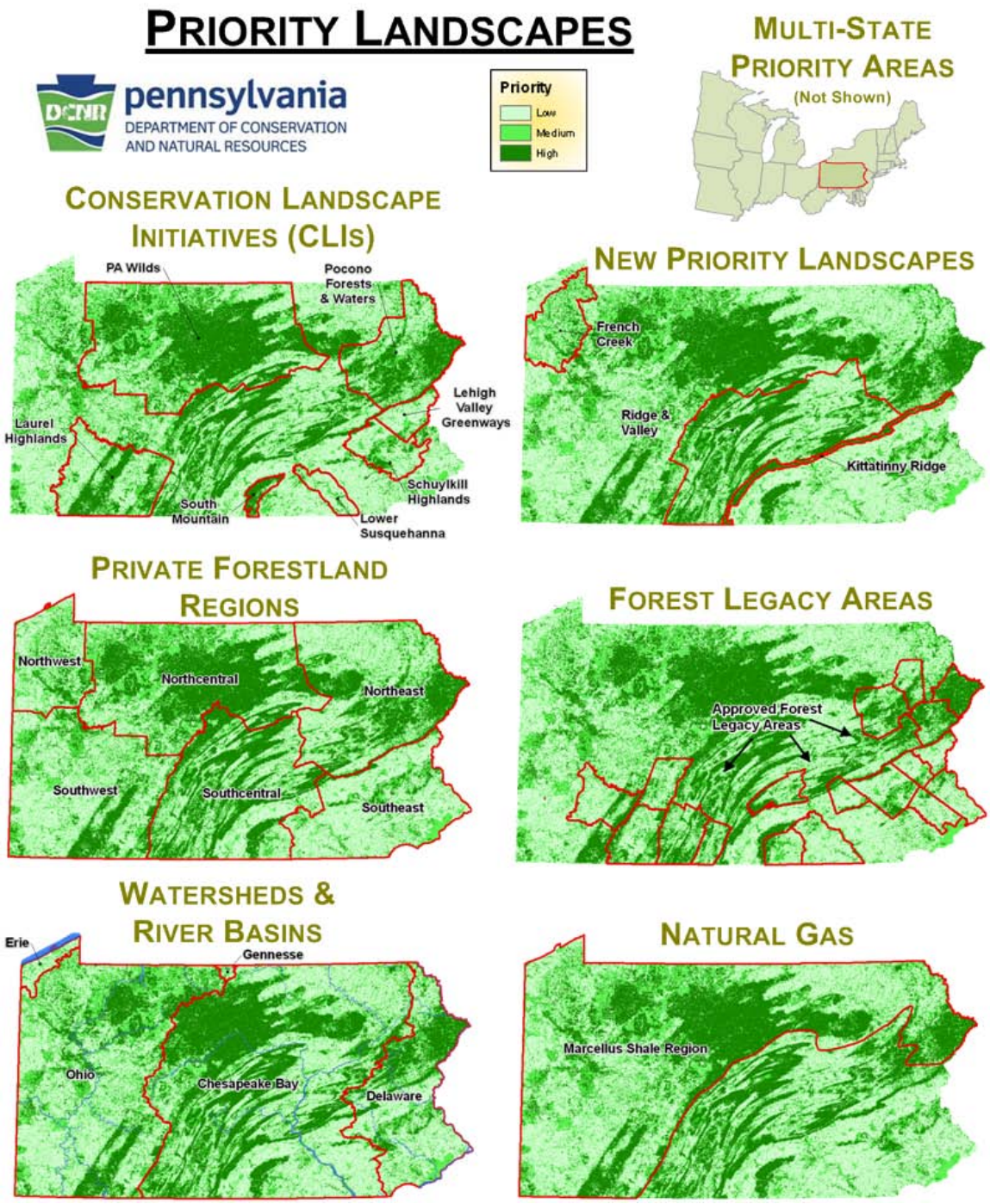
Introduction
A landscape is a defined area of land that provides a basis for organizations, communities, sectors of government, and other groups of people to work together to achieve common goals. Pennsylvania's landscapes are diverse ranging from scattered woodlots in highly developed urban areas to the heavily-forested Pennsylvania Wilds. These landscapes are influenced by many factors including geology, the spatial arrangement and sizes of forested tracts, and local communities and development patterns. Understanding geography and landscape variability helps policy makers and program leaders tailor programs to meet specific local needs while working within a broader statewide context.

Developing regional or landscape-level programs is not a new concept in Pennsylvania. Several models and programs already occur. This section of the Assessment acknowledges and builds upon existing landscape-level approaches while identifying additional areas for future consideration. These landscape areas will be utilized as a basis for implementing the Strategies developed for the Issues identified in Chapter 4 of this Assessment.

Priority Landscape Areas Approach
As part of the Assessment process, seven categories of Priority Landscape Areas have been identified for Pennsylvania:

1. GIS-derived Landscape Areas
2. DCNR Conservation Landscape Initiatives
3. Bureau of Forestry Private Lands Regions
4. Major Watersheds
5. Marcellus Shale Region
6. PA Forest Legacy Areas
7. Northeast Area Multi-state Areas

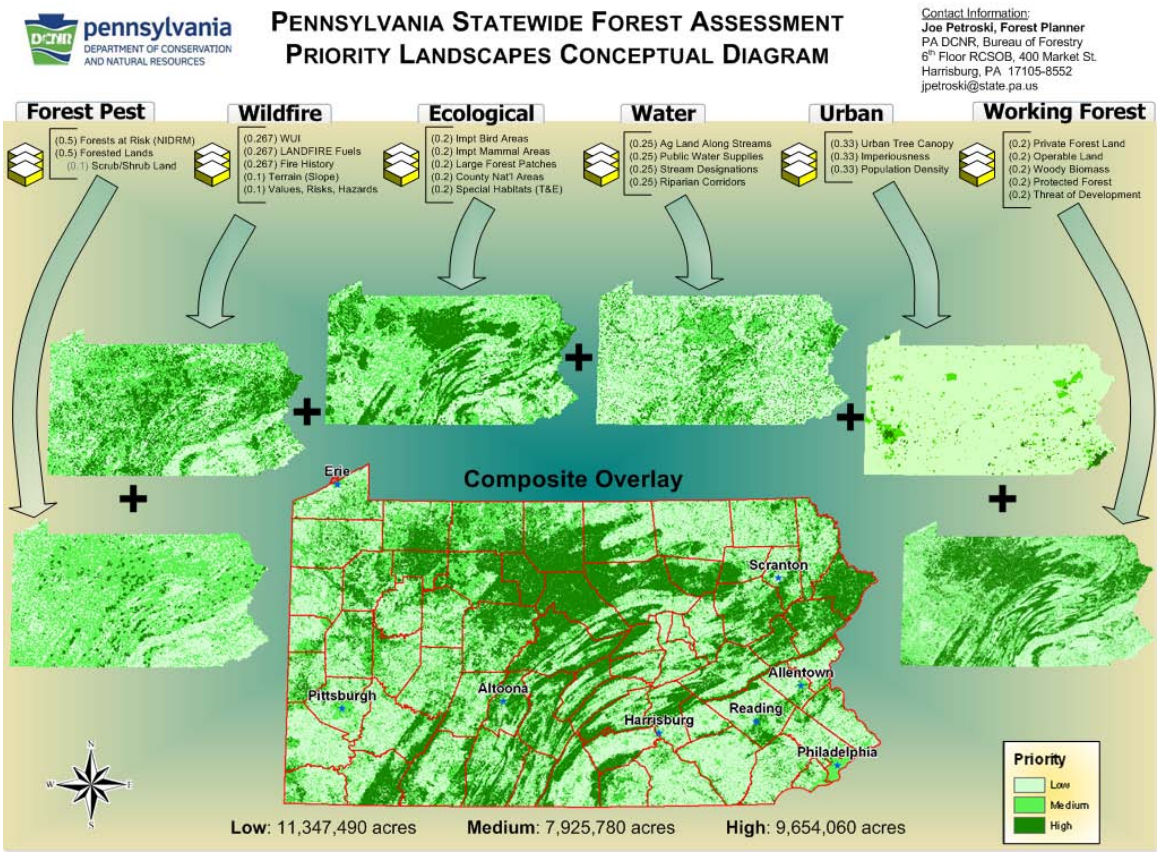
An overview diagram on the following page illustrates the general location of these areas across Pennsylvania. Additional maps are included throughout the remainder of this Chapter.



Important forested areas within defined priority landscape areas of Pennsylvania. Important forested areas are dark green and originate from the composite overlay in Pennsylvania's Forest Assessment GIS Analysis. See Appendix 5A for details on how the composite overlay was derived. The dark green areas show intersecting priorities among six spotlighted forest perspectives – forest pest, wildfire, ecological, water, urban, and working forest. Defined priority landscape areas are outlined in red and labeled.

1. GIS-derived Landscape Areas

Using GIS technologies, the Bureau of Forestry conducted an overlay analysis of 25 natural resource data layers. The diagram below illustrates the methodology of this analysis, which identified priority forests based six themes: (1) Forest Pests, (2) Wildfires, (3) Ecological, (4) Water, (5) Urban, and (6) Working Forests. For each theme, a priority landscapes map was produced that classifies all 28 million acres of the state into high-medium-low priority categories based on the map's theme. The six priority landscape map results were then combined into a composite overlay to show intersecting priority landscape areas.



Conceptual diagram of Pennsylvania's priority landscapes methodology. Priority landscape maps were created for six themes. A composite overlay shows intersecting priority areas among the six themes.

The composite overlay combines the six themes, equally weighted, into a single map that depicts the intersection of priority landscape areas. Some of the highest ranking landscape areas coincide with other landscape or regional efforts already in place such as DCNR's Conservation Landscape Initiatives, which are described below. Additionally, this analysis highlighted other areas with significant resources such as the Kittatinny

Ridge, the Ridge and Valley region in central PA, and significant aquatic resources in Northwestern PA.

As strategies are developed and implemented for the Issues described in Chapter 4, this GIS analysis and future analyses will provide direction for strategy implementation and investment priorities for federal and state funds. Additional analyses within the identified regions and landscapes will provide additional results and maps at local levels. Details on the methodology, including a discussion of each of the six themes, can be found in Appendices 5A and 5B.

2. DCNR Conservation Landscape Initiatives

Throughout the commonwealth, large regions are working together to drive strategic investment and actions around sustainability, conservation, community revitalization, and recreational projects. Known as the Conservation Landscape Initiatives (CLIs), these collaborations are developing in landscapes where there are strong natural assets, local readiness and buy-in, and state level investment support. Several state agencies, local governments, funders and non-profits have worked strategically and collaboratively on the ground for several years in seven CLIs to develop this value-driven, place-based approach:

a. Pennsylvania Wilds

b. Pocono Forests and Waters

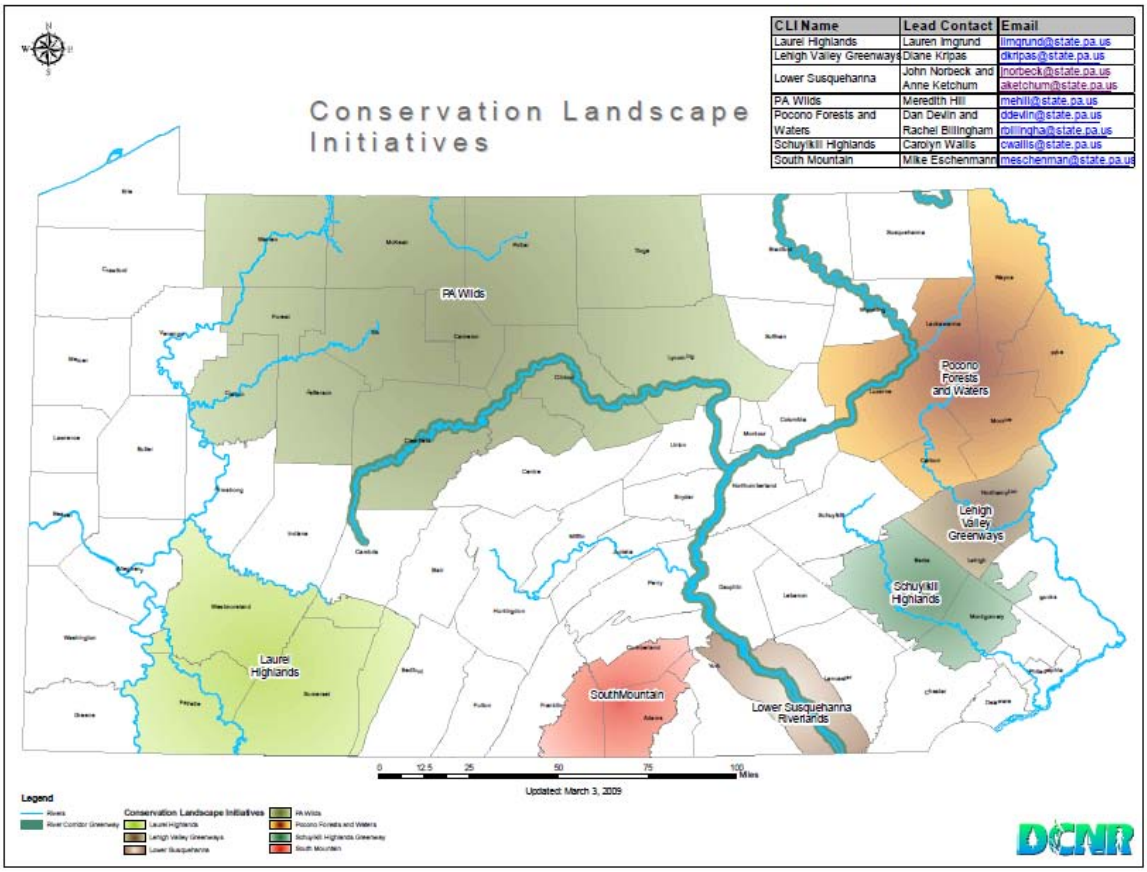
c. Lehigh Valley Greenways

d. Schuylkill Highlands

e. Lower Susquehanna

f. South Mountain

g. Laurel Highlands



These areas are identifying values at a landscape scale, revitalizing communities, and engaging local and regional partners in conservation and economic development. Founded on the regions' sense of place and resource values, the CLIs motivate citizens and elected officials to take on the challenge of effective land use planning, investment, civic engagement and revitalization.

Driven by the values of conservation, sustainability and community revitalization, some of the ingredients that make a community or region ready to consider this kind of strategic collaborative approach include:

- **Presence of DCNR-owned lands –** large blocks of state parks and forests provide the foundation for the landscape and a staffing presence that can help guide the initiative

- **Sense of Place -** regions with a sense of place and identity - many cases based on shared landscape not political boundaries

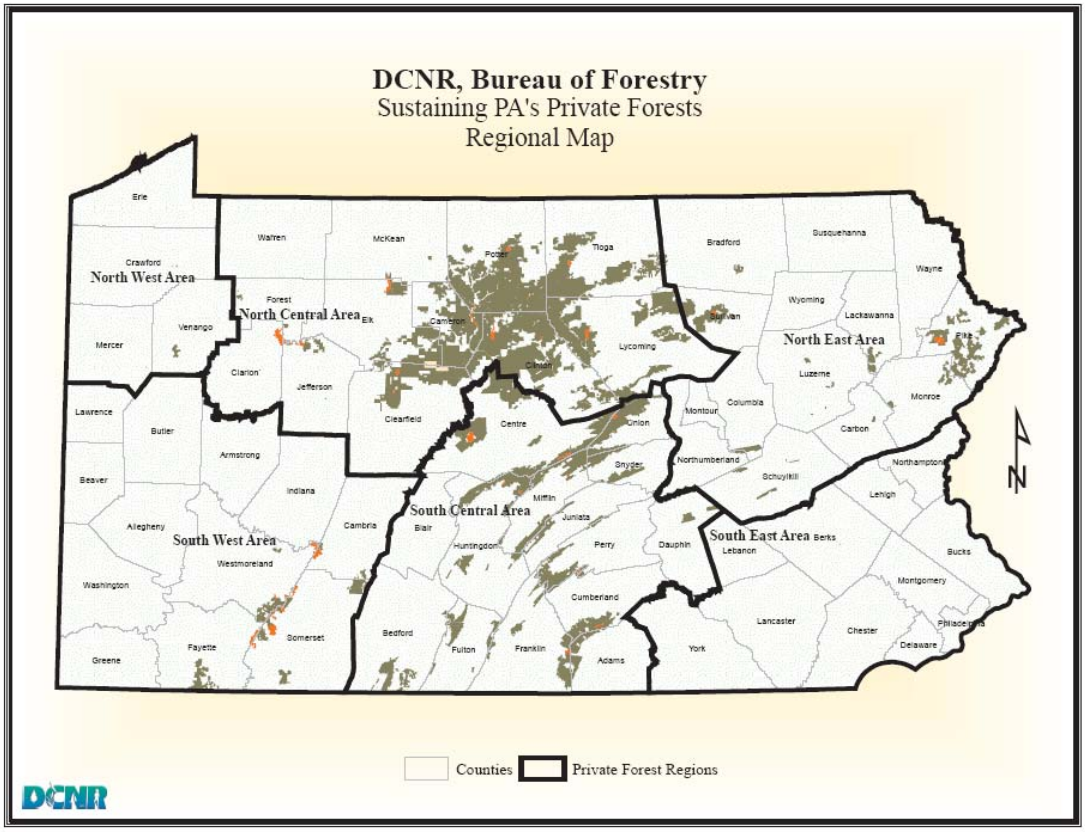
- **Readiness -** made more ready by opportunity or threats -- changes in the economic base, depopulation, or sprawl

- **Engagement -** Civic engagement process that brings people of the region together to identify common values and concerns.

- **Strategic Investments –** State agencies with regional and statewide partners provide high-level leadership, financial support and technical assistance to build better communities, to conserve identified values and to invest in "sustainable" economic development. Partnerships with state agencies and other statewide organizations are necessary to frame and incentivize the process.

3. Bureau of Forestry Private Lands Regions

As presented in *Chapter 2: Forest Conditions and Trends*, large differences occur across Pennsylvania relative to forest conditions and issues affecting sustainability. In an effort to address this variability, the Bureau of Forestry developed a "regional approach" for its private lands programs. The intent of the initiative was to delineate regions of similar ecological, social, and political characteristics and then develop and coordinate outreach and programming specific to the particular region. Staff and stakeholders within the regions would be working toward a shared vision of sustainability, taking into consideration the uniqueness of the region. The map below shows the six regions.



4. Major Watersheds

Pennsylvania contains five major watersheds as shown in the map below.

a. Susquehanna (Chesapeake Bay)

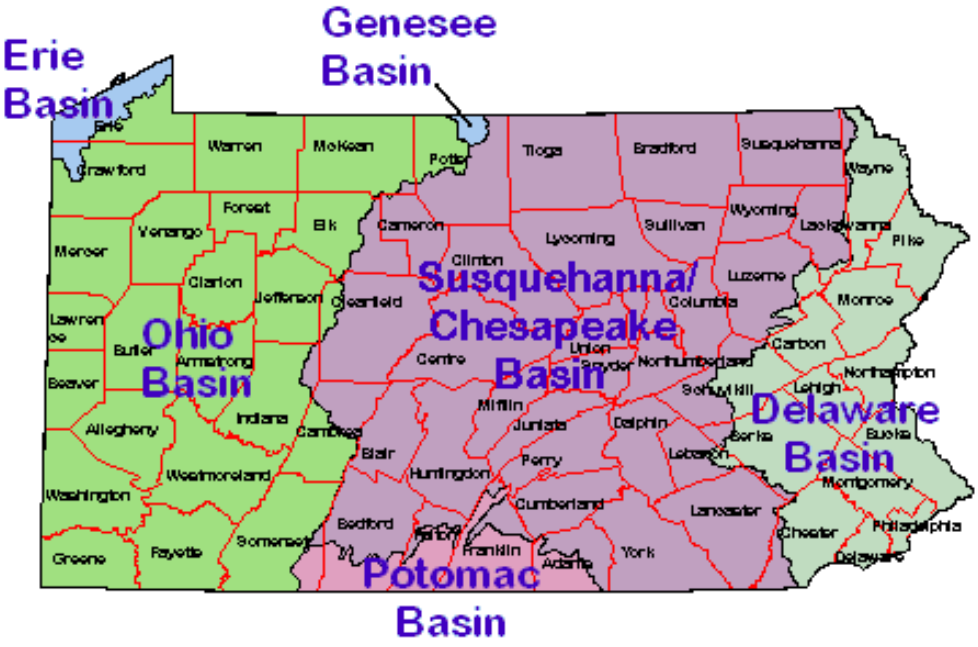
b. Potomac (Chesapeake Bay)

c. Delaware River

d. Ohio River

e. Genesee

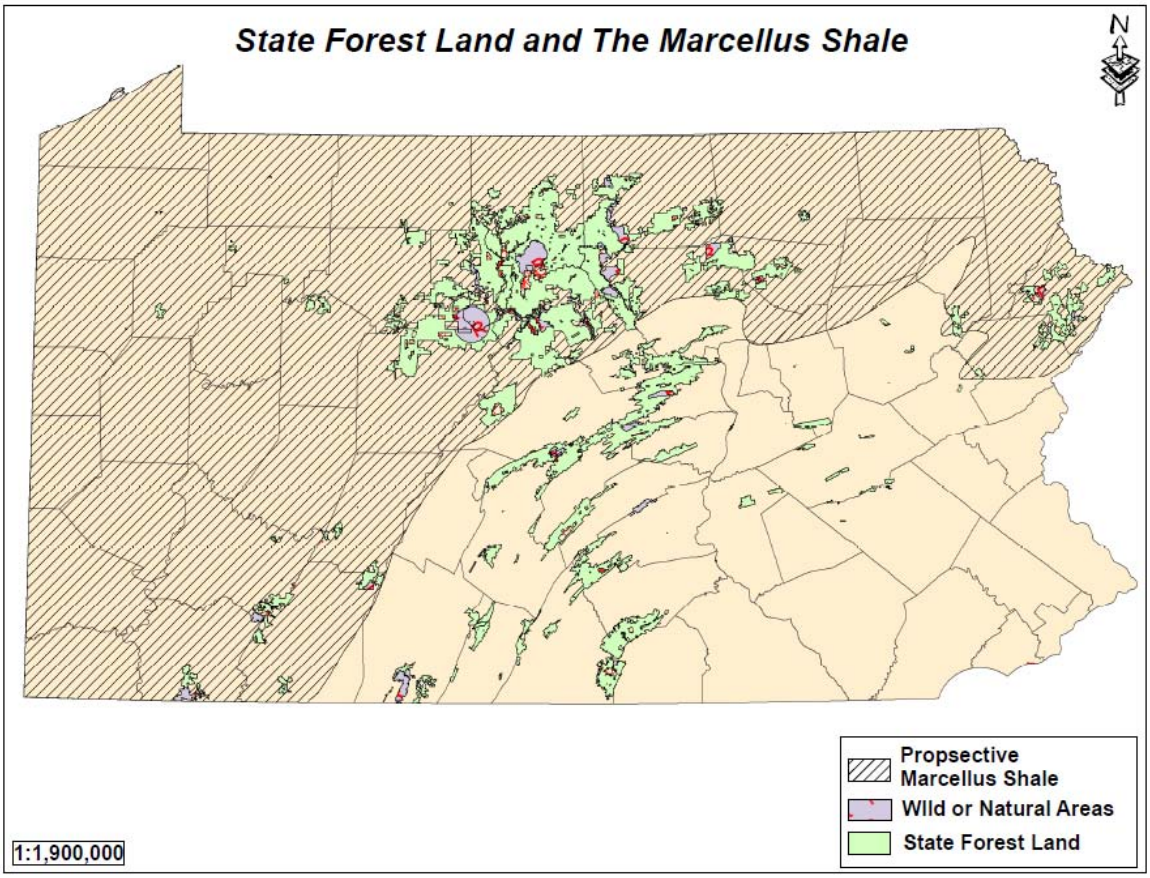
f. Lake Erie



Watersheds are an important planning unit as water quality is highly dependent on land use and particularly the amount of forest cover within the watershed. Many government and non-profit-based efforts are tied to watershed boundaries. In Pennsylvania, the Chesapeake Bay Program, which includes the Potomac and Susquehanna River basins, is a major effort focused on water quality and broader natural resource conservation. Watersheds help to provide a sense-of-place and sense of responsibility for down-stream impacts.

5. Marcellus Shale Region

Oil and gas development in the Marcellus shale region has tremendous potential to affect the social and environmental character of about half of Pennsylvania. Potential negative impacts include increased forest fragmentation, spread of invasive plants, water quality degradation, impacts to plant and animal habitats, and changes to local communities and their social dynamics. Potential positive impacts include increased revenues for conservation, jobs and economic growth, and increased attention toward rural communities and natural resources. Managing and balancing gas development activities within the Marcellus region requires a comprehensive and coordinated approach among agencies, the industry, community leaders, and other stakeholders within the region, including adjacent states which lie in the Marcellus Shale fairway.



6. PA Forest Legacy Areas

The Pennsylvania Forest Legacy Program will be implemented according the current Pennsylvania Forest Legacy Program (FLP) Assessment of Need (AON), which was approved by the Secretary of Agriculture in May of 2002. The AON includes the approved Eligibility Criteria for the Forest Legacy Areas (FLA), the Approved FLAs, specific goals and objectives to be accomplished by the Pennsylvania FLP and the process by which the State Lead Agency will evaluate and prioritize projects to be considered for inclusion in the FLP. A copy of the AON and accompanying Guidebook can be found in Appendix 5C. A copy of the State Lead Agency designation letter, and the AON approval letter can be found in the office of the DCNR Bureau of Forestry Rural and Community Forestry Section.

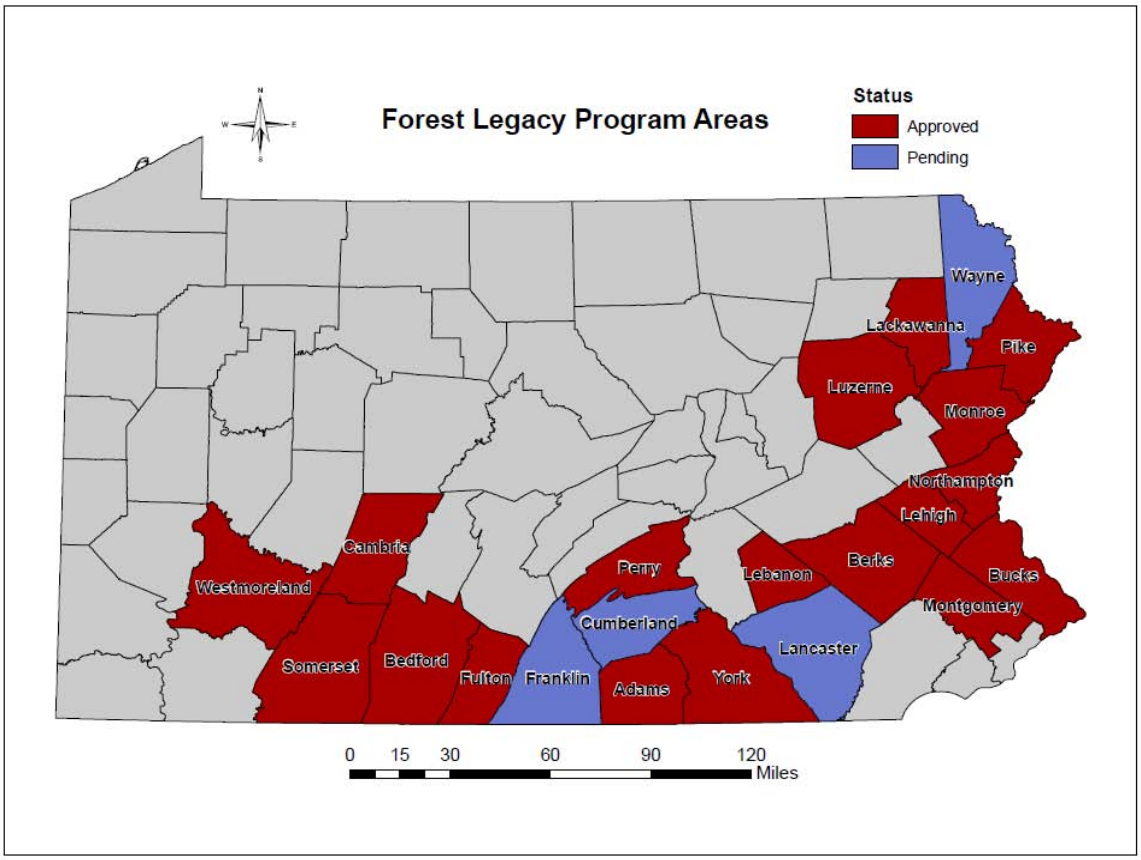
The Forest Legacy Program (FLP) is a voluntary Federal program in partnership with States designed to protect working forests through acquisition and purchase of conservation easements. The map below shows FLAs in Pennsylvania. These FLAs were evaluated on a set of criteria including:

- Timber/Other Forest Products
- Wildlife resources
- Recreation opportunities and resources
- Watershed characteristics
- Scenic Values
- Cultural Resources
- Proposed/New Transportation Corridors
- Population Trends

Pennsylvania has four Forest Legacy properties:

Property Name	**Location**	**Acres**	**Type of Project**
History of Forestry	Pike County	1,191	Conservation Easement
Birdsboro Waters	Berks County	1,844	Conservation Easement
Behr Donation	Bedford County	310 Conservation Easement	
Tree Farm # 1	Adams County	1,466 Forest Legacy funded, 2,581 total	Fee simple acquisition to Michaux State Forest

For additional information on Pennsylvania's Forest Legacy Program, refer the Assessment of Need and Guidebook in Appendices 5C and 5D.


Forest Legacy Program Areas
Status
Approved
Pending
Wayne
Lackawanna
Pike
Luzerne
Monroe
Northampton
Lehigh
Berks
Bucks
Montgomery
Lebanon
Perry
Cumberland
Lancaster
York
Adams
Franklin
Fulton
Bedford
Somerset
Cambria
Westmoreland
0 15 30 60 90 120
Miles

7. Northeast Area Multi-state Areas

One of the requirements of the Assessment and Strategy process is for states to identify multi-state areas of regional priority. The intent is for states to coordinate activities on issues or within specific geographic areas that cross state boundaries. Through several discussions among USFS staff, State Foresters, and state planning and GIS staff, a list of potential multi-state areas was identified for Pennsylvania. Some of these areas have existing programs and others represent new opportunities. DCNR staff will cooperate with staff from neighboring states and the USFS as appropriate. These areas could provide opportunities for USFS grants and other funding. Additional information and maps can be found in Appendices 5E – 5K, or the link following each description below.

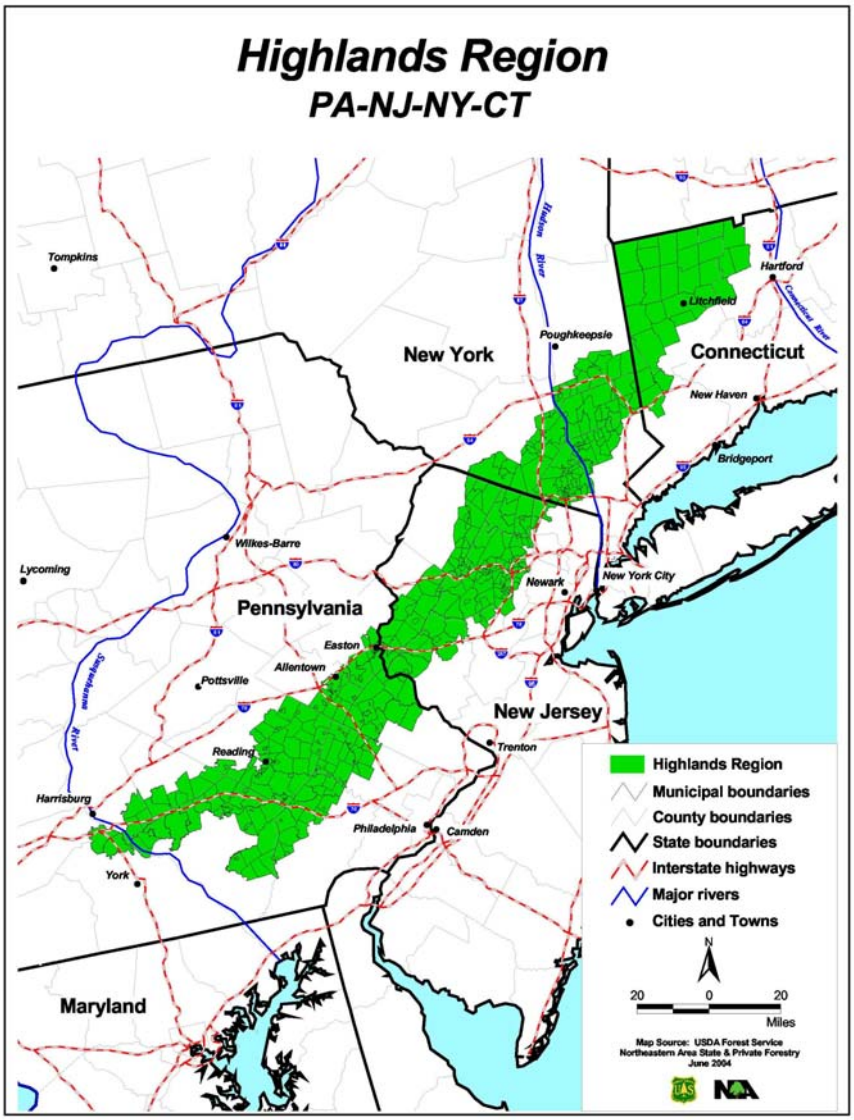
A. Highlands

Rising above the urbanization of the eastern seaboard, the Highlands are a unique series of discontinuous, steep-sided ridges and narrow valleys running for about 1,700 miles in a northeast to southwest direction from Western Connecticut, New York, and northern New Jersey to Reading, Pennsylvania. It varies from 10 to 20 miles in width and contains nearly 3 ½ million acres of forests, farms, and communities. In Connecticut, the Highlands valleys are oriented in a nearly north-to-south direction. In New Jersey, New York, and Pennsylvania, the Highlands form a chain of ridges and hills that extend above the city of Reading. Pennsylvania's Highlands region expands to include the forested hills south and west of the Reading extension.

The careful protection, management, and use of the natural resources located in this nationally significant region are essential for the long-term sustainability of both the natural and built environments that nurture all life for both current and future generations. (Source: http://na.fs.fed.us/highlands/about/index.shtm)

Because of its proximity and attributes to major population centers in the eastern U.S., the region has been the subject of a number of congressionally mandated studies by the USDA Forest Service in cooperation with the States.

Additional information on the Highlands can be found in Appendix 5E.

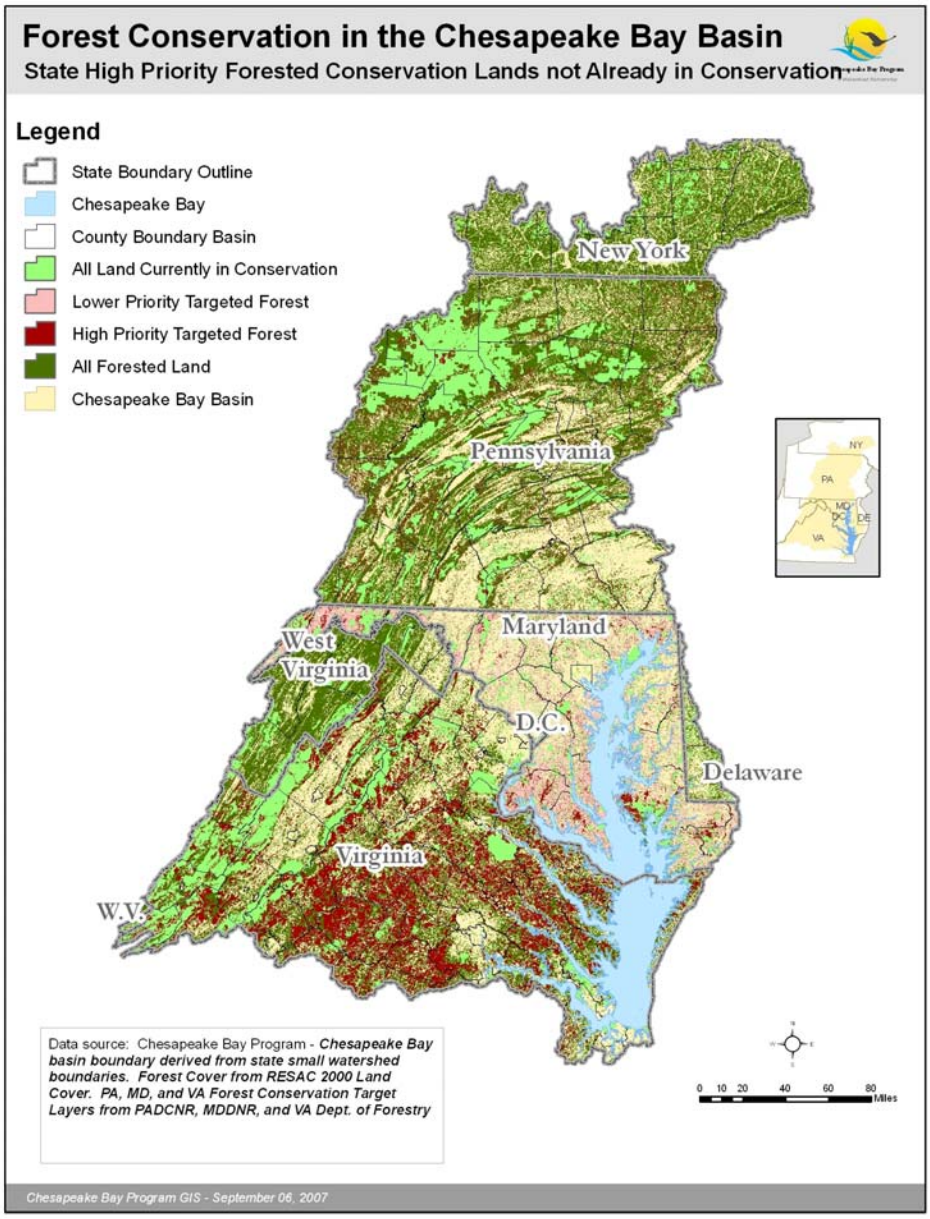


B. Chesapeake Bay Watershed

The Chesapeake Bay is the largest and most productive estuary in North America. More than 64,000 square miles of land in parts of six states – New York, Pennsylvania, Maryland, Delaware, West Virginia, and Virginia – and the District of Columbia drain into the Chesapeake Bay. It is home to over 3,600 species of plants, fish and wildlife. The Bay has struggled for more than 100 years against pressures such as pollutants, overfishing, and development. Land use is the primary threat to the water quality and healthy functioning of the Chesapeake watershed. Many efforts among federal, state, and local partners are directed toward improving water quality within the Bay watershed, most notable the

Chesapeake Bay Program. Pennsylvania will continue to support the Bay program and its efforts.

Additional information on the Chesapeake Bay can be found in Appendix 5F.



C. Delaware River Watershed

The Delaware is the longest undammed river east of the Mississippi, flowing freely for 330 miles from lower New York State through Pennsylvania, New Jersey, and Delaware to the Atlantic Ocean. The Delaware's 13,539 square mile watershed drains about four percent of the continental United States land area and provides drinking water for 17 million people in four states. The river meets tide-water at Trenton, NJ and constitutes the entire boundary between New Jersey and Pennsylvania, most of the boundary between Delaware and New Jersey, and part of the boundary between Pennsylvania and New York.

The Delaware Bay Estuary is the tidal portion, or the lower half, of the Delaware River Basin. The area surrounding the estuary stretches as far west as the Schuylkill River's headwaters near Pottsville, PA, and to the east near Fort Dix, NJ. The vastness of this watershed makes the Delaware Bay Estuary one of the largest estuaries in the country, approximately 6,800 square miles in size. Within these boundaries are over 200 species of fish, the continent's second-highest concentration of shorebirds, and over 400,000 acres of wetlands.

Land use, fragmentation, forest health, and water quality are major issues within the Delaware River watershed, providing significant opportunities for partnership. Additional information on the Delaware River Watershed can be found in Appendix 5G.

Map Source: http://www.state.nj.us/drbc/maps/drb_map2.htm

D. Great Lakes

Lakes Superior, Michigan, Huron, Erie, and Ontario contain 18% of the world's fresh surface water. The Great Lakes Watershed is bounded by the Province of Ontario to the north, and the US states of Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York to the west, south, and east.

The Great Lakes Basin drains 200,000 square miles of land in both the US and Canada. It has over 10,000 miles of shoreline including more than 35,000 islands. Its natural habitats include:

- wetlands - 300,000 acres of coastal wetlands,
- sands – the world's largest collection of freshwater sand dunes,
- islands – the world's largest freshwater island system, and
- alvars - 95% of the world's alvar system. Alvars are unique communities characterized by shallow soils over linestone/marble bedrock with distinct vegetation.

The Great Lakes provide approximately 4.2% of the US drinking water. They are essential to commerce, trade and transportation of goods. They link to both the Atlantic Ocean via the St. Lawrence River, and the Gulf of Mexico via the Illinois and Mississippi Rivers. Recreational vessels are also able to reach the Hudson River through the Erie Canal. One-third of all recreational boats in the US are registered in the Great Lakes Basin. The Great Lakes support a $1 billon recreational fishing industry and over $35 billion annually in general recreation and tourism.

Opportunities exist to improve the water quality of the lakes as well as water quality and habitat conditions of the watersheds feeding the lakes. The Environmental Protection Agency is currently leading an effort known as the Great Lakes Initiative aimed to restore the health of the Great Lakes.

Additional information on the Great Lakes Initiative can be found in Appendix 5H.

Map source: USFS.

E. Ohio River Basin

The Ohio River is 981 miles (1582 km) long, starting at the confluence of the Allegheny and the Monongahela Rivers in Pittsburgh, Pennsylvania, and ending in Cairo, Illinois, where it flows into the Mississippi River and eventually the Gulf of Mexico. The Ohio River passes through or is adjacent to the states of Illinois, Indiana, Kentucky, Ohio, West Virginia, and Pennsylvania. Portions of New York, Virginia, Maryland, Tennessee, North Carolina, Georgia, Alabama, and Mississippi are also within the Ohio River Basin.

Land use in the Ohio River Basin is a mix of urban/industrial, row crops/intensive agriculture, pasture and forested. The Ohio River plays an important role in the economic fabric of the region. There are over 1,000 manufacturing facilities, terminals, and docks in the Ohio River Basin that shipped and received tonnage in 1998. The Port of Pittsburgh includes 41 miles of the Ohio River, 91 miles of the Monongahela River, and the entire 72 navigable miles of the Allegheny River. The port shipped and received almost 53 million tons of commodities in 1998, making it the largest port in the Ohio River Basin and the largest inland port in the United States.

The Ohio River is a direct source of drinking water for more than three million people. A number of issues have been identified relating to water quality issues in the basin. The combined effects of industrial pollutants, urbanization, agriculture, mining and other land uses are increasingly threatening clean water supplies. Forested landscapes play a key role in providing a broad range of ecosystem services, including clean water. Efforts are underway at the Federal level to explore opportunities for restoration efforts similar to those in place for the Chesapeake Bay.

Additional information on the Ohio River Watershed can be found in Appendix 5I.

F. I-95 Corridor

Overview: The I-95 corridor, running through 10 Northeastern Area States and the District of Columbia, is the densest, most richly connected network of metropolitan areas in the nation (RPA, 2007). Its larger support area, encompassing fourteen Northeastern states, contains the unique natural landscapes and estuaries that provide the drinking water, food and fiber production, wildlife habitat, carbon sinks, and recreational amenities that support life along the corridor. But the I-95 corridor's environmental assets are increasingly threatened by rapid growth at the metropolitan fringe, which

consumes open space and fragments forests. The goal of protecting critical landscapes along the I-95 corridor is also challenged by the multiplicity of local governments, counties, and states, all with different land use policies and regulations, and a public often unaware of the many values these landscapes bring to their communities.

The development patterns of the 5 metropolitan regions making up the I-95 corridor are pretty well understood; less well understood are the new patterns formed where such metro areas tend to blur together into larger complexes. These complexes have recently been labeled as "megaregions" (UPenn, 2004, RPA 2007). Many of the environmental and economic challenges faced by the five major metro areas within the I-95 corridor megaregion– Boston, New York, Philadelphia, Baltimore, and Washington, D.C. – are not unique to each region but derived from their common experience of geography, history, culture, and global economic change. Taken as a whole, these areas comprise the critical landscapes that help shape and define the megaregion and supply the natural resources on which its large population depends (RPA, 2007).

The rate of land consumption in the Northeast continues to accelerate, endangering natural systems like watersheds and estuaries, wiping out agricultural land and open space, and compounding congestion (RPA, 2007). Overriding trends in population growth, land use, and economic specialization, along with common threats like the high cost of housing, rising income inequalities, and climate change, affect the health and future prosperity of the entire corridor.

In the coming years, the states within the I-95 corridor will need to work together to address common challenges that threaten the megaregion's prosperity, environment and quality of life. Certain challenges – watershed management and impacts of climate change – require coordinated action to address ecosystem services, infrastructure, and economies that span multiple states. Other challenges – efforts to increase canopy cover in center cities – can benefit from common strategies and approaches to shared challenges. The assumption made here is that the sum ecosystem benefits of I95 corridor States working together is greater than them working apart.

Additional information on the I-95 Corridor initiative can be found in Appendix 5J.

G. Appalachian Region

The Appalachians are among the oldest mountains on Earth. They extend almost 2,000 mi from the Canadian provinces of Newfoundland and Labrador in the northeast, southwestward to Alabama in the U.S. They include the White Mountains in New Hampshire, the Green Mountains in Vermont, the Catskill Mountains in New York, the Allegheny Mountains primarily in Pennsylvania, the

Blue Ridge Mountains in Virginia and North Carolina, the Great Smoky Mountains in North Carolina and Tennessee, and the Cumberland Plateau extending from West Virginia to Alabama. Their highest peak is Mount Mitchell in North Carolina.

The Appalachian Region referred to here focuses more on the Mid-Atlantic States and south, more so than the Appalachians that extend into New England region. The region (see map below) is a 205,000-square-mile area that follows the spine of the Appalachian Mountains from southern New York to northern Mississippi. It includes all of West Virginia and parts of 13 other states including Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia.

Major forest conservation challenges include

- water quality
- abandoned mine lands
- Marcellus shale development
- forest health concerns and invasive species
- maintaining working forests and a viable forest products industry
- introducing biomass, carbon trading, and ecosystem services into private forest management
- conservation education
- landscape-level habitat planning
- outdoor recreation and greenways
- land use and suburban sprawl

Additional information on the Appalachian Region initiative can be found in Appendix 5K.

H. Reforestation of Abandoned Mine Lands – MD, OH, PA, KY, VA, TN, AL, WV

West Virginia Department of Forestry is currently pursuing opportunities, in conjunction with the states listed above, to establish reforestation areas on any previously mined lands that are in need of reforestation as a result of past mining practices. Pennsylvania is supportive and will cooperate as opportunities arise. Pennsylvania has over 200,000 acres of abandoned mine lands.

I. Conservation Education – NJ, DE, MD, PA, OH, DC, WV

The Mid-Atlantic Conservation Education (MACE) cooperative, representing the forestry agencies in the above states, was very active from about 1995 – 2005. Since that time, retirements, changing personnel, budget cuts, etc. have caused the group to become less active. Their major focus was to work on conservation education activities that were common to the Mid-Atlantic States. Previous projects included an educational forestry CD ROM, a Forestry Activity Guide for Teachers, Project Learning Tree correlations with state science teaching standards, and other related projects. The formerly met twice per year, but this has since tailed off. MACE's goal was to assist one another in elevating the overall quality and quantity of conservation education activities and programs in their states. West Virginia has started a dialogue to help the group become active once again and to work on issues that are common to the respective states—Pennsylvania supports this effort.

J. Development Issues Along the I-79, I-81, I-68, and I-64 Corridors – KY, PA, VA, MD, WV

West Virginia Department of Forestry has identified land use and related development pressures along several interstates, including I-79 and I-81, which cross into Pennsylvania. Impacts include fragmentation and parcelization of forests, unplanned urbanization, water quality issues, and other similar problems. The WVDOF has requested the cooperation of adjacent states to explore opportunities to minimize impacts to forests and other natural resources, as well as resolve related issues of mutual concern.

K. Sustaining Traditional Timber Markets and Developing Non-Traditional Markets in the Appalachian Region – PA, MD, VA, WV, KY, OH

The ability to effectively manage the region's forests in the future will be based in large part on sustaining existing markets in order to economically sell products. Without this, and without the development of new markets and new products, it will be extremely difficult to manage our forests in a sound, scientific manner. West Virginia has expressed interest in exploring solutions to these problems with adjacent states. Pennsylvania supports this effort.

L. Mid-Atlantic Fire Compact Activities – WV, VA, OH, PA, DE, NJ, MD

Numerous joint activities presently occur within this existing multi-state organization. These activities are encompassed by the federal grants in Firewise, State Fire Assistance, Volunteer Fire Assistance, and special grants and typically involve efforts in fire prevention, detection, and suppression. Working together, these states often pool efforts and knowledge related to firefighting equipment, vehicles, personal protective equipment, education, and training. It is likely that many of the future advances in the fire program will involve participation in the Mid-Atlantic Fire Compact.

Summary

Pennsylvania's landscapes are highly diverse and variable. While statewide policies and program objectives are critical for working toward a shared vision, acknowledging regional differences and targeting specific landscapes allows managers to customize program delivery. Many regional and landscape-based programs have been functioning in Pennsylvania for years and have proven effective. The Bureau of Forestry intends to continue to support these efforts while looking for new opportunities, such as those identified in the GIS analysis. Additional, more detailed analysis will aid in more clearly delineating areas and setting specific strategies. Below is a list of all the areas described in this chapter.

Summary List of Priority Areas

1. GIS-derived Landscape Areas

    a. Forest Pest Areas

    b. W ildfire Areas

    c. Ecological Areas

    d. Water Resource Areas

    e. Urban and Community Forest Areas

f. W orking Forests

g. Com posite Overlay

h. Potential new priority areas

i. NW PA, French Creek Watershed

ii. Ridge and Valley Region

iii. Kittatinny Ridge

2. DCNR Conservation Landscape Initiatives

a. Pennsylvania Wilds

b. Pocono Forests and Waters

c. Lehigh Valley Greenways

d. Schuylkill Highlands

e. Lower Susquehanna

f. South Mountain

g. Laurel Highlands

3. Bureau of Forestry Private Lands Regions

a. Northwest

b. Northcentral

c. Northeast

d. Southwest

e. Southcentral

f. Southeast

4. Major Watersheds

a. Susquehanna (Chesapeake Bay)

b. Potomac (Chesapeake Bay)

c. Delaware River

d. Ohio River

e. Genesee

f. Lake Erie

5. Marcellus Shale Region

6. PA Forest Legacy Areas

a. Approved Counties

i. Adams

ii. Bedford

iii. Berks

iv. Bucks

v. Cambria

vi. Fulton

vii. Lackawanna

viii. Lebanon

ix. Lehigh

x. Luzerne

xi. Monroe

xii. Montgomery

xiii. Northampton

xiv. Perry

xv. Pike

xvi. Somerset

xvii. Westmoreland

xviii. York

b. Pending Counties

i. Cum berland

ii. Franklin

iii. Lancaste r

iv. Wayne

7. Potential Multi-state Areas

a. Highlands

b. Chesapeake Bay Watershed

c. Delaware River Watershed

d. Great Lakes

e. Ohio River Basin

f. I-95 Corridor

g. Appalachian Region

h. Reforestation of Abandoned Mine Lands: MD, OH, PA, KY, VA, TN, AL, WV

i. Conservation Education: NJ, DE, MD, PA, OH, DC, WV

j. Developing Issues along the I-79, I-81, I-68, and I-64 Corridors: KY, PA, VA, MD, WV

k. Sustaining Traditional Timber Markets and Developing Non-traditional Markets in the Appalachian Region: PA, MD, VA, WV, KY, OH

l. Mid-Atlantic Fire Compact Activities: WV, VA, OH, PA, DE, NJ, MD

Chapter 6

Summary

Pennsylvanians are fortunate to live in a state that abounds with nearly 17 million acres of forest providing countless benefits and services. These forests make up a diverse Pennsylvania landscape including trees in towns and cities, fragmented woodlots among farm fields, and large forested tracts along major ridges and the more than 2 million acres of public lands known as the Pennsylvania Wilds. Clean air and water, recreation opportunities, plants and wildlife, and wood and other economic values all come from this vast resource. Taking stock of our forest is necessary for ensuring its sustainability for future generations. This Assessment documents the current conditions and trends of the forest, identifies priority issues, delineates important landscapes across the Commonwealth, and sets the stage for developing long-term management strategies.

An analysis of eighteen indicators of sustainability revealed a cautionary sustainable conclusion, with many causes for concern. Some indicators such as forest health, forest composition, and fragmentation and parcelization rated low and represent major cause for concern. Other indicators including overall amount of forestland, water quality, recreation opportunities, and species of concern received more favorable ratings. Overall, Pennsylvania's forests tend toward a sustainable condition, but with some areas of major concern.

Based on the sustainability analysis and stakeholder input, eight priority issues were identified:

1. Land Use
2. Forest Health
3. Forest Management
4. Clim ate Change
5. Communicating Natural Resource Values
6. Energy Development
7. Wildland Fire and Public Safety
8. Plant and Animal Habitat

Along with the benefits and services described in Chapter 2, these eight priority issues give us a comprehensive look at the forest, including threats and opportunities for both new and continued engagement. In addition, a GIS analysis highlights priority landscape areas across the Commonwealth that again reflects both new and existing efforts.

Altogether, this process has built a solid foundation for developing strategies aimed to sustain our valued forests. Part II of this overall effort proposes long-term strategies, relates them to the priority landscape areas, identifies partnership opportunities, and lists indicators of success.

Implementation of the strategies will require continued partnerships among stakeholders and prioritization of available resources, as existing resources are insufficient to address every strategy. As we begin to implement the resulting strategies over the next five years, leveraging federal, state, and other resources, this Assessment provides a basic foundation for continued strategic planning. Particularly, the sustainability analysis in Chapter 3 documents baseline conditions that we can use to track the results of our investments and efforts in conserving our treasured forests.