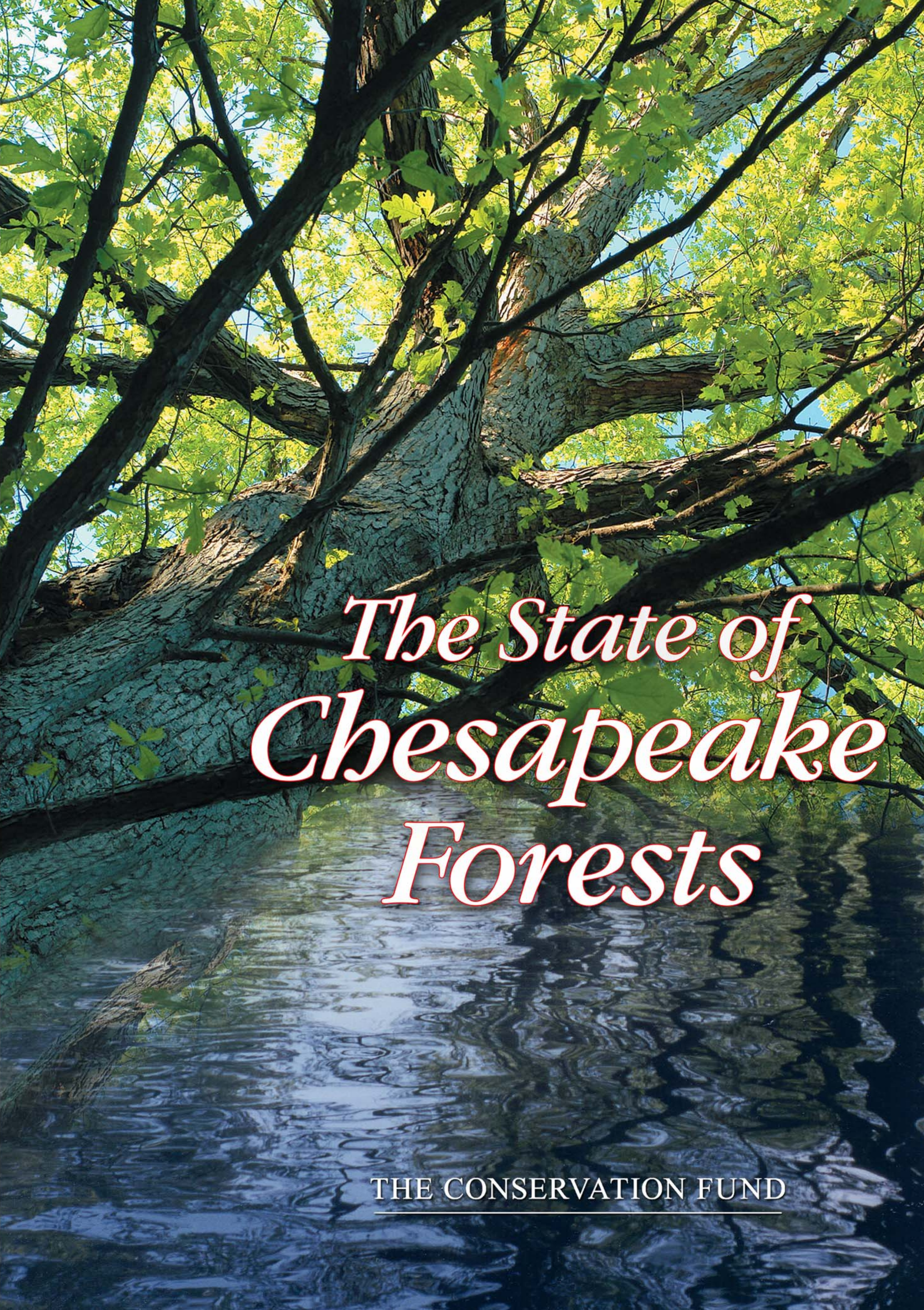

The State of Chesapeake Forests

THE CONSERVATION FUND

The State of
Chesapeake Forests

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THE CONSERVATION FUND

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The Northeastern Area (NA) is a unit of the State and Private Forestry branch of the USDA Forest Service. Its mission is to lead and support sustainable forest management and use across the landscape to provide benefits for the people of 20 Northeastern and Midwestern States and the District of Columbia. NA works with State forestry agencies and other partners to influence the wise management, protection, and sustainable use of urban and rural forest resources and provides financial support and professional expertise to States, private forest landowners, nonprofit groups, tribal nations, and communities. The NA Chesapeake Bay Watershed Forestry Program was established to bring direct support for Chesapeake Bay restoration and stewardship goals. For more information on State and Private Forestry Programs, visit www.na.fs.fed.us.

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September 2006

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FORWARD

We have always put a lot of faith in the Chesapeake Bay's resilience—in its ability to bounce back from environmental insults. In the 1970's, Mother Nature delivered the Bay a fierce blow—the worst rain and flooding in perhaps two centuries. That decade sent the ecosystem into a tailspin from which it still has not recovered. In retrospect, it is not so surprising.

Tropical storm Agnes in 1972, combined with several more unusually wet years in the Bay's history, came at a time when much of the historic resilience of the watershed was depleted. The Bay's major system of resilience, the forest that once covered most of the watershed, was 40% gone. Together, the forests, wetlands, bay grasses, and oysters, once constituted a marvelous system of buffers and filters, stabilizers, and regulators. They lent the Bay a tremendous resilience, a capacity to absorb environmental insult and recover.

Ultimately, the Bay depends on the quality and quantity of rainwater that runs from the lands of its watershed; and no other land use—pasture, cornfield, lawn, or urban street—consistently delivers the clear, pure water received from the forest. We can only speculate about the quality of freshwater flows to the pristine Bay that existed when the old-growth forest covered almost all the watershed from New York to Norfolk. Forests that have not been altered by man are so rare and scattered now, that even most professional foresters have never studied their workings. Nonetheless, study after study confirms that even today, the forested lands of the watershed are the most beneficial use to which we put the land in terms of water quality. This includes well-managed commercial and private forestlands, which from the Bay's standpoint are a healthy alternative to both development and agriculture.

Just by growing, forests in the Bay's watershed today are sopping up an estimated 184 million pounds of nitrogen from polluted air each year that would wash into watershed if it fell on paved streets. The forests are thus accomplishing about three times the annual reduction of nitrogen achieved by all the technological pollution control efforts of the last two decades combined. And the trees do it for free, while other solutions cost billions. Yet, we rarely think of the trees in this way.

Today's environmental problems stem from both how many people live in a place and how they live—the per capita consumption of land and natural resources. The wasteful conversion of open space to developed lands removes the Bay's filters and buffers and developing wetlands and forests is a largely irreversible process. But to assign this blame to "industry" or "agriculture" or "developers" is to ignore a critical fact. Many of the problems with the Chesapeake Bay are the cumulative impact of fulfilling the wants and needs of the people who live here. People often multiply their impact by a factor of one when they should be multiplying by the 16 million who inhabit the Bay's watershed. We are wasting too much land on paving and using too much energy. We are frittering away the heritage of the places we live—the character of our natural landscapes, the community of our small towns, and the vitality of our urban centers. Fortunately, the alternatives leading to a restored Bay do not mean an impoverished existence; rather, they may lead to an even higher quality of life.

> ***We must learn to see the Bay whole, as water and watershed and airshed inseparably linked; to see the bay as a system whose forests are every bit as much components of pollution control and environmental health as sewage treatment plants and sediment fences. It seems easy to accept spending $50 million or more on sewage treatment, but the protection or restoration of a filtering, cleansing forest is "uneconomic" to invest in. Forests—so vital for wildlife, clean water, and clean air—must be also seen as essential to restoring the Bay and to maintaining our quality of life. We must regain the Bay's natural resilience through the natural systems like forests that help the Bay help itself!***
>
> *Tom Horton*
>
> *Excerpts from Turning the Tide: Saving the Chesapeake Bay*

Another major concern is that if the Bay and our watersheds continue in an unrestored state, political leaders, decision-makers, and we who live around the Bay, will redefine success. As public memory of a truly healthy estuary recede, the concept of "restored" may also be reduced to a more "achievable" state. With fishing closed to shad since 1979, adults who have never caught a shad are not overly worried about bringing back what they have never had. The same goes for oysters, bay grasses, and streams. Each new generation experiences a marginal Bay, one more degraded than that of decades ago. This point of view inevitably leads to lower expectations and less pressure on politicians to do right by the Bay.

What must we do then, to save the Bay? Despite notable efforts and successes, the challenge is not being met. Just holding the line against further decline is not restoration. If the wealthiest, most powerful, and technologically advanced nation in the history of the planet cannot live in a place without ruining it, what message does that send to the rest of the world? We need more than a reinvigorated commitment to fighting for the Bay and the environment. We must redefine the nature of the struggle.

PREFACE

Many organizations compile information and data on the value, trends, and threats to the condition and sustainability of forests in the Chesapeake Bay watershed. The State of Chesapeake Forests report pulls together much of this varied information to provide a resource for governments, environmental organizations, and other groups interested in establishing forest protection and sustainable management as a key strategy for improving the Bay watershed's environment, economy, and quality of life.

The State of Chesapeake Forests

Introduction:

At first glance, forests are thriving in the Chesapeake Bay watershed. Chesapeake forests as a whole represent one of the most expansive hardwood forests in the world and contain a tremendous diversity of plants, wildlife, and habitats. These same forests provide residents with invaluable services, like clean air and water, wood for builders and craftsmen, and places for recreation and spiritual renewal. Residents also see trees almost everywhere they go—while driving to work, walking in their communities, and visiting local parks. However, we are slowly losing and fragmenting these forests, eating away their ability to protect the Bay and provide people with the goods and services they desire. Within these seemingly healthy forests, many forces are threatening functions that are critical to the environment, economy, public health, and quality of life of the region.

Natural and human-induced disturbances like fires, storms, and pests have shaped the extent, diversity, growth, longevity, and character of Chesapeake forests for thousands of years. However, new forces like sprawling development, air pollution, invasive species, and overabundant deer populations magnify stress on forests and may significantly alter future forest ecosystems.[1] How governments, forestland owners, developers, environmental groups, and others respond to the cumulative impacts of these forces of change will determine the future of Chesapeake forests and our ability to sustain the health of the Bay.

WHY ARE FORESTS IMPORTANT TO THE CHESAPEAKE BAY WATERSHED?

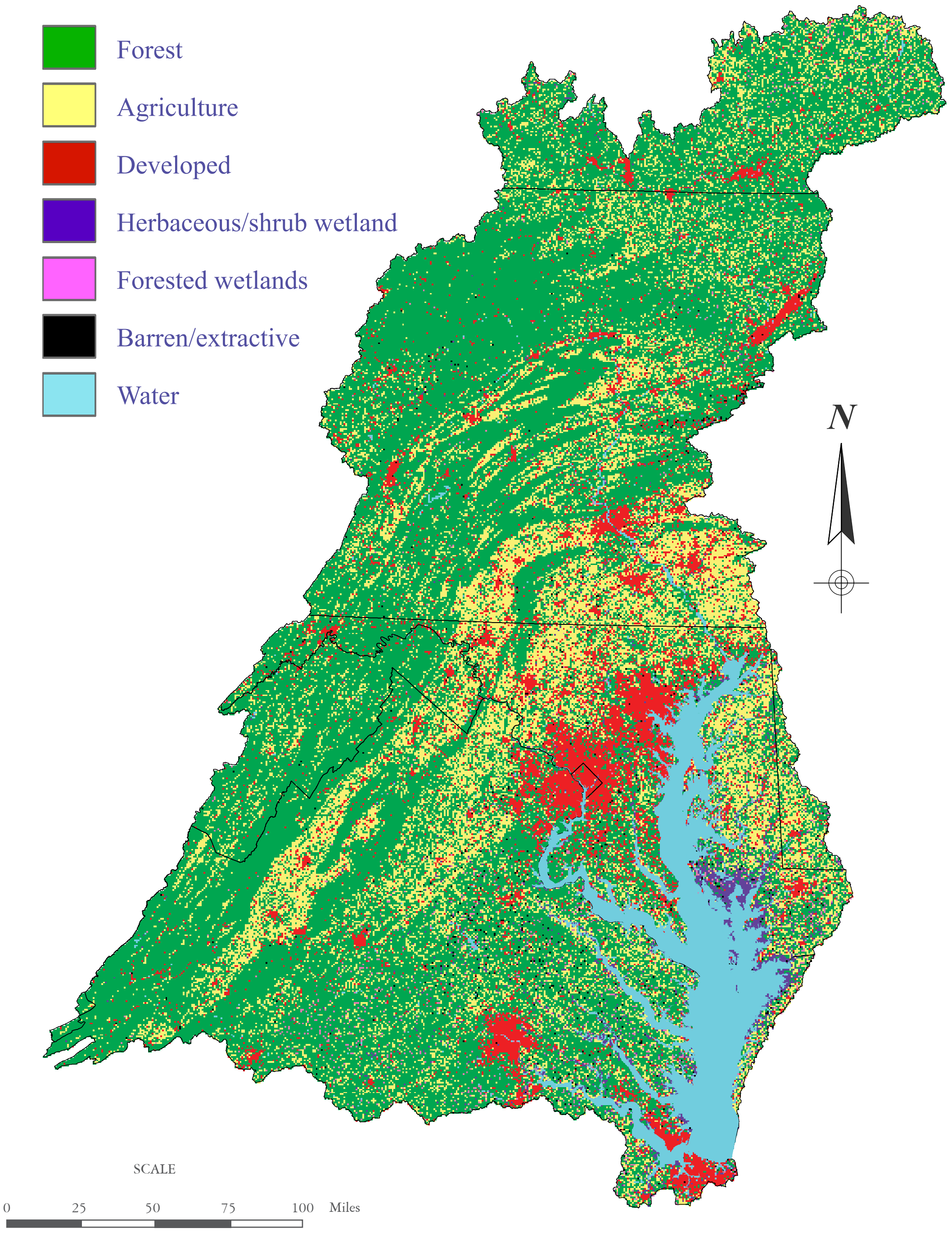
In a phrase, healthy forests are the key to watershed function. In a general sense, the declining health of the Chesapeake Bay can be traced to the replacement of forestland with farmland and development across the Bay watershed. The loss of forestland is so damaging because the Bay ecosystem is dependent on trees, having evolved in a landscape that was almost completely covered by forests. The wildlife and plant communities that Native Americans utilized and early European explorers such as Captain John Smith encountered were dependent on forests for food and shelter. Fish and other aquatic organisms lived in streams where forests moderated temperatures, controlled water flow, offered habitats in submerged roots and fallen branches, prevented excess sediment and nutrients from entering streams, and leached a "watershed tea" of nutrients that formed the foundation of the freshwater food chain and supported the Bay's benthic or bottom-dwelling communities.

While forest conditions have changed considerably over the past 400 years, Chesapeake forests remain critical to the health of the Bay and its watershed. People are more dependent than they realize on the varied benefits provided by forests. When it comes to forests, we are likely getting much more than we pay for.

Chesapeake forests:
<u>Protect Water Quality</u> - Forests act as 'sponges' by capturing rainfall, reducing runoff, maintaining the flow of streams, filtering nutrients and sediment, and stabilizing soils. Riparian forests that buffer streams significantly reduce the amount of excess nutrients (such as nitrogen and phosphorus) that enter the water, sometimes by as much as 30 to 90 percent. Mature trees also provide root systems that hold soils in place, helping to stabilize streambanks and reduce erosion.

<u>Offer Habitat for Fish and Wildlife</u> - Healthy forests provide food, shelter, nesting sites and safe migration paths for the Chesapeake Bay's aquatic and land animals. Streamside forests shade the water beneath their canopies, maintaining cooler water temperatures in summer, an important factor for spawning fish. Decaying leaves and wood are essential

LAND COVER, 2000



INTERPRETATION: Forestland makes up 60% of the total land cover. Agriculture (21%) and development (9%) are focused in and surrounding the Richmond-Washington-Baltimore corridor and in the valleys of the Appalachian Mountains. Remaining forested (1%) and herbaceous/mixed wetlands (2%) are found along river corridors and coastal areas.

SOURCE: MA RESAC 2000

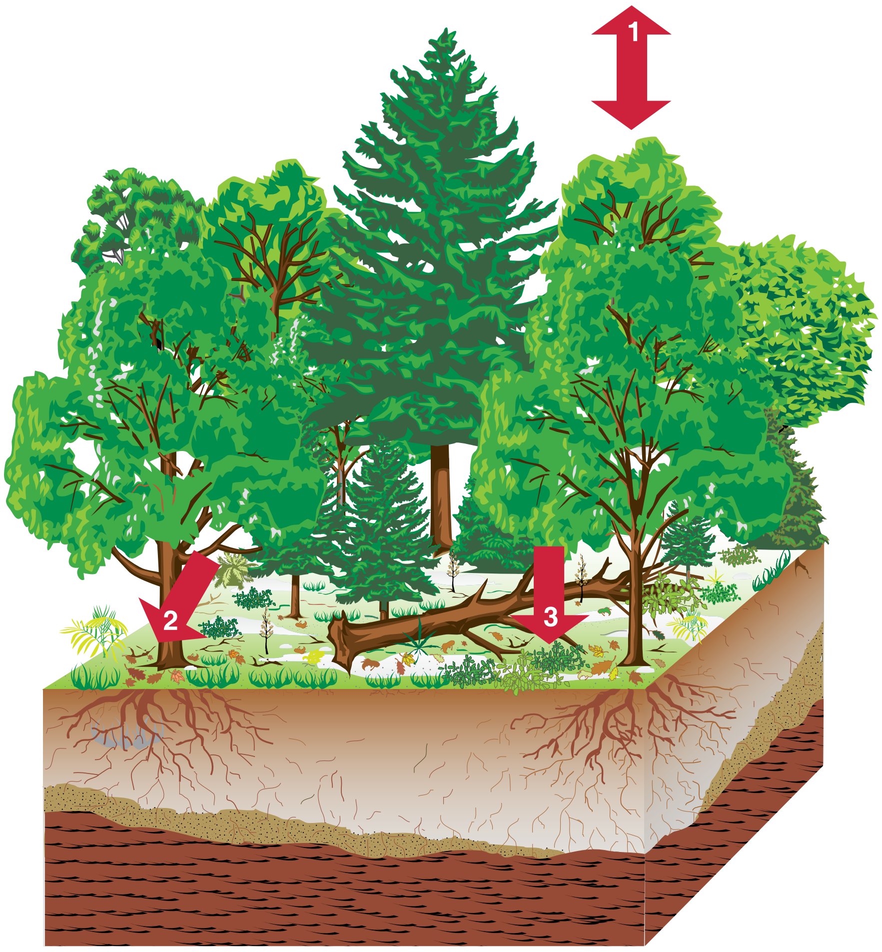
links in the Bay's food chain.

Improve Air Quality - Forests absorb or trap nitrogen, particulates and other pollutants in the atmosphere that are released by cars, factories, farming, and construction. In cities, tree canopies reduce summer temperatures and the generation of harmful pollutants like ozone.

Improve our Quality of Life and Encourage Recreation - Forests offer us places in which to reflect and experience natural beauty and solitude. They foster active outdoor recreation, such as fishing, hiking, camping, and cross-country skiing. Tourism and recreation contribute to the region's economy.

Enhance the Economy - Forests provide billions of dollars a year to the Bay watershed economy in the form of services like clean air and water, wood and paper, jobs and income, higher property values, improved physical and mental health, and recreational opportunities.

Forest Functions



1
- intercepts and slows percipitation
- removes carbon and other pollutants
- releases oxygen
- moderates climate by releasing water into the air and provides shade

2
- filters and traps pollutants from the forest floor and soil
- moderates floods

3
- stores nutrients and water
- prevents erosion

What Does a Healthy Forest Look Like?

A healthy forest is a complex, dynamic community of plants, animals, and soil. Healthy forests contain multiple layers of vegetation—each providing important functions. It is this complexity of interdependent parts and diversity of structure that makes forestland capable of providing clean water and diverse habitats. The top layer, referred to as the canopy, provides protection and shade for plants and animals, while also intercepting and slowing rain. Below the leafy roof is the understory—a layer of smaller trees and shrubs. Here, young trees begin to grow and eventually replace older ones as they die. The next layer, the forest floor, includes the grasses, herbs, vines, mosses, and other plants that live close to the soil. Plants, microorganisms, worms, insects, fungi, bacteria, and other living things populate the rich layer of decaying leaves and wood that forms the forest floor. This layer is rich in organic material and a storehouse of nutrients. The litter on the forest floor also protects the underlying soil. Healthy forests often contain more living biomass in the soil below ground than what is found above it.

Healthy forests also contain a diversity of plant species, ages, and sizes that allow the ecosystem to bounce back from disturbances and provide a variety of habitats. A rich diversity of species provides insurance in case disease, drought, or other conditions severely deplete any one species. Healthy forests are also dynamic, constantly adapting to disturbances like wildfires, storms, and pests. For example, the current dominance of oak throughout Chesapeake forests has been supported by the tree's ability to survive frequent, low-intensity fires that cleared out less fire tolerant competition like red maple.

Many of the Chesapeake's forests remain healthy and serve our needs today. However, centuries of widespread deforestation, destructive land management practices, and the impacts of pests and invasive plants have significantly altered the health of forests and, subsequently, their ability to sustain watershed health. Today's Chesapeake forests have recovered greatly from their condition at the turn of the twentieth century but still contain the legacy of past land uses. As a result, today's forestland is:

- Less abundant, particularly in the heavily populated Coastal Plain
- More heavily fragmented, restricting wildlife movement
- Of even-age and-size; "born" in the early 1900s
- Less biologically diverse
- More structurally homogenous, having lost layers of vegetation and large woody material on the forest floor

THE SETTING: CHESAPEAKE BAY WATERSHED

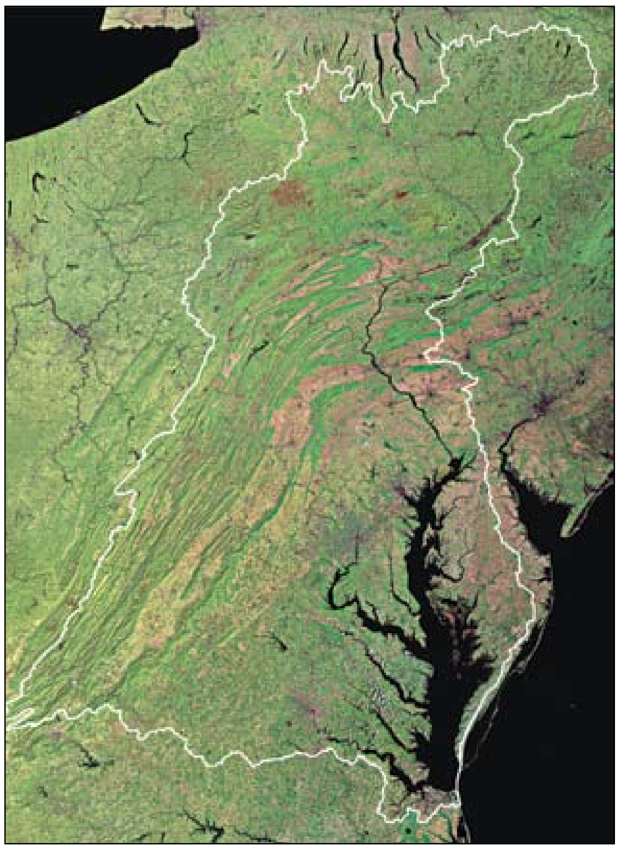
> *"The Chesapeake Bay, rich in cultural heritage as the cradle of our nation, and internationally known as a magnificent estuary abundant in natural resources, is truly an American treasure deserving of national recognition."*
>
> *Chesapeake Executive Council*

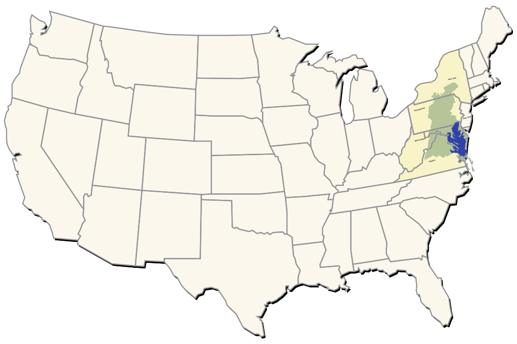
Around 18,000 years ago as the last Ice Age ended, rising sea levels fed by melting glaciers dramatically inundated the Susquehanna River gorge and intruded into river valleys branching off east and west. This nascent bay developed into the shape we associate with the modern Chesapeake Bay around 5,000 years ago. The Bay is the largest and was once the most productive estuary in the United States. Its watershed encompasses 64,000 square miles—over 44 million acres. At the heart of the American experience and home to some of our most powerful political and economic engines in the country, the region's rolling hills and temperate climate have helped shape the national psyche.

The expansive Chesapeake Bay watershed extends from Cooperstown, New York in the north to Cape Henry, Virginia in the south and from the Appalachian Mountains in the west to the Atlantic Ocean in the east falling 4,000 feet to the sea. More than 40 major rivers wind their way to the Bay and ultimately, the Atlantic Ocean through expansive mixed forests, freshwater ponds, and rich tidal marshes, forming a complex and intimately interconnected natural system. This complex ecosystem supports more than 3,600 species of plants and animals and has shaped the commerce and culture of the region for 400 years.[2]

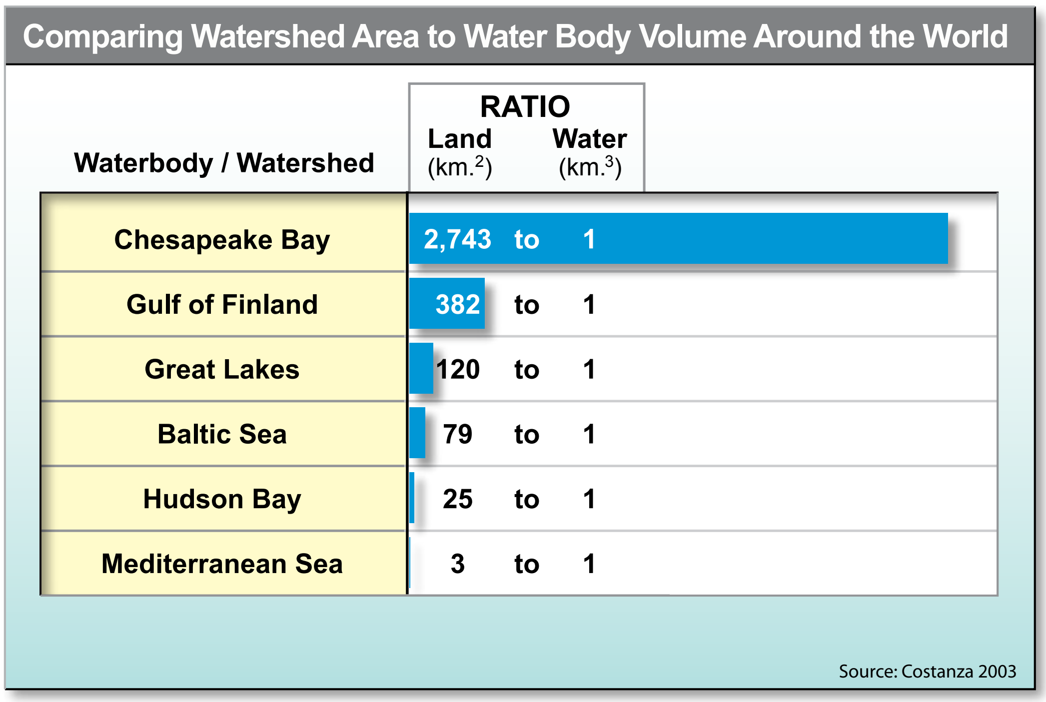
The Bay itself is 200 miles long and ranges in width from 3.4 miles near Aberdeen, Maryland to 35 miles near the mouth of the Potomac River.[3] It has an intricate shoreline that snakes over 5,000 miles in length—more than the shoreline of the entire Pacific Coast of the United States. But describing the Bay itself does not fully illustrate the importance of the land's influence on the water. While the Bay itself is quite large, its watershed is 16 times more expansive giving the estuary the largest land to water volume ratio of any water body on Earth.[4] The principle reason for the Bay's dominance in these statistics is not its size, but rather its extreme shallowness. The Bay's average depth is only 21 feet, meaning a person could wander over more than 700,000 acres of its bottom and still keep their head above water. This shallowness also gives the Bay its amazing productivity but also points out its sensitivity to what goes on in its watershed.

As water flows through the watershed, sediment, nutrients, chemicals, and other substances, wash off the surrounding land into streams, and eventually find their way to the Bay. Due to its broad





Comparing Watershed Area to Water Body Volume Around the World



Waterbody / Watershed	RATIO Land (km.^{2})		RATIO Water (km.^{3})
Chesapeake Bay	2,743	to	1
Gulf of Finland	382	to	1
Great Lakes	120	to	1
Baltic Sea	79	to	1
Hudson Bay	25	to	1
Mediterranean Sea	3	to	1

Source: Costanza 2003

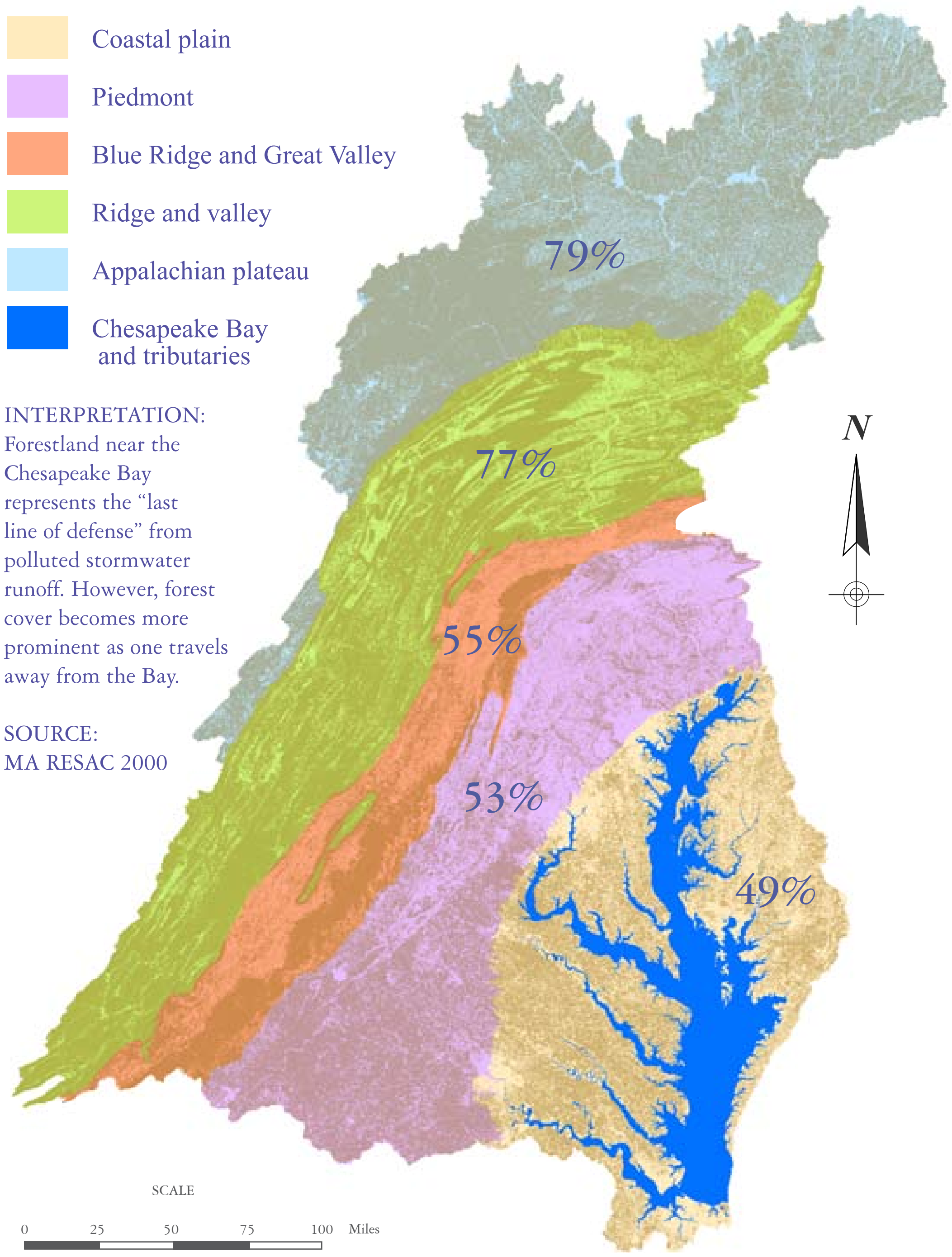
and shallow nature, pollutants easily settle in the estuary. Once pollutants enter the Bay, they tend to stay for long periods. It is easy to understand how development, agriculture, and many other activities on land, even those that occur hundreds of miles from the Bay, are strong determinants of the estuary's health. The good news is that actions taken to protect and improve the land, and its forests, no matter where they occur, have a cumulative ability to restore the Bay.

While not as extensive as before European settlement, forestland now covers 58% of the Bay watershed, a larger proportion than any other single land cover. The largest remaining blocks of forestland occur in regions with steep slopes and on poorly drained soil—areas not particularly amenable to development or agriculture. In general, forest cover increases as you travel farther away from the Bay. Larger blocks of forest are protected as state and federal forests or parkland.

Agricultural land is most often found in valleys, on the fringes of the urban centers, and in the relatively flatter central portion of the Bay watershed and coastal peninsula of the Eastern Shore.

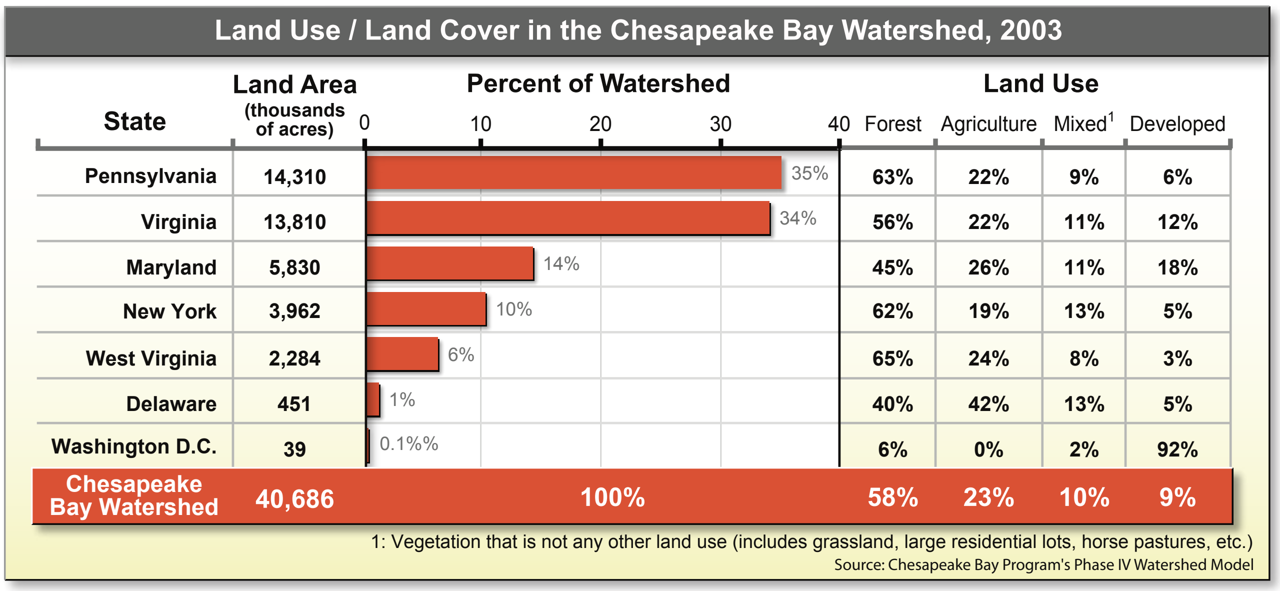
Over 16 million people inhabit the Bay watershed with most people living in the urban centers of Baltimore, Maryland; Washington, D.C.; and Richmond, Virginia.[3] Other smaller urban centers include the York-Lancaster-Harrisburg region, the Binghamton area in New York, and the Virginia "Tidewater" region (Norfolk, Hampton, and Newport News) near the mouth of the Bay.

PERCENT FOREST BY PHYSIOGRAPHIC REGION



INTERPRETATION: Forestland near the Chesapeake Bay represents the "last line of defense" from polluted stormwater runoff. However, forest cover becomes more prominent as one travels away from the Bay.

SOURCE: MA RESAC 2000



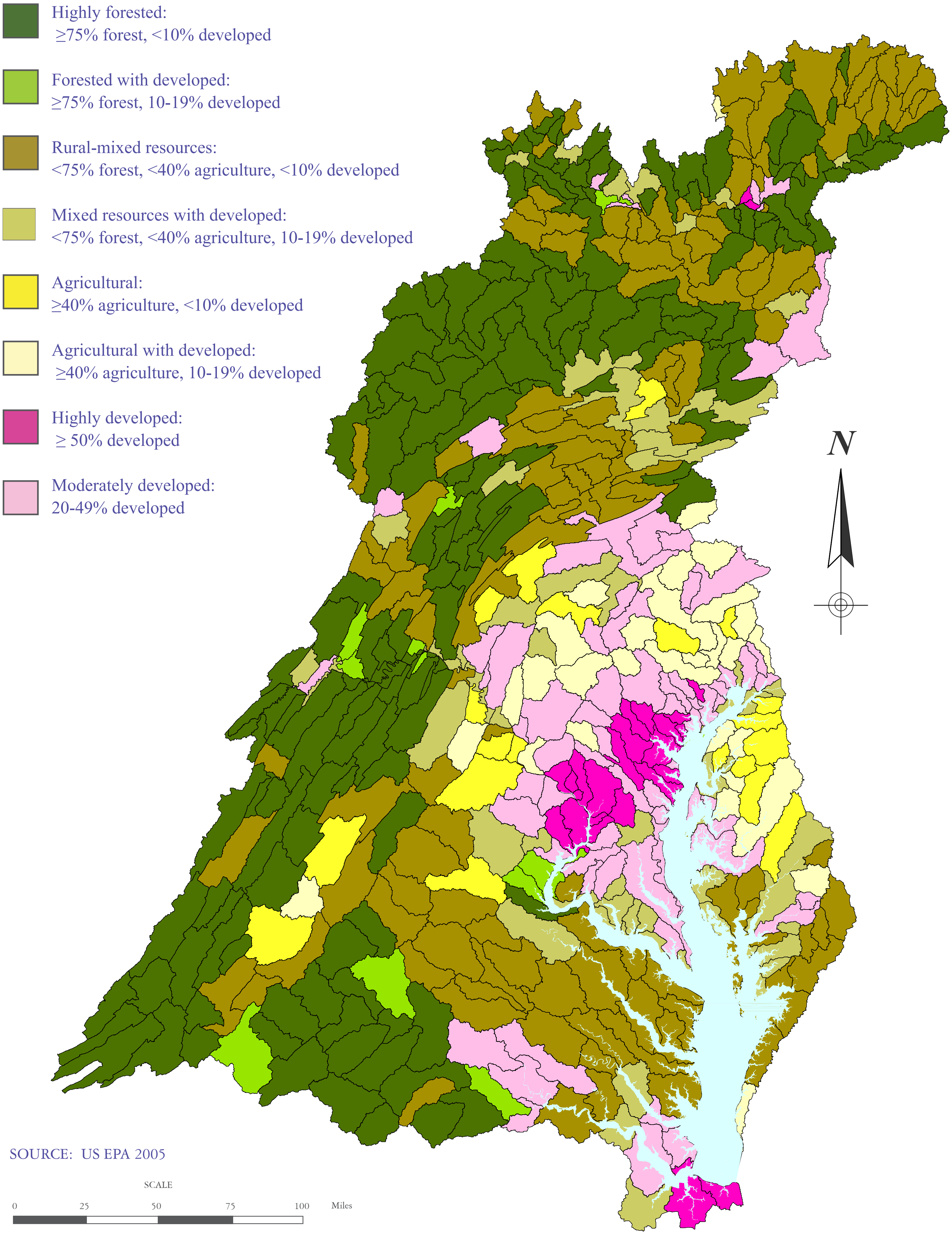
Land Use / Land Cover in the Chesapeake Bay Watershed, 2003

State	Land Area (thousands of acres)	Percent of Watershed	Forest	Agriculture	Mixed[1]	Developed
Pennsylvania	14,310	35%	63%	22%	9%	6%
Virginia	13,810	34%	56%	22%	11%	12%
Maryland	5,830	14%	45%	26%	11%	18%
New York	3,962	10%	62%	19%	13%	5%
West Virginia	2,284	6%	65%	24%	8%	3%
Delaware	451	1%	40%	42%	13%	5%
Washington D.C.	39	0.1%%	6%	0%	2%	92%
Chesapeake Bay Watershed	40,686	100%	58%	23%	10%	9%

1: Vegetation that is not any other land use (includes grassland, large residential lots, horse pastures, etc.)

Source: Chesapeake Bay Program's Phase IV Watershed Model

WATERSHED CATEGORIES



SOURCE: US EPA 2005

FORCES OF CHANGE

New forces like sprawling development and an overabundance of deer are significantly altering forest ecosystems.[1] The effects of the following forces of change on the special characteristics and critical ecosystem functions of Chesapeake forests are discussed throughout this report.

Sprawl

Between 1982 and 1997, the Chesapeake Bay watershed lost over 750,000 acres of forestland to development—a rate of 140 acres a day and equivalent to the loss of 20 cities the size of Washington D.C.[5] Additionally, by 1997, people in Mid-Atlantic region were using almost 130% percent more area of development than they did in 1954. This inefficient use of land, often referred to as sprawl, is characterized by low-density development located away from existing community services such as schools, stores, and wastewater treatment facilities. The loss of forestland is significant because it represents a permanent loss of water filtering capacity, wildlife habitat, and many other functions.

Roads, housing subdivisions, farms and other human uses also divide 60% of Chesapeake forests into disconnected fragments surrounded by other land uses.[6] Fragmentation introduces a suite of negative influences including invasive species and wildfire.[7]

Parcelization

"Parcelization" is the breakup of larger land ownerships into smaller ones. Over the past ten years, the number of family forest owners in the Bay watershed increased by nearly 25% representing 23,000 new family forestland owners per year. In addition, the average size of forested landholdings decreased from 21 to 16 acres per family forest owner.[8] This parcelization of forests often corresponds with a decline in the percentage of forestland that is actively managed for wildlife, timber, recreation, or other uses, which increases the risk of conversion and fragmentation and restricts access to residents.[9] For foresters who provide professional advice to landowners, this also represents a daunting administrative challenge. The economic lure of forestland speculation, transfer of forestland within families, and changing economics in the forest products industry have all contributed to the parcelization of Chesapeake forests.[10]

Lack of sustainable management

Essentially, few forests of the Chesapeake Bay watershed have been untouched by logging, mining, development, or other activities over the past 400 years. Where fragments of original forests remain their size and the nature of what surrounds them often renders these remaining old forests less resilient to major disturbances. Sustainable forest management is needed to mitigate human influences and to ensure the future provision of ecosystem services like water filtration, habitat, and carbon sequestration. While governments and forest product companies have worked hard to increase the use of sustainable management, its practice on family owned land is lacking; a fact important to the Bay watershed where families own 64% of all forestland. As an indicator, only a third of family forestland owners have sought professional advice on land management questions and even fewer have developed forest stewardship plans.[8]

Additionally, landowners that do decide to utilize their land for wood products, recreation, or other uses often do not seek out and use professional assistance and can end up damaging the long-term economic and environmental value of their forest. For example, by removing the biggest, best, and most valuable trees, a short-term management practice called "high grading" leaves poorer quality trees to regenerate the forest, eliminates wildlife food sources and nesting sites, and reduces the long-term economic value of the forest.

Overabundant deer

In many forests across the Bay watershed, white-tailed deer have become one of the greatest threats to forest health. The original forest has become fragmented and surrounded by farms and suburban gardens, deer have far more plentiful and nutritious food sources. This fragmented landscape results in numerous refuges for deer where hunting is prohibited. Locally high deer populations are eliminating forest regeneration—depleting biodiversity across the Bay watershed—by consuming large amounts of vegetation, and influencing forest composition by selectively browsing.

Fragmentation

Parcelization

Invasive Insects and diseases

Invasive forest pests and associated diseases will continue to alter forest conditions in the Bay watershed. Some past introductions such as chestnut blight, Dutch elm disease, beech bark disease, and gypsy moth have had long-term, devastating impacts on Chesapeake forests.

Invasive plants

The Chesapeake Bay watershed is infested with invasive plants; many of which are now permanent components of Chesapeake forests. In addition, the disturbed habitats in which invasives thrive in will continue to spread with human activity. Invasive plants, often exotic, grow and reproduce rapidly, killing, and out-competing other species in the process. In addition, as invasives take over habitats they lower the quality of food sources and shelter options for wildlife, eliminate host plants of insects, and compete with plants for pollinators. Invasive plants are especially problematic for a forest reestablishing in a clearing.

Fire suppression and wildfires

The removal of naturally occurring forest fires has had major impacts on Chesapeake forests and increased their vulnerability to catastrophic wildfires. Tree species vulnerable to fire like red maple and tulip poplar have thrived, while fire-resistant species like oak have declined.[11] The prolonged absence of fire has increased the density of some species. Dense vegetation is more prone to drought and excessive accumulation of woody debris on the forest floor increases the likelihood of severe wildfires.

Air pollution

Prolonged exposure to nitrogen deposition and other air pollutants over decades has led to the acidification of forest soils in the Bay watershed. This, in turn, has caused tree mortality, stunted growth, and increased the transfer of pollutants from forests to streams. Air pollution can also increase the susceptibility of trees and other plants to a multitude of stressors including insects and diseases.

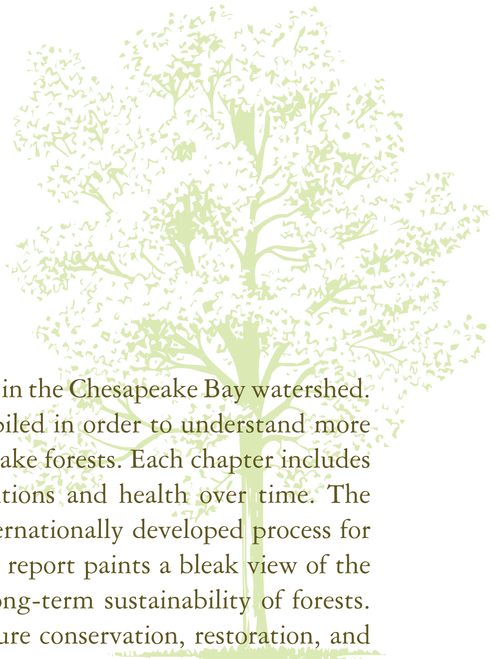
Climate change

Climate change will directly affect tree growth and survival in Chesapeake forests due to higher temperatures and altered precipitation regimes. An analysis of potential affects on tree species noted that 37 of the 75 tree species considered would be reduced in overall abundance under climate change scenarios. Changes in tree species abundance would also shift current forest habitats northward essentially pushing out maple/beech/birch and expanding oak/hickory and southern pines.[12]

Forests may experience indirect affects of climate change such as a higher abundance of pests, greater fire frequency, and changes in climate-sensitive soil processes such as erosion and decomposition. Potential changes in the frequency of extreme weather events such as hurricanes may also affect forests.

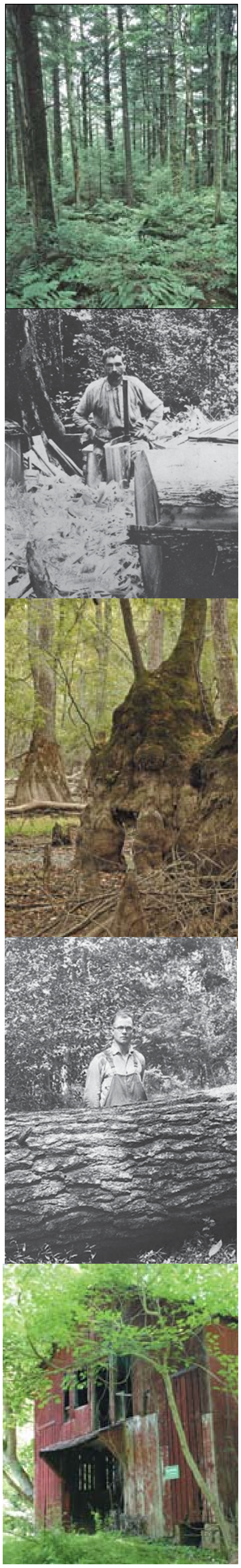
Clockwise from top left: Japanese barberry, Japanese honeysuckle, Kudzu, Canada thistle, and English ivy.

Photos by: Barry Rice, James H. Miller, and Dan Tenaglia



CHAPTER IN PERSPECTIVE

This publication provides a base of information and analysis related to forestland in the Chesapeake Bay watershed. The collection of data, graphics, case studies, and other information was compiled in order to understand more fully the value, trends in condition, and threats to the sustainability of Chesapeake forests. Each chapter includes a model indicator that organizations can use to track trends in forest conditions and health over time. The indicators are based on The Montreal Process Criteria and Indicators—an internationally developed process for assessing progress toward sustainable forest management. While much of this report paints a bleak view of the trends in forest condition, choices can be made that will better ensure the long-term sustainability of forests. To this end, a collection of potential strategies are also presented to guide future conservation, restoration, and management efforts of state agencies, regional environmental groups, and other organizations interested in the sustainability of Chesapeake forests and the Bay itself.



Chapter 1:

Linking the Past to the Present

Key Findings

- Native Americans shaped Chesapeake forests for thousands of years, though their influences were localized and most prominent along coastal areas.

- When Europeans arrived in the 17th century, they found vast, resilient, and diverse forests dominating 95% of the watershed.

- The comparatively brief period of European settlement had dramatic and lasting effects on forest age, composition, structure, and distribution as well as water quality.

- By the late 1800s, nearly 50% of forestland had been harvested for agriculture, fuel, timber, and other uses.

- Throughout the 20th century, "new" forests grew back on abandoned farmland and in heavily logged forests. Forests now cover approximately 58% of the Bay watershed, a recovery that reflects the natural resiliency of forests.

ANCIENT CHESAPEAKE FORESTS

Tens of thousands of years of natural and cyclic change established the forests that early North American inhabitants first traversed some 13,600 years ago.[1] These forests were primarily filled with conifers: fir, spruce, and pine. The abundance of cold-tolerant species reflected the influence of the recent ice age. Today, you can see and touch similar forest communities in areas such as the headwaters of the Potomac River in West Virginia, Mt. Rogers in Virginia, and Bear Meadows in Pennsylvania. Just west of the Chesapeake Bay watershed, in Maryland's Swallow Falls State Park, an ancient hemlock forest, moist and sensitive to fire, provides a chance to experience a cool, dark woodland, with deadfalls of centuries-old trees.

CHESAPEAKE FORESTS AT EUROPEAN SETTLEMENT

European settlers in the early 1600s found a vast and spectacularly diverse forest dominating approximately 95% of the Chesapeake Bay watershed. Along the Bay and its rivers, these newcomers found a seemingly infinite variety of trees that were astonishing in their "bulk and antiquity."[2] Ancient oak, yellow poplar, eastern hemlock, beech, loblolly pine, white pine, American chestnut, and other species in these forests stood as much as 40% higher than those living today.[3] The trees of Chesapeake forests also reached magnificent widths, some rivaling the size of giant sequoias. The largest tree known to exist in West Virginia, a white oak, grew to 10 feet in diameter 31 feet off the ground and was well over 1,000 years old.[4] Captain John Smith wrote about encountering trees, including the cypress, which had circumferences of 18 feet.[5]

> ***"…there is a kind of wood we called cypress, because both the wood, the fruit, and leaf did most resemble it, and of those trees there are some near three fathoms about at the foot {18 feet}, very straight and 50, 60, or 80 {feet} without a branch."[6]***
>
> ***- Captain John Smith***

EARLY FOREST COMPOSITION

In general, upland from rivers and the Bay, forests were composed of hardwoods, mostly oak and hickory, while pines dominated more sandy soils.[7] In Pennsylvania, early land surveys show an abundance of white oak in pre-European settlement forests. A botanist from the early 19th century noted that "large forests, nine tenths of which consisted of white oaks," dominated western Pennsylvania.[8] Oak, American chestnut, and hickory were major components in all but the northernmost forests in Pennsylvania, where American beech dominated across the New York border, mixed with eastern hemlock, sugar maple, and birch.[9]

Under the lofty hardwood canopies grew a diverse, shade tolerant layer of shrubs such as eastern hophornbeam, viburnum, and witch hazel. In the moist duff of the forest litter grew ferns, violets, lady's slipper, and mosses.[14] Interlocking tree roots conserved soil and water, and reduced the amount of sediment and nutrients that stormwater runoff could carry to nearby waterways. Around these roots existed invaluable, immense, and long-lived symbiotic associations with fungi, which efficiently recycled nutrients in the soil. Therefore, forests were stingy in their release of nitrogen and phosphorus to adjacent streams, which resulted in clear waters feeding the Bay.

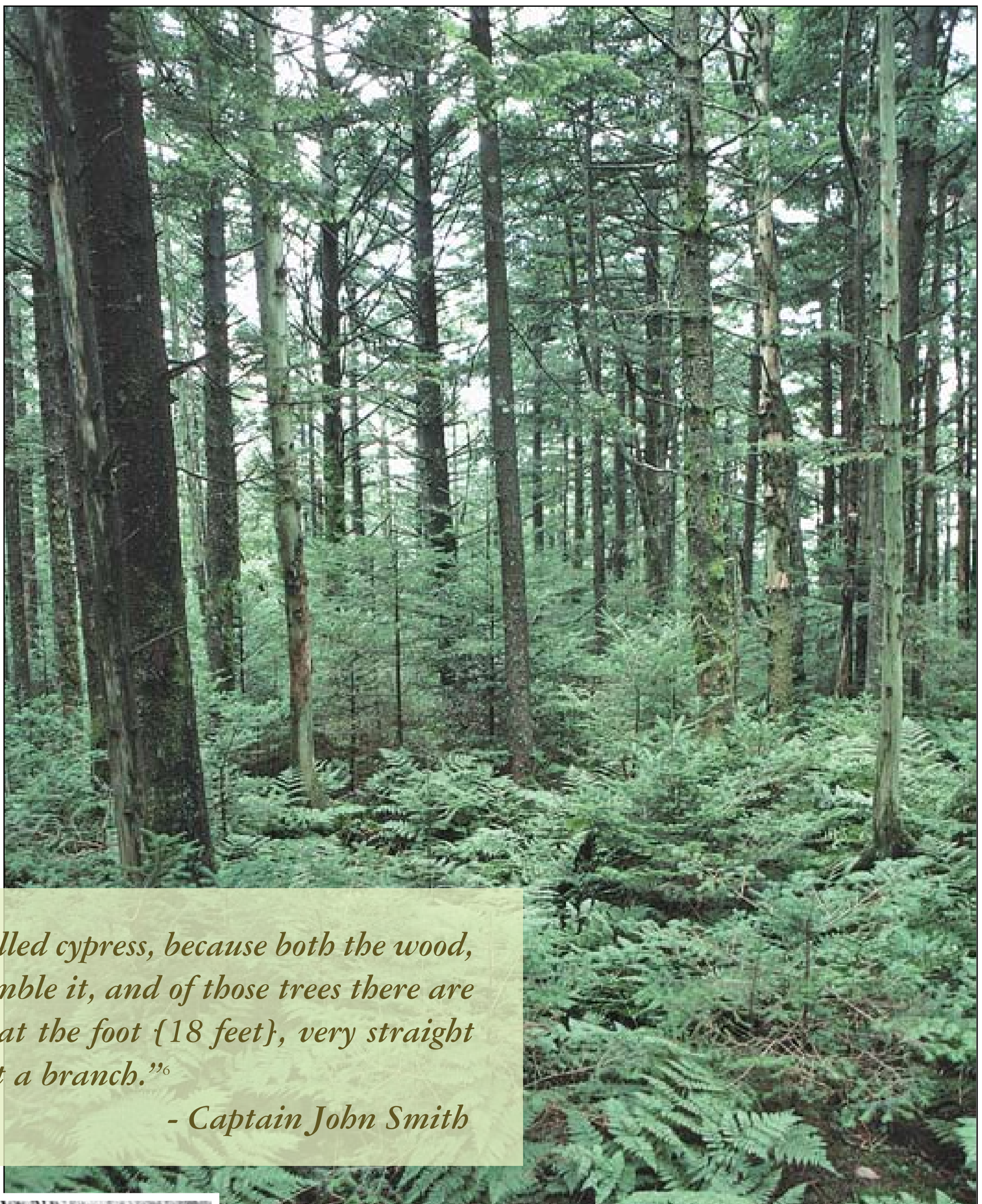


Photo: Gary P. Fleming © VA DCR Natural Heritage

Frasier Fir Forest with Mountain Wood fern/Mt. Rogers, Virginia

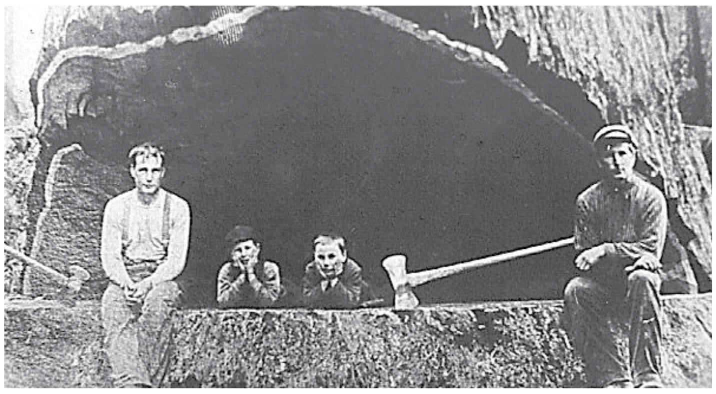
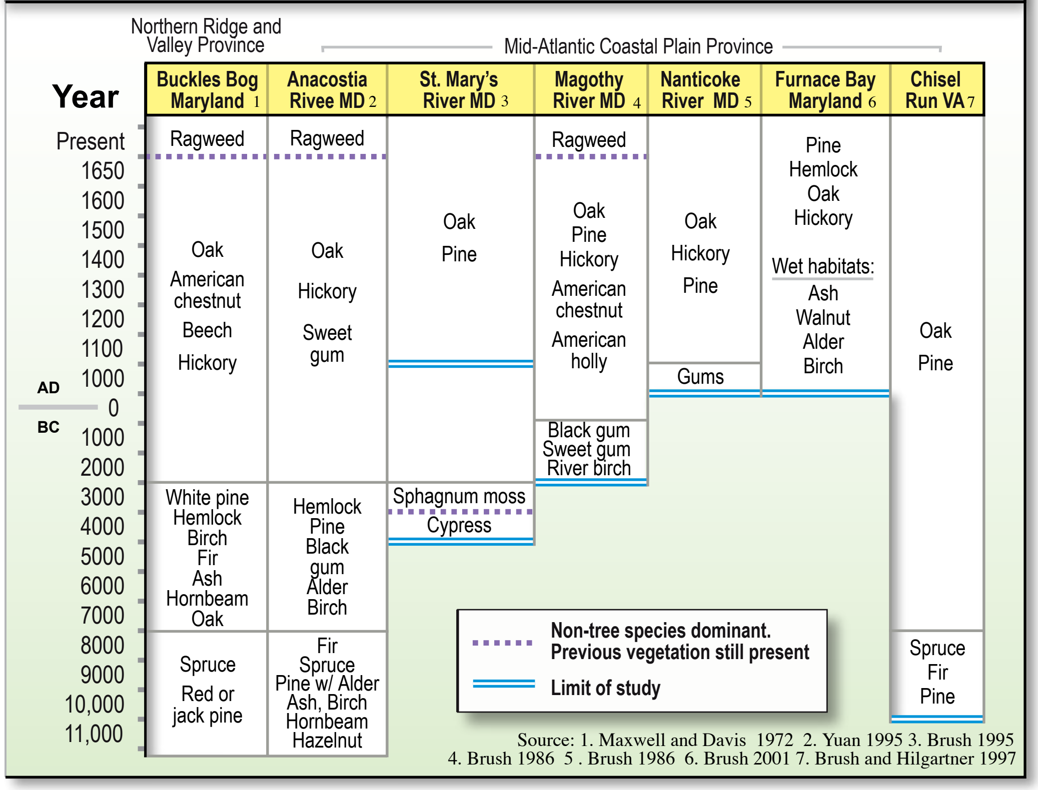


Photo: McClain Printing Company

White Oak/West Virginia, 1913

Dominant Vegetation in Chesapeake Forests: 11,000 B.C. - Present



Source: 1. Maxwell and Davis 1972 2. Yuan 1995 3. Brush 1995 4. Brush 1986 5 . Brush 1986 6. Brush 2001 7. Brush and Hilgartner 1997

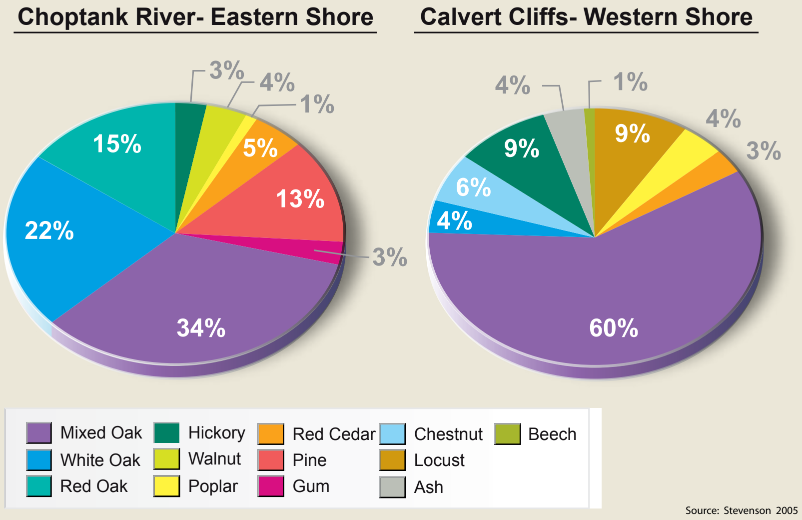
HISTORIC FOREST COMPOSITION IN THE MARYLAND COASTAL PLAIN

Early 17th century land patents or deeds used trees to mark property lines and other points of interest. A study of these patents on the Eastern and Western Shores of Maryland provides insight into the composition of forests in the Coastal Plain and Piedmont areas at the time of European settlement.[10]

Along the Western Shore, the Calvert Cliffs area was dominated by oak in the 1600s, especially white oak.[11] The dominance of oak is not surprising, given that oak is still a major forest component there.[12] However, the original surveys list no pine trees, in spite of their current prevalence. This suggests that pine was not a significant fraction of the forest on the Western Shore at that time. Before European settlement, the Calvert Cliffs area also lacked red maple and hosted a large number of locust trees. This indicates that fire was a common occurrence, because the thin bark of red maple makes the species particularly vulnerable to fire and locust often colonizes an area after disturbance.[13]

The Eastern Shore patent describes property that runs along the Choptank River in Dorchester County. According to the land patents in the 1600s, oak was even more dominant along the Choptank than on Calvert Cliffs. Today, oak is not as abundant, having declined as land clearing and fire suppression took place on the Eastern Shore.

Forest Composition on Maryland's Eastern and Western Shores in the 1600s



Source: Stevenson 2005

WILDLIFE

A large, diverse forest led to a richness of the region's wildlife, which amazed early explorers and settlers. Large mammals such as the white-tailed deer, black bear, elk, and even woodland bison roamed the forests, while huge numbers of turkey, heath hens, grouse, and seasonal hosts of waterfowl lived in forest habitats. Great flocks of passenger pigeons, the most numerous bird species on the continent, could block sunlight as they migrated and foraged for nuts throughout the Bay watershed.[15]

APPEARANCE

While European settlers found forests widely distributed across the Bay watershed, the forests were not uniform. Natural processes like high winds, fires, and hurricanes created significant forest openings every 800 to 14,000 years.[9,16] These natural events, along with heavy grazing by herbivores like deer and elk, maintained areas of grassland and open woodlands. While the exact amount is debated, early reports suggest the Shenandoah Valley in Virginia and Wyoming Valley along Pennsylvania's Susquehanna River had some large grassland areas.[17]

Early explorers remarked on the park-like setting of coastal areas in the mid-Atlantic. Captain John Smith observed that a "man could gallop a horse through these woods."[18] These open woodlands were the result of brush-clearing fires set by Native Americans to improve the ease of hunting, production of herbs, the driving off or killing dangerous animals, and many other uses.[9] In general, these fires occurred every few years with a low intensity and localized effects. However, in more populated regions, fire could substantially alter the landscape. In the early 1600s, 30 to 40 acres were cleared for every individual in Virginia.[18]

The Native American population for the principal portion of the Chesapeake Piedmont and Coastal Plain provinces was between 24,000 and 33,000 people in the 16th century.[19] In 1608, Native Americans living along the lower Potomac River, from below Great Falls to its mouth, ranged from a low of 5,500 to a high of 11,000 people.[20] However, Native American communities were severely impacted by European diseases such as small pox and thousands of Native Americans died soon after European contact.

FOREST USE AND CHANGE

17TH CENTURY: EUROPEAN SETTLEMENT BEGINS

Most scholars agree that the first centuries of settlement by Europeans produced the most extensive environmental change in the Chesapeake Bay region since the last ice age.[19] European settlers viewed the removal of forest as a requirement for economic development and saw the overarching forest resource as limitless. To the settlers stepping off a shallop on untouched shoreline, the wall of forest—which they faced with only an axe, flint, and steel—was daunting. Even John Smith, who often showed appreciation for natural resources, commented, "…all the country is overgrown with trees whose droppings continually turneth their grass [a grazing resource valued by the English] to weeds by reason of the rankness of the ground. Which would soon be amended by good husbandry."

Initially, the impact of colonists on the Chesapeake environment was minimal and focused primarily in coastal areas, where colonists sought land already cleared by the Indians. However, Europeans quickly began to mold the landscape in new ways. Timber resources were of great interest, perhaps second only to gold, which was never found in quantity. John Smith loaded the ship "Phoenix" with eastern red cedar as the first real useful cargo to leave Jamestown for England in 1608. The next year, a ship arrived that was specially fitted to accept long timbers for masts and other spars, only to find that she was still too short to contain the great trees brought down for transport. The resource became so valued that by the middle of the 1600s colonists had established a booming trade in ship masts and lumber.

Colonists also cleared the land to produce crops, primarily tobacco, and to provide firewood, their chief fuel source. By the end of the 17th century, settled areas were already facing shortages of easily worked timber used for homes and garden fences. Livestock, especially pigs, foraged at will in nearby woodlands, which had disastrous effects on herbaceous plants and soil structure. By the 1700s, Europeans were bringing plants with them across the Atlantic, creating a landscape in settled areas where one in every ten plants collected by colonial botanists was non-native.[21]

Photo: Maryland State Archives

From Forest to Farm/Western Maryland

18TH CENTURY: EXPANSION OF AGRICULTURE AND LOGGING

By the mid-1700s, 20 to 30% of forestland in the Bay watershed had been cleared to accommodate the growing population and its cash crop, tobacco.[2] By the American Revolution, all of the Tidewater and most of the Piedmont of Maryland and Virginia were occupied or actively being settled.[22] This land clearance began to adversely affect water quality as the loss of trees and other vegetation allowed greater soil erosion. The effects of erosion were perceived as early as 1753, when a Pennsylvania settler wrote:

"… our runs dry up apace, several which would turn a mill are now scarce sufficient for the farm. The reason is this. When the country was covered with woods, the rain that fell was detained by the woods and so had time to insinuate into the earth and contribute to our springs and runs. But now the country is clear'd and the rain as fast as it falls is hurried into our creeks and washes away the soil...and makes shoals in them, and hence creeks told by Mr. Penn to be navigable are no longer so."[23]

Timber shortages at home, plus long wars on the European continent, led the English to export greater quantities of wood from the colonies. In the Chesapeake and Carolinas, nearly 100 billion board feet—equal in area to the size of the Maryland—were logged

Photo: Maryland State Archives

Hillside Deforestation/Keyser Ridge, Garrett County, Maryland

during the colonial period alone.[18] Oak and pine were especially valued for shipbuilding. An English warship could require as many as two thousand oak trees in its construction.[19] In addition, the English sought the tall and straight eastern white pine to create masts greater than 30 inches in diameter for their larger ships.[9]

19TH CENTURY: DEMANDS OF THE INDUSTRIAL AGE

By the late 1800s, 40 to 50% of the land in the Bay watershed had been cleared of forests.[2] In the heavily settled Coastal Plain, as much as 80 to 90% of the landscape was deforested—covered with herbaceous vegetation or used for agriculture and other human uses.[16] From 1860 to 1910, settlers cleared forests at a rate of over 8,500 acres per day in the United States.[24] By 1880, logging replaced agriculture as the leading cause of deforestation.[9]

The ecological impacts of deforestation began to show in earnest in the 1800s. Water tables and water quality in streams and estuaries continued to fall as their natural buffers were removed. Soils that were slowly built by perhaps an inch every 600 years were quickly washed into streams.[25] During the late 1800s, soil erosion in the northeastern United States increased six-fold, from 100 to 600 tons per square mile.[26]

Photo: Maryland State Archives

Hemlock Storage Shed/Curtis Bay, Maryland

The huge influx of sediment had profound effects for aquatic life in the Bay by decreasing oxygen and burying habitat for bottom-dwelling species, like the oyster. This new ecosystem favored greater numbers of floating planktonic organisms and swimming creatures that dwell in the water column.[27]

At the same time, populations of many forest wildlife species reached their lows because of over hunting and habitat loss. By the 1890s, there were almost no white-tailed deer in Pennsylvania and very few in other portions of the Bay watershed. Today, twice as many deer die due to car collisions in the Eastern United States than existed in 1890.[28] Along with deer, populations of black bear, beaver, and other wildlife were either extirpated or severely depleted.

Fuel

Until the late 1800s, wood was the primary source of heat, light, and building materials in the United States. An era of cold temperatures from the mid-14th century to mid-19th century, known as the Little Ice Age, required colonists to burn immense quantities of wood to stay warm. A single household could consume 20 to 40 cords [i] of wood annually. The residents of Philadelphia alone consumed 140,000 cords of wood between 1826 and 1827, requiring the harvest of more than 7,000 acres of woods.[9]

Charcoal—produced by the slow burning of wood—fueled furnaces, foundries, and factories to meet the surging demand for iron in the 1800s.[28] Bay watershed residents needed considerable amounts of iron for tools, horseshoes, and cookware, as well as to expand the growing network of railroads.[29] For the average furnace, it took 20,000 to 30,000 acres of woodland to produce enough charcoal to smelt 1,000 tons of iron a year.[2] In addition, millions of pounds of iron ore were mined from forested wetlands for use in the smelting process.[29] Across the country, 5 billion cords of wood were harvested on approximately 200,000 square miles of woodland to fuel trains, furnaces, and steamboats between 1810 and 1867.[30]

Fencing

Wood was also used prodigiously to construct fences. In fact, the volume of wood used for fencing exceeded that of lumber until the 1840s. One mile of the classic "split rail" worm fence required 6,500 lengths of timber.[18] By 1850, there were enough miles of wooden fence in the United States to encircle the earth 120 times.[15]

Building Construction

The population of the United States was booming by the mid-19th century. While it had taken 150 years for the colonies to reach a population of 3 million people, the population grew seven-fold in the 65 years between 1785 and 1850, reaching more than 23 million. Development in the East and settlement of the mid-western prairie led to a large demand for imported timber. Approximately 10 million dwellings were built in the United States between 1860 and 1900, and the vast majority of these were constructed with wood.[9]

Mining

Coal exploitation in the Chesapeake region began in the 1840s. In Western Maryland's Allegany and Garrett Counties, there was a high demand for props to support the walls and ceilings of mining tunnels. The hills surrounding the mouth of mines were often denuded for mine props. Coal exploitation also had

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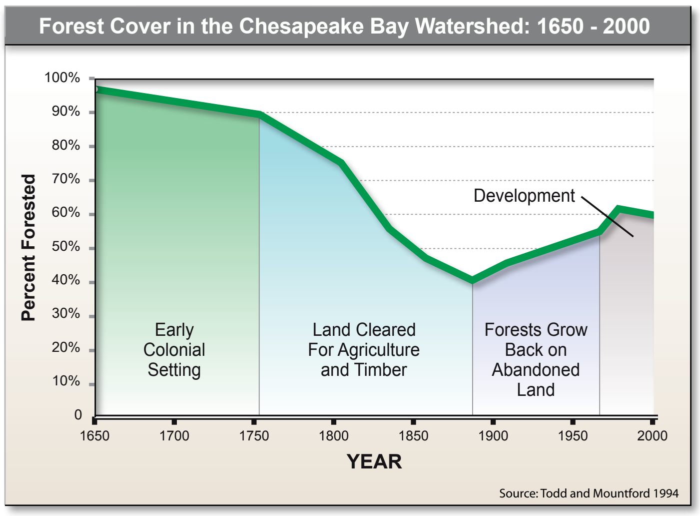
[i] A "cord" is a stack of wood 4ft x 8ft x 4ft

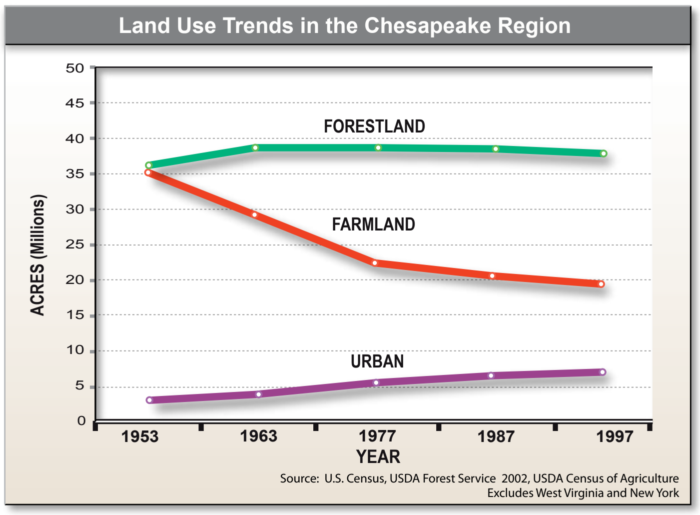
profound and disastrous consequences for many Chesapeake tributaries in the western drainage states, because the water leaching from the mines was acidic enough to kill vegetation and stream organisms, rendering the streams devoid of life.

Railroads

Coal enabled the expansion of commercial railroads beginning in the 1830s. Trains, in turn, exerted additional demands on Chesapeake forests. Early tracks required a constant supply of wood ties, cribbing, and trestles. The first trains burned firewood in large quantities, and woods near the tracks were quickly cut to meet this demand. Wood-burning steam engines threw vast showers of sparks, which in dry weather caused countless brush and forest fires.[9]



Source: Todd and Mountford 1994



Source: U.S. Census, USDA Forest Service 2002, USDA Census of Agriculture
Excludes West Virginia and New York

Leather Tanning

The high tannin content in hemlock bark made the tree especially valuable to the leather industry. Pennsylvania's old growth forests of hemlock, with stands so dense in the northern part of the state that they were dubbed the Black Forest, provided approximately half of the hemlock used in the leather industry at the turn of the century. In the late 1800s, large tanning operations were harvesting 1,000 acres of hemlock a year. By the 1920s, Pennsylvania's seemingly inexhaustible supply of hemlock essentially disappeared.[9]

TWENTIETH CENTURY: EXTENSIVE CLEARING ENDS

While the records are incomplete for the turn of the century, it is clear that 60 to 70% of Chesapeake forests were gone as a result of agriculture, logging, and other uses.[2] Nearly all of West Virginia's forests had been harvested by 1930. Mature white pine was essentially eliminated from Pennsylvania because of the harvesting of 32 billion board feet of lumber by 1900.[9] This equals to over 100 million board feet per year over the previous 300 years. In 2002, Pennsylvania harvested around 13 million board feet of white pine.[31]

Maryland's first state forester, Fred Besley, noted that early logging operations consistently removed the most valuable trees from the forest—often the largest and most well adapted trees—leaving regeneration of the next forest to stump sprouts and, generally, less healthy trees.[30] This unsustainable harvesting practice, known as high grading, continues on many private lands today.

A NEW FOREST IS BORN

Chesapeake forests today are largely a product of many changes in land use over the past 400 years. With so much woodland removed for agriculture in the 19th century, today's forests are primarily regrowth, with only small, scattered enclaves of undisturbed forest. Until the late 20th century, the Bay watershed saw nearly a hundred years of increasing overall forest cover.[36,37,38] Much of the regrowth took place on former farm fields, as America's agricultural production shifted westward, dairy incentives declined, farm policies changed, and marginal farm lands proved uneconomical.

AMERICAN CHESTNUT

The American chestnut was an extremely valuable and common tree throughout most of the pre-European Chesapeake Bay watershed even if the tree was less dominant than past research has suggested.[9,32,33] In virgin forests throughout its range, mature American chestnut trees averaged up to five feet in diameter with many specimens reaching 8 to 10 feet. Some trees reached 100 feet high.[7]

In 1901, chestnut blight was introduced to the East Coast in nursery stock from Asia. The blight quickly began to kill chestnut leaves, flowers, and stems. By 1950, the blight had decimated the species. Because the roots of the American chestnut are not affected by the blight, its sprouts survive a few years, but within 10 to 15 years they become infected and die.

After filling important ecological niches in Chesapeake forests for millennia, American chestnuts have been reduced to an understory shrub. The Blight Commission of 1911 noted that chestnut comprised between 8 and 50% of all trees in Bay counties with a median value of 25%.[34] However, in the same counties today, American chestnut trees exist as only a small fraction of the total number of trees.[35]

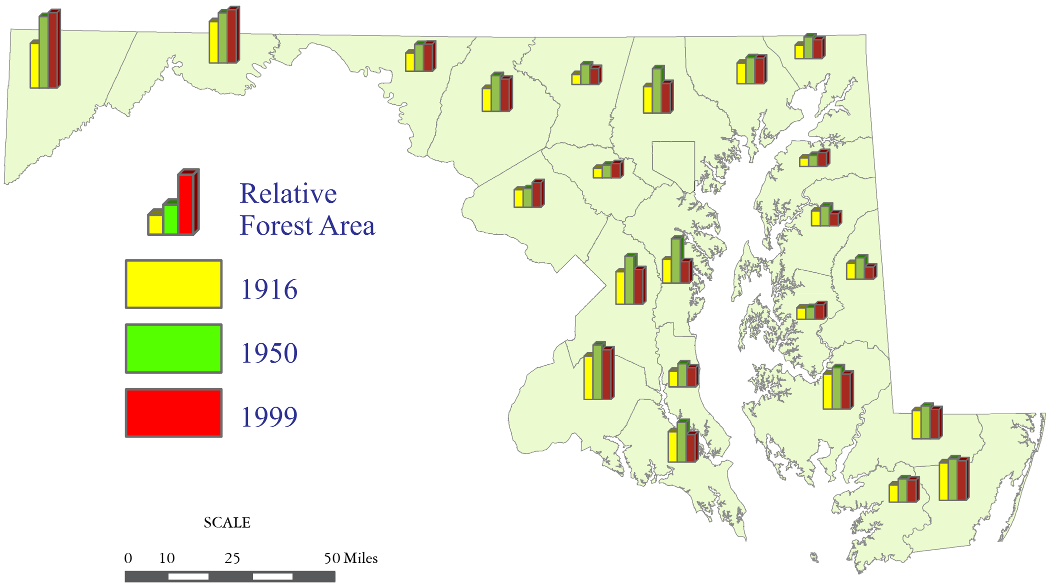
Blight resistant varieties and hybrids with Asian trees are currently being developed and tested in field studies with the goal of returning the American chestnut to Eastern forests. In 2005, a blight-resistant American chestnut was planted on the White House lawn to commemorate Arbor Day. Within a decade, the chestnut may begin their return to Chesapeake forests.

Photo: Ted Weber

Humans have repeatedly used the growing forest for timber, pulp, firewood, and development throughout the 20th century. Furthermore, changes such as the decline of white oak, white pine, and eastern hemlock, as well as the disappearance of species like the American chestnut, have altered forest composition. The loss of the American chestnut, because of its toughness and durability, had a big impact on the American wood market. As late as the 1980s, 16 to 18 inch chestnut logs left behind on the forest floor were collected and sawn commercially.[39] The shift in forest composition has created conditions favorable to other species such as black cherry and red maple—which today enjoys a remarkable and unprecedented dominance of the forest.[9]

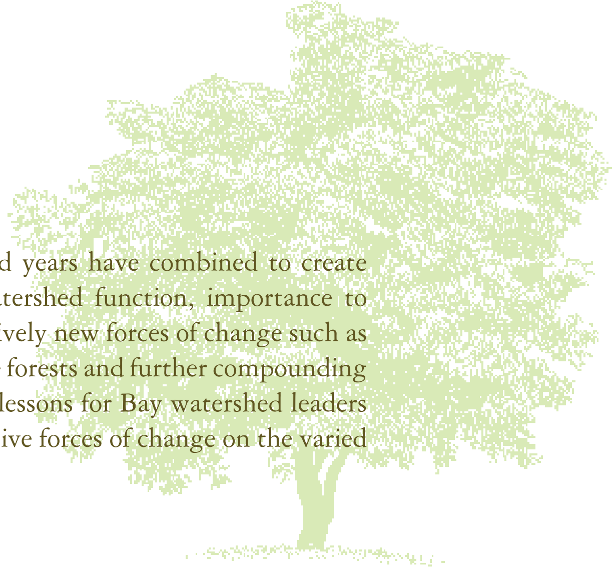
The new forest is much more heavily fragmented than the once vast and contiguous Chesapeake forest. Only 40% of Chesapeake forests contain the "interior" conditions of early forests. The 133,000 acres of forest in Baltimore County, Maryland, are separated into more than 9,000 individual pieces by farms, developments, and roads. Less than 0.1% is in patches 100 acres or larger.[30] Furthermore, development and disturbance of previously eroded or legacy sediment ensures that sedimentation rates remain high today, even though forest cover has greatly expanded throughout the watershed.[40]

Forest Cover Trends in Maryland



Source: 1. Besley, F.W. 1916
2. USDA Forest Service / NE Forest Experiment Station 1955
3. USDA Forest Service / FIA 2005

CHAPTER IN PERSPECTIVE



Land management and natural events over the past several thousand years have combined to create today's forest conditions and define its value as habitat, role in watershed function, importance to quality of life, and ability to contribute to the regional economy. Relatively new forces of change such as suburban sprawl are greatly increasing human influence on Chesapeake forests and further compounding historic effects. The history of Chesapeake forests provides numerous lessons for Bay watershed leaders to consider as they grapple with the influence of multiple and cumulative forces of change on the varied functions of forests.

Chapter 2:

The Human-Influenced Forest

KEY FINDINGS

- The Chesapeake Bay watershed contains some of the most extensive hardwood forests in the world's temperate latitudes.
- We have lost forestland at a rate of 100 acres per day since the mid-1980s.
- Nearly all of Chesapeake forests have been altered to some degree by human activities and are legacies of past land use decisions.
- More than 750,000 acres of forest—equal to 20 Washington D.C.s—have been lost since 1982, primarily to sprawling development.
- At least 36% of Chesapeake forests are vulnerable to development.
- Sixty percent of Chesapeake forests are fragmented by housing subdivisions, farms, and other human uses.
- Forty percent of all forestland occurs within the wildland-urban interface, a zone where human effects are particularly significant.
- More people own forests than ever before, but they own increasingly smaller parcels with nearly 70% of all family forest owners holding less than 10 acres. This trend, known as "parcelization," threatens forest sustainability.
- Financial incentives for forest conservation and stewardship are insignificant. As a result, forests are primarily managed for short-term economic gains, not managed at all, or sold for development.

Shifting Trends in Forest Cover

The Chesapeake Bay watershed contains some of the most significant reserves of hardwood forests in the world's temperate latitudes.[1] However, human-influenced shifts in the extent and pattern of this globally significant resource are altering the ability of Chesapeake forests to provide habitat, high quality drinking water, recreational opportunities, and other services that plants, animals, and people depend on.

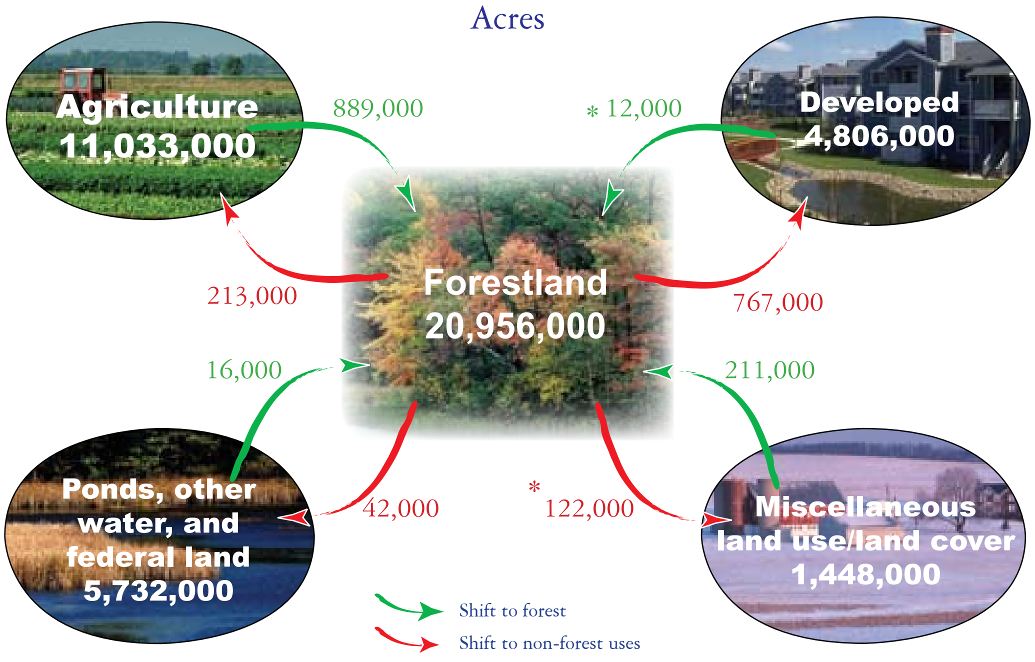
Losing Ground After a Century of Growth

Today, forests cover 58% of the Bay watershed and are the dominant landscape feature of all Bay watershed states except Delaware, where land is primarily agricultural.[2] But after a century of expansion, the extent of Chesapeake forests is declining. The amount of forestland available for wildlife, recreational opportunities, water purification, and other uses has declined by approximately 2%, translating to a loss of over 60 acres per day since 1973 and 100 acres every day since the mid-1980s.[3,4]

Development has been the largest cause of forestland loss for at least the past 15 to 20 years. Between 1982 and 1997, the Bay watershed lost more than 750,000 acres of forestland to development—an area equal to 20 Washington D.C.s.[5] The conversion of forestland to development represents a permanent loss of water filtering capacity, wildlife habitat, and many other functions. Much of this development takes place in recently built suburban areas, away from existing community services such as schools, businesses, and wastewater treatment facilities.

Most forestland is lost through sprawling suburban development, where development consumes more land than is necessary. Even though the average household size decreased over the past 30 years, the average home size increased by 50% and the average residential lot size increased by 60%.[6] This low density, automobile-dependent development now ranks among the top threats to the Bay's recovery and the chief threat to forests.[7] In a study of the 83 most sprawling cities in the United States, Washington, D.C., ranked 26th. Norfolk, Virginia Beach, and Newport News, Virginia, ranked 37th, and Baltimore, Maryland, ranked 64th.[8] Maryland (8th) and Pennsylvania (13th) are also among the top 15 most sprawling states.[9]

Shifts in Chesapeake Forests 1982 - 1997



Source: USDA NRCS / NRI 2005
Note: Statistics are estimates
*Estimates are marginal in terms of statistical reliability.

At-least 36% of all forestland is at high risk to development over the next 5-10 years. For more information, see Chapter 7.

Between 1982 and 1987, nearly 900,000 acres of cropland and pastureland reverted to forest.[5] Much of this forestland likely emerged on marginal agricultural lands because of abandonment and natural succession rather than deliberate replanting. Because the land coming into forests is almost certainly of lower soil quality than the land going out of forest production, it is likely that the overall forest productivity or growth rate has also declined. In addition, the pioneer trees (such as tulip poplar and black locust) that first claim abandoned farmland have resulted in lower quality habitat and economic potential than in surrounding forests.[10]

While forest trends at the Bay watershed scale are instructive, they hide important local and regional trends in Chesapeake forests:

- Virginia: In the 18 years between 1984 and 2002, Virginia lost more than 5% (461,000 acres) of its forestland. Almost 60% of Virginia's counties lost forestland, most from the areas surrounding Richmond, Norfolk, and Washington, D.C.

- Maryland: Maryland lost 6% (141,000 acres) of its forestland between 1986 and 1999. While there were large gains of forestland along the lower Eastern Shore, more than 60% of all counties lost forestland. Most of the loss occurred in the Washington, D.C.- Baltimore area.

- Pennsylvania: Between 1989 and 2003, Pennsylvania lost approximately 1% (100,000 acres) of its forestland. More than 50% of its counties lost forestland. Most of the loss occurred in the Harrisburg area. Statewide losses were tempered by increases of as much as 24% in more rural counties.

- Delaware: Between 1986 and 1999, Delaware forestland decreased by 1% (3,000 acres).

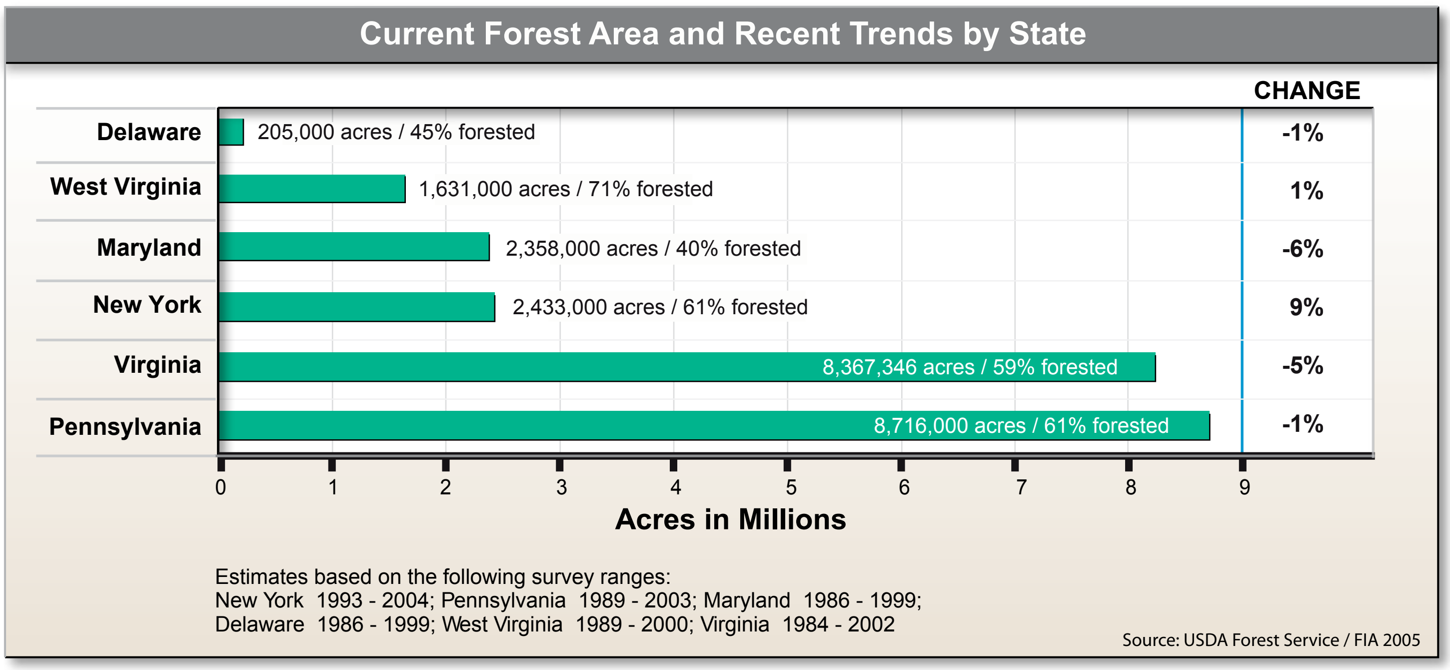
- West Virginia: Between 1989 and 2000, West Virginia gained forestland in more than 70% of its counties. West Virginia gained only 1% (21,000 acres) of Chesapeake forestland, due to large declines in Hampshire County.

- New York: New York gained nearly 9% (200,000 acres) of forestland between 1993 and 2004. Most of these gains were due to the abandonment of grazing lands used in the dairy industry.[3]

POPULATION GROWTH

Between 2000 and 2004, nine of the 100 fastest growing counties in the United States were located in the Bay watershed. Loudon County, Virginia, located a few miles from Washington, D.C., was the fastest growing county in the nation. However, population growth has not been restricted to urban areas. Allegheny County, Virginia, nestled in the Appalachian Mountains, was the 12th fastest growing county over the same period.[11] The Bay watershed population will continue to rise—approaching 19 million by 2030—and more homes, roads, and other types of development will be built in order to accommodate these new residents.[12] The ways in which this growing population is accommodated will have a large effect on the extent, condition, and management of Chesapeake forests.

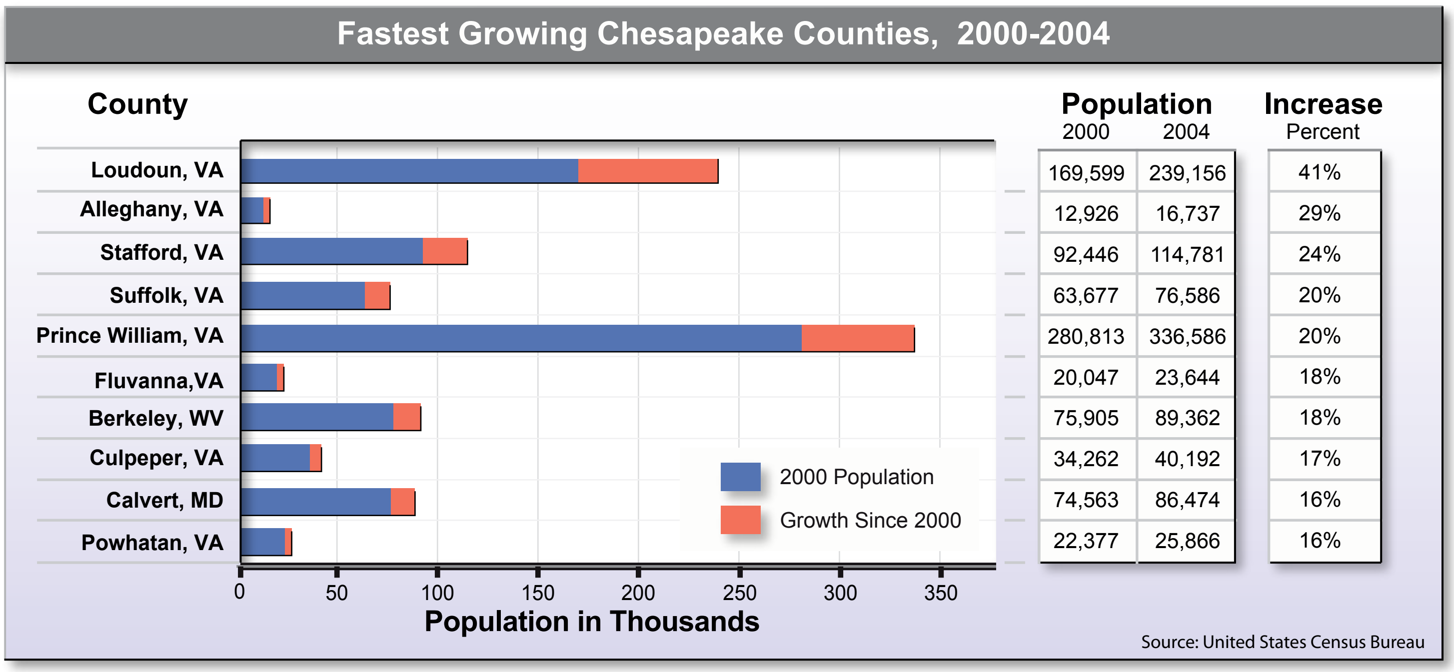
Current Forest Area and Recent Trends by State



Estimates based on the following survey ranges:
New York 1993 - 2004; Pennsylvania 1989 - 2003; Maryland 1986 - 1999;
Delaware 1986 - 1999; West Virginia 1989 - 2000; Virginia 1984 - 2002

Source: USDA Forest Service / FIA 2005

Fastest Growing Chesapeake Counties, 2000-2004



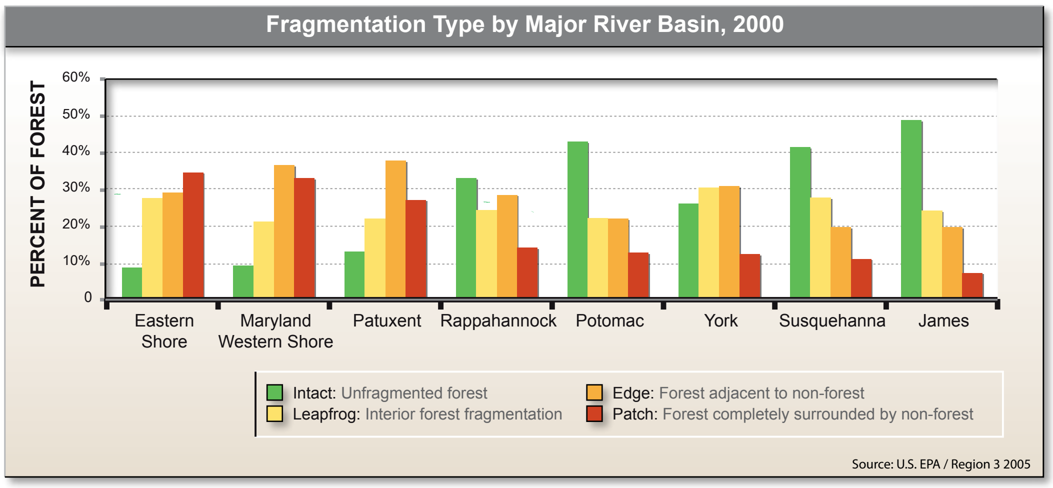
County	Population 2000	Population 2004	Increase Percent
Loudoun, VA	169,599	239,156	41%
Alleghany, VA	12,926	16,737	29%
Stafford, VA	92,446	114,781	24%
Suffolk, VA	63,677	76,586	20%
Prince William, VA	280,813	336,586	20%
Fluvanna,VA	20,047	23,644	18%
Berkeley, WV	75,905	89,362	18%
Culpeper, VA	34,262	40,192	17%
Calvert, MD	74,563	86,474	16%
Powhatan, VA	22,377	25,866	16%

Source: United States Census Bureau

THE FRAGMENTED FOREST

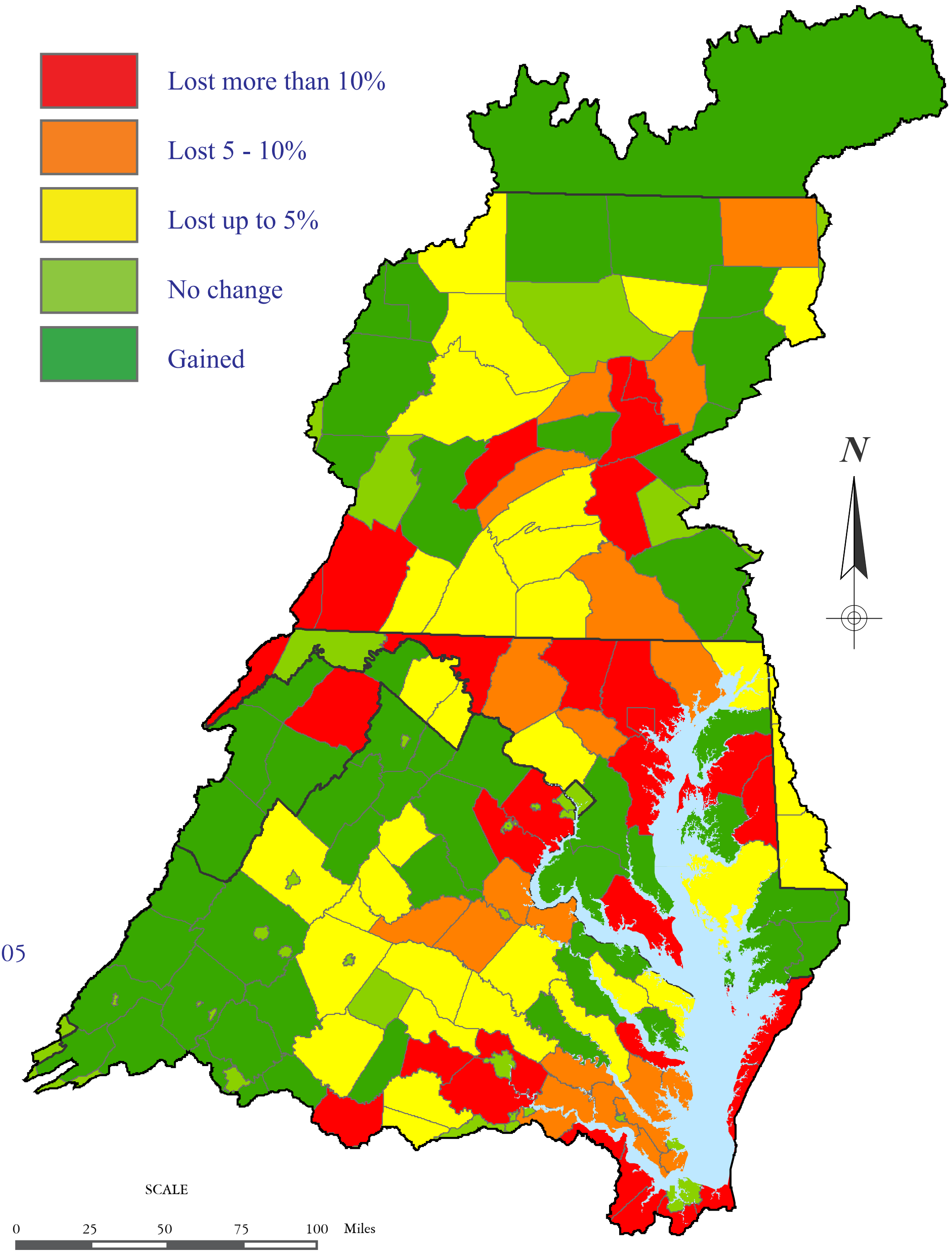
Roads, housing subdivisions, farms, and other human uses divide 60% of Chesapeake forests into disconnected fragments surrounded by other land uses.[13] Fragmentation reduces total habitat area and isolates animal and plant populations. It also introduces negative influences—known as edge effects—to nearby forestland, leaving it more vulnerable to invasive species and sources of wildfire. The increase of forest stressors and nearby human populations makes forest management increasingly difficult, particularly for invasive species and forest products.[14] Road construction also increases stormwater runoff and nutrient delivery to streams.

More than 40% of forestland is characterized by "leapfrog fragmentation," where human uses have jumped over existing development and punched holes in forest interiors.[13] Leapfrog fragmentation is especially damaging because it introduces edge effects deeper into intact forests and tends to attract further development.[15]



Source: U.S. EPA / Region 3 2005

COUNTY FOREST COVER TRENDS



TIME PERIODS:
New York 1993 - 2004
Pennsylvania 1989 - 2003
Maryland 1986 - 1999
Delaware 1986 - 1999
West Virginia 1989 - 2000
Virginia 1984 - 2002

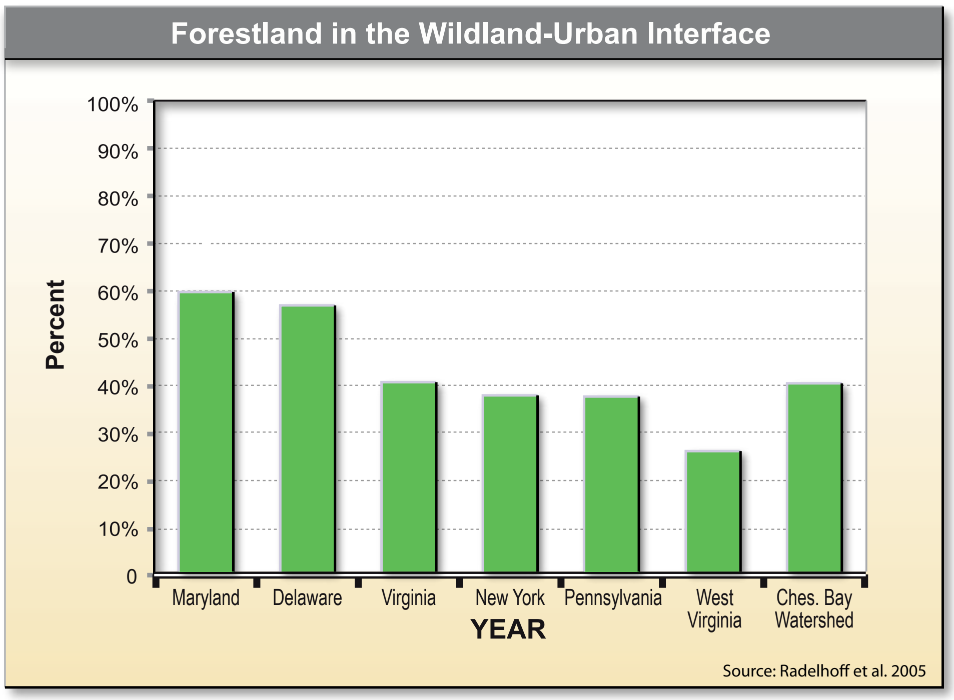
INTERPRETATION:
Over the past 20 years, the Chesapeake Bay Watershed has lost around 2% of forestland. The amount of change varies significantly however across the region. The greatest loss occurs in rapidly suburbanizing regions.

SOURCE: USDA Forest Service / FIA 2005

THE WILDLAND-URBAN INTERFACE

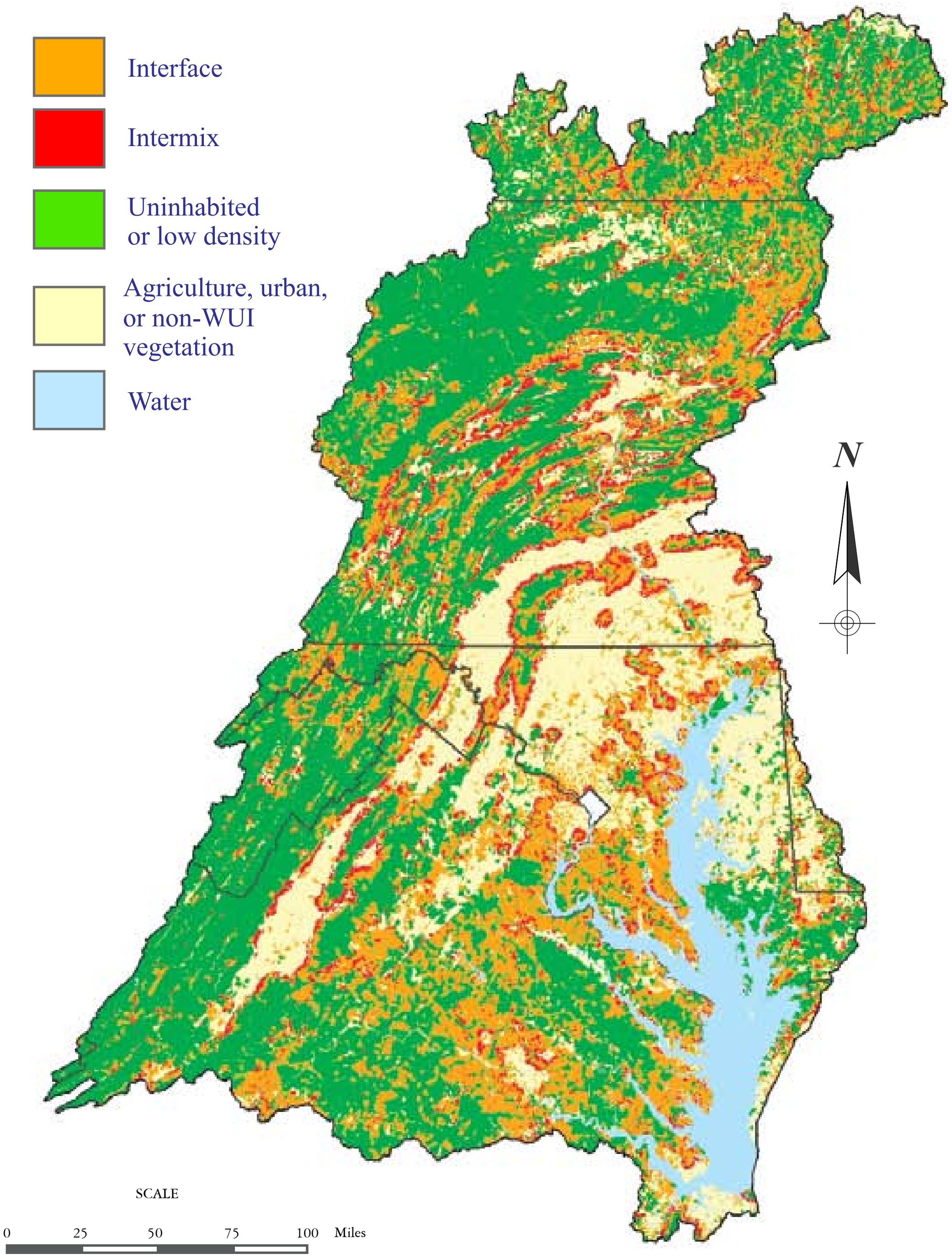
Currently, 40% of all Chesapeake forests are influenced by development.[16] These forests exist in areas that are transitioning from rural forest to mixed uses dominated by development, known as either the wildland-urban interface or intermix. The interface includes residential development with at least one house per 40 acres. The intermix contains the same residential density range, but is nested within intact forests. An analysis of deforestation patterns in the Baltimore, Maryland region, revealed that the wildland-urban intermix is common with large lot residential development,[17] which consumes more land and requires greater amounts of infrastructure than more compact forms of development that include a variety of land uses.[18]

Another way to describe the pattern of forests across the Chesapeake landscape is to consider how much land is relatively free from human influence. The Wilderness Society mapped the degree of "wildness" in the Bay watershed. The term "wildness" reflects the land's naturalness and freedom from human control. As such, wildness captures not only important elements of ecological integrity, but aspects of the land relating to the human experience of a place, like remoteness and provision of solitude.[19] The wildest remaining areas are mostly located in southern and western Virginia and northern Pennsylvania. These regions have low population density, little development, and few pollution sources. Virginia still has more than 387,000 acres of roadless areas—the most of any state east of the Mississippi.[20]



Source: Radelhoff et al. 2005

WILDLAND-URBAN INTERFACE



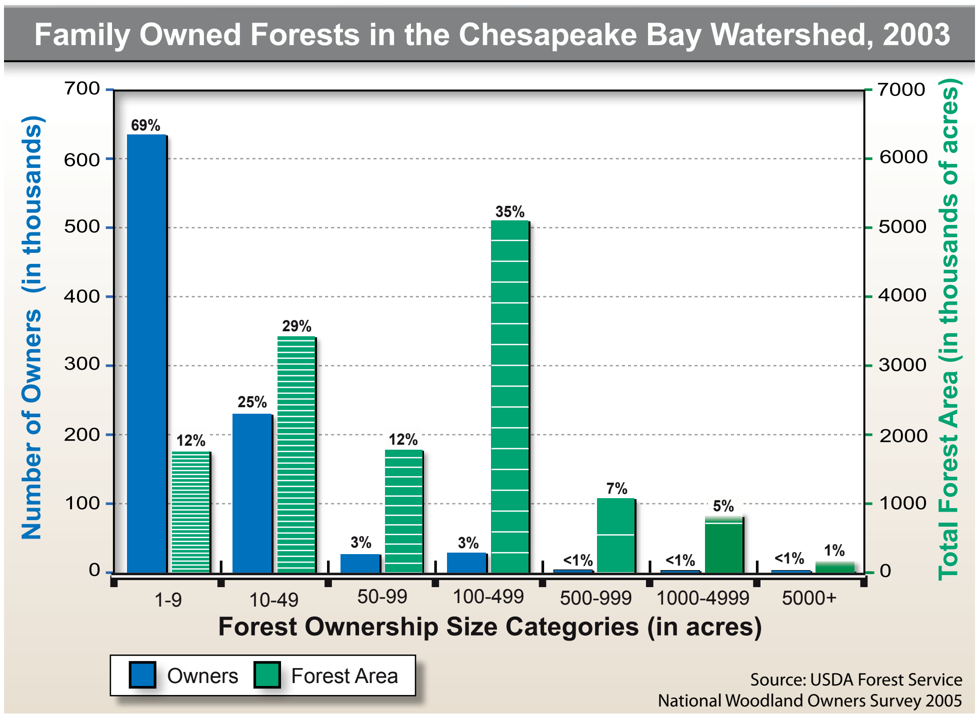
INTERPRETATION:
Around 40% of all Chesapeake forests occur in areas of transition between forestland and development known as the wildland-urban interface and intermix. The interface is essentially development with more than one house per 40 acres within 1.5 miles of intact forest. Intermix is development in the same density range that occurs within intact forests - a type of fragmentation that leapfrogs forestland edges to create holes in the interior.

SOURCE: Radelhoff et al. 2005

PARCELIZED FORESTS

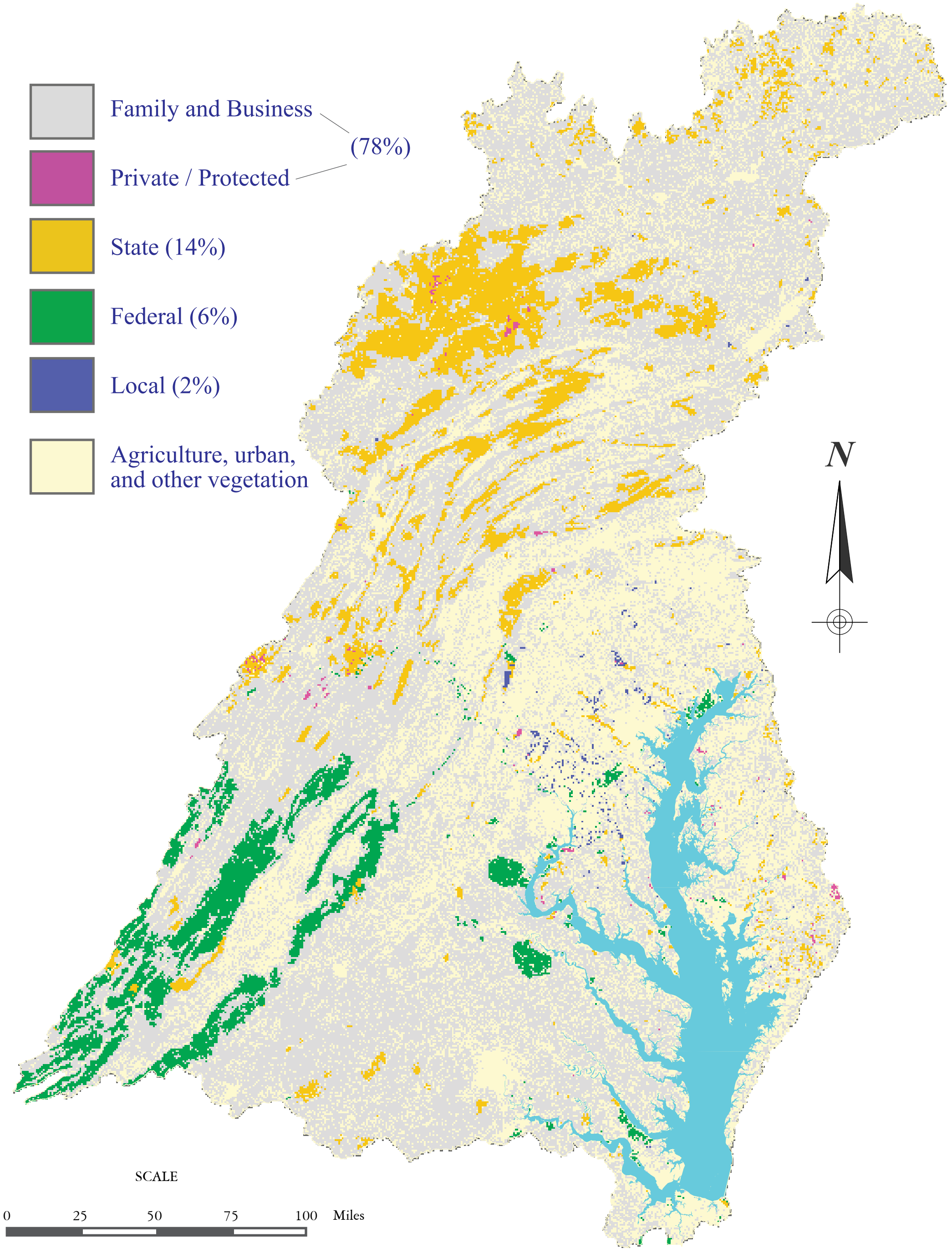
Forest parcelization occurs when large tracts are sub-divided and sold to multiple owners. The land may remain mostly forested, but the complexity of the ownership pattern changes dramatically. This trend has dominated Chesapeake forests in recent decades and is increasing the risk of forest loss. Forest parcelization is caused by a number of factors, including rising land values, the sale of industrial forestland, and use of large lot zoning by local governments. This condition often creates a self-reinforcing cycle, as development brings new roads, sewers, and other infrastructure to formerly forested areas, and the surrounding forest becomes increasingly accessible for development. As land values rise, forest owners consider further parcelization to offset increased tax rates.[21]

In the past decade alone, the Bay watershed has experienced a 25% increase in the number of family forest owners. Their numbers will continue to rise in the near future, in part because more than 70% of family forest owners are more than 55 years old. Over the same period, the average size of family forests decreased by 24%. Today, almost 70% of family forest owners own less than 10 acres. A large contiguous forest broken into many smaller ownership tracts, brings added difficulties in reaching landowners, reduces the likelihood of active management, and increases the risk of forest loss to other uses. While there are exceptions, the size of a forest holding is an important factor in determining whether the owner is likely to use expert forest information, feels "connected" to the forest as a resource, and become engaged with the larger forestry community.[10]



Source: USDA Forest Service
National Woodland Owners Survey 2005

FORESTLAND OWNERSHIP



INTERPRETATION:
Nearly 80% of forests are privately owned (64% Family and 14% Business). Therefore, forestland conservation, restoration, and management on private lands will determine the future breadth and condition of Chesapeake Forests.

SOURCE: Chesapeake Bay Program 2005, USDA Forest Service/National Woodland Owners Survey 2005

Photo: Baltimore County, Maryland

In Baltimore County, Maryland, dozens of ownerships (blue) dissect the riparian forest corridor (red) increasing the difficulty of managing and conserving the forest.

FOREST MANAGEMENT

SUSTAINABLE MANAGEMENT

Over the past 400 years, change has affected forest conditions in almost every area of the Chesapeake Bay watershed. In many areas, the forest we see as just a collection of trees belies the legacy of historic changes that affect the health and future growth of the forest and the benefits it will provide to wildlife, water, and people. Historic and current forces of change are limiting the natural ability of forests to sustain their long-term health, growth, diversity, and overall integrity. For example, the few areas of forest that were never cleared for logging or farming are too small to withstand disturbances like insect outbreaks or hurricanes.

Often, active management of surrounding forests can enhance their sustainability. While governments and forest product companies have worked hard to increase the use of sustainable management, the practice is still limited on family-owned land. There remains a substantial debate among professional foresters and many in the public about the role and nature of forest management and forest harvesting. However, without the use of sustainable forest management, the vital watershed services of Chesapeake forests—their ability to clean water, nurture wildlife, and store carbon—are significantly diminished.

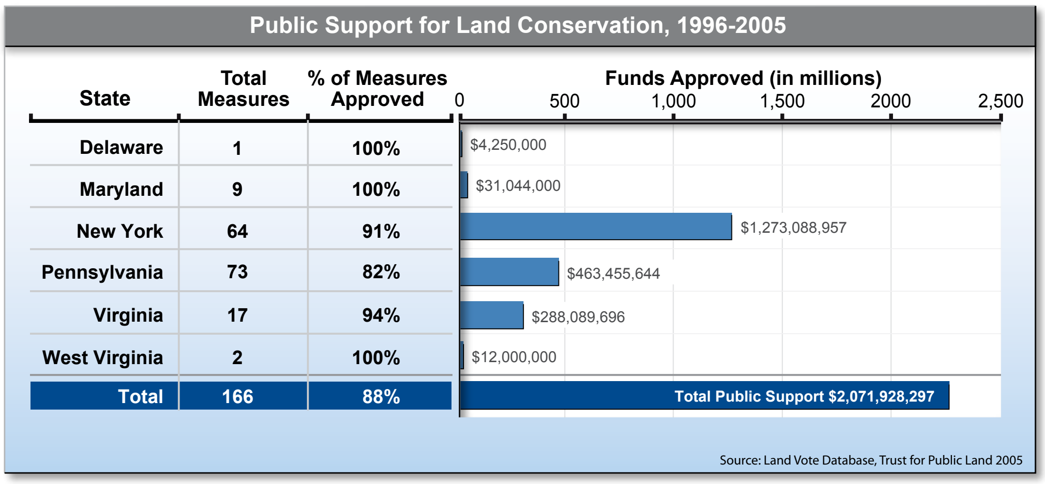
In rural landscapes, sustainable forest management can focus on restoring functioning, self-sustaining forest ecosystems. The removal of trees through harvesting is one of many management tools. Many Chesapeake forests are overcrowded due to their regrowth on abandoned fields, fire suppression, and the use of poor harvesting methods in the past. Thinning a forest at the right age can relieve these conditions and provide space for trees to grow. Other methods such as controlled fire, reforestation, and deer fencing can be used to improve overall forest conditions. Harvesting can also be used to imitate the effect of natural fire by creating forest openings and controlling the dominance of undesirable or competing tree species. The removal of individual or small groups of trees can mimic the natural small canopy openings that develop when trees die.

Without professional assistance or education, most landowners are not aware that sustainable forest management can provide long-term income and healthy wildlife habitat. Too often, the decision by a landowner to harvest trees is made to maximize short-term profit at the expense of future sustainability. In the long run, these approaches can shift plant composition, reduce average tree size, limit regrowth, and lower biodiversity, making the entire forest less productive for both timber and wildlife. One problematic practice is to "cut the best, and leave the rest"—also known as high grading. Removing all of the biggest, best, and most valuable trees can leave only less fit or poorer quality trees to regenerate the forest. High grading not only reduces future economic return, but also reduces the overall health of the forest for generations and eliminates wildlife food sources and important habitat features.

THE VITAL ROLE OF FAMILY FOREST OWNERS

While land use decisions by all owners are important, family-forest owners in the Chesapeake Bay watershed will ultimately decide whether forests are managed sustainably, converted to other land uses, or left alone. Currently, more than 900,000 family forest owners hold 64% of all forestland in the Bay watershed. Fewer than 20% of owners (2,500 acres) have written forest management plans and only a third (5,000 acres) have sought professional advice, even though the benefits of sustainable forest management are becoming better known.[22]

Most forest owners would likely agree with the principles of sustainable forest management, since most want to protect the scenery, wildlife, and long-term integrity of their land.[21] There is also a strong public desire to protect forestland and other natural resources throughout the Bay watershed. For instance, between November 1996 and May 2005, citizens in Bay watershed states voted "yes" on more than 88% of measures introduced to support the conservation of



Public Support for Land Conservation, 1996-2005

State	Total Measures	% of Measures Approved	Funds Approved (in millions)
Delaware	1	100%	$4,250,000
Maryland	9	100%	$31,044,000
New York	64	91%	$1,273,088,957
Pennsylvania	73	82%	$463,455,644
Virginia	17	94%	$288,089,696
West Virginia	2	100%	$12,000,000
Total	166	88%	Total Public Support $2,071,928,297

Source: Land Vote Database, Trust for Public Land 2005 natural and scenic landscapes, making more than $2 billion available for these efforts. In more than 40% of the measures, citizens actually voted to directly tax themselves.[25]

Why, then, are the majority of family forest owners not managing their land or seeking professional assistance? Although state and federal forestry agencies have created professional landowner assistance programs, the availability of these programs alone has not been enough incentive. One key reason is that no comprehensive program exists to adequately reward small tract family forest owners who sustainably manage their land, despite the multiple economic, societal, and ecological benefits that these forests bring to the Bay watershed and its residents.[26] In contrast, agricultural landowners can currently avail themselves to a plethora of programs that provide millions in financial support for conservation practices. In 2004, Chesapeake states received over $130 million to provide financial assistance to farmers to support conservation practices on their land.[27] These agricultural incentives totaled more than 11 times the amount that forestry received from the USDA Forest Service.[28] Furthermore, forestry funding was mainly to make technical assistance available, unlike the farming programs that provided financial incentives directly to landowners.

Also, traditional methods of providing education and assistance to forest landowners are simply not able to reach the thousands of new forest owners being created by continued parcelization. The difficulty of educating so many landowners reduces the likelihood of sustainable forest management and increases the opportunity for forest loss or harmful harvesting practices. Owners of small private forests are also less likely to accommodate public access for recreation.

WHAT IS SUSTAINABLE FOREST MANAGEMENT

Sustainable forest management considers the entire forest ecosystem—all the parts of a forest—and not just the valuable timber trees. Forestry is sustainable if it plans for the future health of the forest ecosystem and considers wildlife, soil, and water resources. Consideration of both short- and long-term economic returns is compatible with sustainable management. Forestry is not sustainable when it removes value from the forest in the short term while sacrificing future regeneration or regrowth of a new forest.

The specific goals and practices of sustainable forest management depend on the nature of the forest itself and its place in the surrounding landscape. Because forests exist in a variety of settings—rural, suburban, and urban—they have a different mix of stressors and desired benefits. Rural management may focus on enhanced wildlife habitat, drinking water supplies, and the value of products the forest produces. Suburban forest management may strive to connect forest habitats separated by development, infiltrate rainfall for groundwater recharge, and protect the health of streams. Urban management emphasizes increased tree cover to remove air pollution, reduce storm water runoff, enhance communities, create parks, and provide other social and environmental benefits.

Forest certification legitimizes and ensures sustainable public and private forest management and provides access to new markets like green builders by providing a "seal of approval." The American Tree Farm system has certified over 3,500 forests representing sustainable management on nearly 900,000 acres in the Chesapeake Bay watershed.[23] The Forest Stewardship Council has certified nearly 2 million acres of Chesapeake forests—the majority occurring on state forestland in Pennsylvania.[24]

Photo: Don Outen

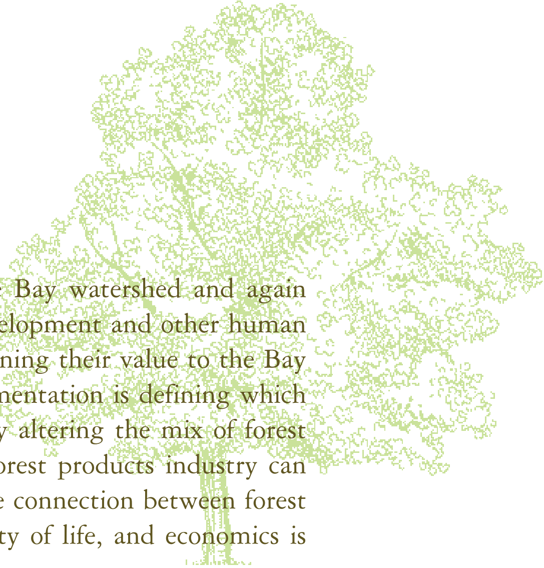
A Sustainably Managed Forest

INDICATORS FOR SUSTAINABLE CHESAPEAKE FORESTS

As human influences grow in the Chesapeake Bay watershed, indicators will be critical to tracking forest conditions and progress towards sustainability. The following indicators will help organizations address key findings presented in this chapter:

- Forest and total land area
- Forestland lost to development
- Net change in forestland

CHAPTER IN PERSPECTIVE



After a century of expansion, forests now cover 58% of the Chesapeake Bay watershed and again provide a "sense of place" for most of the region. However, sprawling development and other human activities are compromising the condition of Chesapeake forests and redefining their value to the Bay watershed's environment, economy, and quality of life. For example, fragmentation is defining which forest-dependent plant and animal species thrive in the Bay watershed by altering the mix of forest habitats. The degree of human activity is also influencing whether the forest products industry can still provide a valuable source of jobs and income to many rural areas. The connection between forest condition and the function of forests for biodiversity, water quality, quality of life, and economics is explored throughout this report.

Chapter 3:

The Importance of Forests as Habitat

KEY FINDINGS

- The Chesapeake Bay watershed has some of the most biologically diverse forests in the nation.
- Forests are more homogenous in age, size, and composition than at any other time over the past several thousand years, resulting in major shifts in forest habitats.
- More than 99% of the pre-settlement eastern deciduous old-growth forest ecosystem is gone.
- Forest loss and fragmentation have left only 40% of Chesapeake forests capable of producing enough habitat to support healthy populations of interior forest-dwelling species.
- Oaks are the most voluminous and ecologically important trees in today's Chesapeake forests, but in many places, the number of oak seedlings and saplings are insufficient to replace the existing forest.
- Red maple is becoming the most dominant species in Chesapeake forests, replacing tree species with greater habitat value.
- Deer populations are out of balance, making deer a key factor impacting forest health and sustainability.
- Invasive forest pests and plants have permanently altered the native biodiversity of Chesapeake forests and the habitats they provide. The continued introduction of new pests is a serious concern that could have significant consequences.
- Over 6 million acres or 45% of the Bay watershed's network of forests and wetlands is vulnerable to development.

THE COMPOSITION OF CHESAPEAKE FORESTS

The combination of a warm and moist climate, mountainous topography near coastal plains, deep soils, and confluence of northern and southern species has allowed the forests of the Chesapeake Bay watershed to become one of the most diverse temperate forests in the United States.[1] Chesapeake forests contain a rich mix of ferns, groundcover plants, shrubs, and trees.[2,3]

SHIFTS IN FOREST TYPE

Currently, four types of forestland make-up 92% of all Chesapeake forests. Each type is dominated by a different set of tree species:

- Oak/hickory
- Oak/pine
- Maple/beech/birch
- Loblolly/shortleaf pine

The remaining 8% of the forest consists of nine additional forest types, including white/red/jack pine and oak/gum/cypress, which occur along the edges of the Chesapeake Bay watershed and its waterways.

Forest types are associated with unique plant and animal communities. For example, oak/hickory forests are dominated by oak and hickory trees, but include many other species reflective of local conditions including red maple, flowering dogwood, mountain laurel, blueberry, mayapple, and jack-in-the-pulpit. Associated animals include the blue jay, wild turkey, eastern gray squirrel, eastern chipmunk, and spotted salamander. Forest types change because of human disturbance (such as fire suppression, planting and harvesting, development, and grazing) or because of natural succession. Changes in climate affects the range of different forest types.

Half of all forest types in the Bay watershed lost area between the mid-1980s and early 21st century. The plants and animals associated with these forest types were likewise affected. The area of maple/beech/birch increased 20%, while oak/pine and loblolly/shortleaf pine each lost approximately 10%. Oak/hickory acreage remained essentially unchanged.[4] Other forest types gained enough area to minimize total forest loss, but the decrease of individual forest types reduces overall biodiversity. This is because different plants and animals live in different types of forests.

CHANGE IN TREE SPECIES

Oaks are the most important trees in Chesapeake forests to wildlife and provide numerous other benefits such as soil stabilization and high timber value. White and red oaks are the most abundant species in the Bay watershed in terms of volume, with over 13 billion cubic feet.[5] Before European settlement, large oak populations were fostered by frequent low-intensity fires that were either set deliberately by Native Americans or resulted from natural sources. Oak survives fire better than other trees, like red maple, because of its thick insulating bark and prodigious ability to re-sprout from dormant buds that occur at or below the soil surface.[6]

Major Forest Types in the Chesapeake Bay Watershed

Forest Type	Area in Acres (thousands)	Percent of Forestland	Change 1987-2001	Dominant Species	Associated Species
Oak Hickory	11,964	52.4%	-0.3%	White oak, Red oak, Chestnut oak, other Upland oak and Hickory	Yellow poplar, Sweetgum, Red maple, Mountain laurel, Blueberry, Mayapple
Maple Beech Birch	5,268	23.1%	19.5%	Sugar maple, Beech or Yellow birch	Cherry, Red maple, Ash, Elm, Basswood, Eastern hemlock, White pine, Viburnum, Witch hazel
Loblolly Shortleaf pine	2,000	8.8%	-7.4%	Loblolly pine, Virginia pine	Pitch pine, Oak, Hickory, Black gum, Sweetgum
Oak Pine	1,696	7.4%	-10.5%	Red oak, Hickory, White ash, Loblolly pine, or Virginia pine	Black gum, Sweetgum, Sourwood, Yellow-poplar, Striped wintergreen, Maple leaved arrowwood
White, Red & Jack pine	657	2.9%	-20.4%	Eastern white pine, Red pine or Jack pine	Eastern hemlock, Aspen, Birch, Maple, Blueberry,
Elm Ash Cottonwood	428	1.9%	-13.0%	Elm, Ash or Cottonwood	Willow, Sycamore, Birch, Maple, Hackberry, Poison ivy, Blueberry
Oak Gum Cypress	309	1.4%	4.4%	Sweetgum, Nuttall oak, Willow oak, Sweet bay magnolia, Black gum, Swamp tupelo, Red maple, Cypress	Cottonwood, Willow, Ash, Elm, Hackberry

Source: USDA Forest Service / FIA 2005

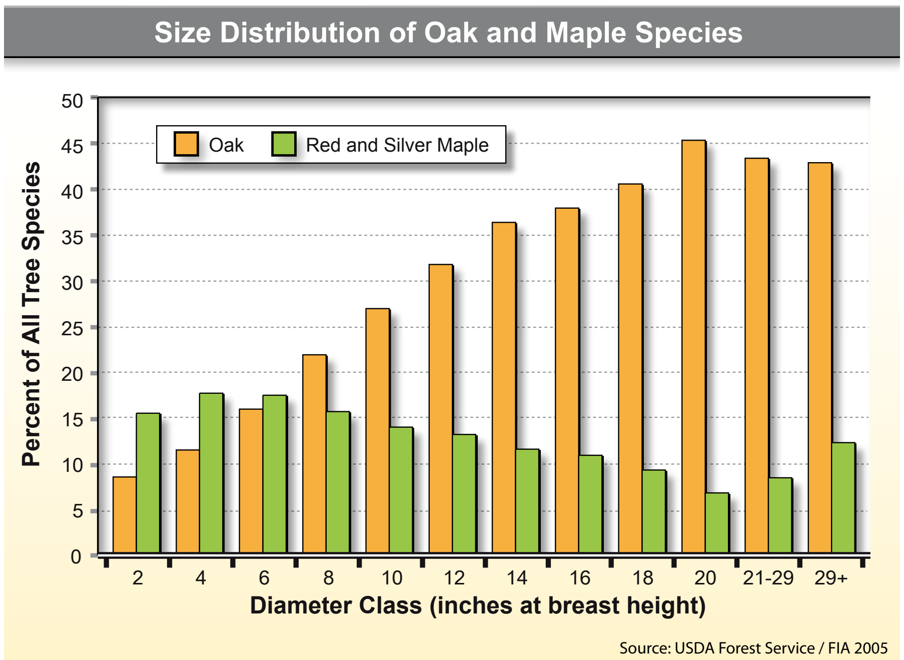
In many parts of the Bay watershed, the prominence of oak in future Chesapeake forests is uncertain.[7] Oak is in decline across the Bay watershed because of unsustainable timber harvesing practices, fire suppression, repeated gypsy moth infestations, and over-browsing by deer.[8] A study in West Virginia has shown that there has not been enough regeneration to sustain most major oak species over the last 50 years.[7] While history suggests that approximately 3,600 seedlings per acre would be needed to replace an existing stand of northern red oak, current oak seedling densities seldom exceed 970 seedlings per acre—primarily due to deer browsing.[8] Preliminary studies show similar deficiencies in hickory seedling densities as well.[9] In all regions of the Bay watershed, oak volume has declined in the past 20 years.[6] Studies show similar trends in all states in the region. For example:

- Oak trees in Virginia declined from 34% of all trees in 1966 to 18% in 2001.[6,10]
- The total tree volume of Maryland's oak species declined from 45% in 1950 to 28% in 1999.[11]

Perhaps most alarming, young oak seedlings are under represented throughout Chesapeake forests, indicating that the trees will have a lower presence in the region's future forests.[6]

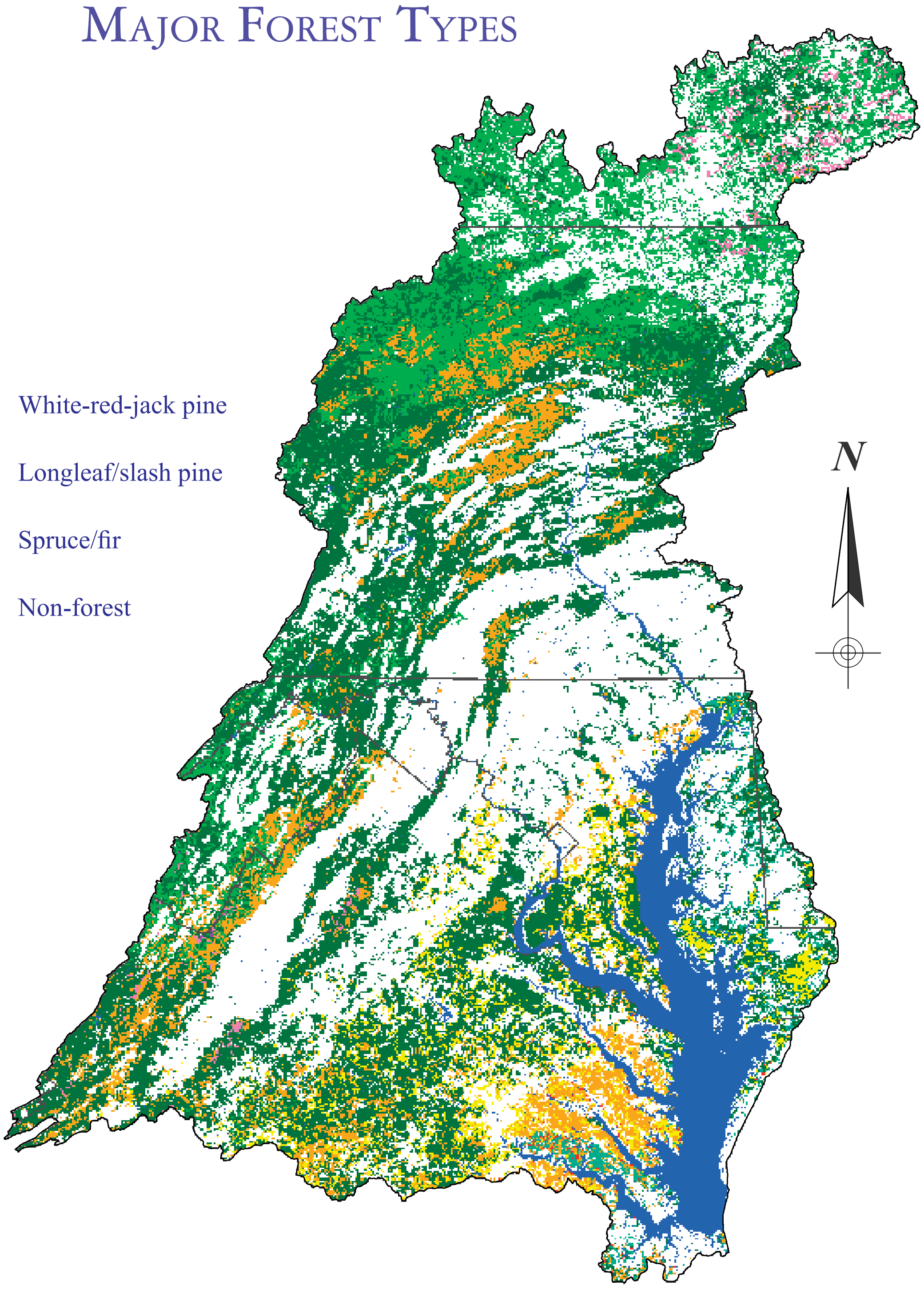
Red maple has greatly expanded its range over the past 100 years. While red maple is by far the most abundant tree in the Bay watershed today, it was not included in a list of more than 600 kinds of trees and other plants by naturalists in colonial Maryland.[20] Today, red maple comprises 90% of forest regeneration in Pennsylvania and has been the most widespread species in the state for the past 25 years.[21,22] The success of red maple is unnatural, however, because of its resistance to diseases that commonly affect competing species, fire exclusion, the selective harvesting of more prized timber, and the tree's ability to survive in a wide variety of soils and climate.

With more than 2 billion trees, red maple is almost three times as numerous as the next most common species, black gum. Maples are the second most abundant species group in terms of volume, with more than 7 billion cubic feet.[6] However, if oak regeneration continues to fail and young maples grow larger, maple will likely assume prominence as the most voluminous tree in the watershed.


Size Distribution of Oak and Maple Species

Source: USDA Forest Service / FIA 2005

MAJOR FOREST TYPES



🟩 Oak/Hickory

🟩 Maple/Beech/Birch

🟧 Oak/Pine

🟨 Loblolly/shortleaf pine

🟩 Oak/gum/cypress

🟪 White-red-jack pine

🟥 Longleaf/slash pine

🟪 Spruce/fir

⬜ Non-forest

INTERPRETATION:
The Oak/Hickory (52%) and Maple/Beech/Birch (23%) forest types dominate the area of forest cover. Eleven other forest types make up the remaining 25%. Longleaf/Slash pine and Spruce/fir are localized in southern Virginia and high-elevation areas respectively.

SOURCE: National Atlas 2005

SCALE

0 25 50 75 100 Miles

HARVEST CHOICES EFFECT FOREST TYPE

By high grading their forests, landowners may unknowingly degrade forest conditions for several decades or more, reducing the long-term economic and ecological value of their land. A hypothetical oak/hickory forest located in central Pennsylvania was used to model the impacts using a "diameter limit cut"—a common form of high grading that removes trees over a certain diameter.[23]

Before harvesting in 2003, the model forest is dominated by red maple, hickory, and red oak, but also includes dogwood, striped maple, chestnut oak, and white ash. All trees on the property more than 15 inches in diameter are then harvested to maximize profits. This initial harvest removes most of the red oak and red maple, and smaller amounts of hickory and striped maple. As is common, the landowner conducts three more harvests over the next 50 years, removing trees greater than 13, 11, and 9 inches in diameter respectively. By 2053, the original forest has drastically changed. The forest canopy is composed of a few remaining hickory, with dogwood in the forest midlayer. Chestnut oak and white ash have been completely removed and striped maple, red oak, and hickory are greatly reduced.

On the other hand, young red maple and sweet birch have thrived in the conditions provided by the removal of the larger trees. Red maple—released by the large tree harvest in the first year—becomes the most numerous species in the stand, followed closely by sweet birch. Sweet birch, not present in the original forest, colonizes the forest and prevents slower growing species like oak from establishing in forest gaps. Of these two species, 99% of the trees are less than three inches in diameter. In the end, the forest stand is much more dense and slow-growing than the original stand, with more than 1,100 additional trees per acre and 16% more canopy cover.

As gaps are created by the loss of the few remaining hickory trees, the stand will eventually be a red maple/sweet birch forest with significantly less economic and ecological value than the original oak/hickory forest that existed before the high grading took place.

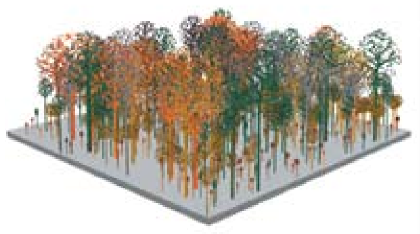
State and private foresters can provide guidance and help create management plans to ensure economic and ecological sustainability.

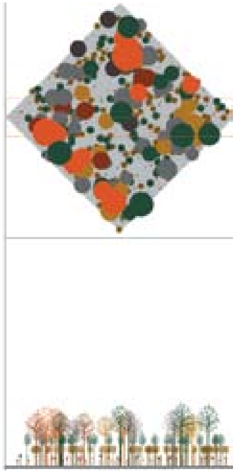
Forest Conditions
Before First Harvest, 2003

Tree	Tree color	Trees/Acre
Red Maple	Red	181
Hickory	Dark Green	159
Red Oak	Orange	111
Dogwood	Brown	55
Striped Maple	Gray	35
Chestnut Oak	Gold	12
White ash	Black	6
Sweet birch	Light green	0
TOTAL		**561**

Diameter (in)

Mean	Min	Max
3.2	0.3	32.6



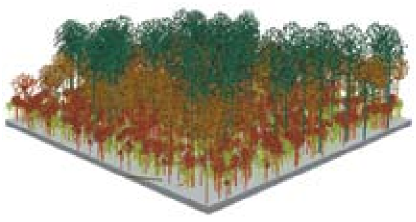


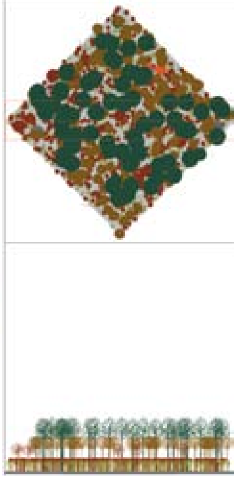
Forest Conditions
50 Years After Initial Harvest, 2053

Tree	Tree color	Trees/Acre
Red Maple	Red	754
Hickory	Dark Green	144
Red Oak	Orange	67
Dogwood	Brown	3
Striped Maple	Gray	3
Chestnut Oak	Gold	0
White ash	Black	0
Sweet birch	Light green	715
TOTAL		**1,685**

Diameter (in)

Mean	Min	Max
3.7	2.3	11.8





This analysis was created using stand visualization software (SVS). SVS allows landowners to collect data and create images of their forests and visualize how their forests will change in response to management action and natural events.

RARE AND UNIQUE FOREST HABITATS

Longleaf Pine

In the southeastern United States, 98% of pre-settlement longleaf pine forests were lost by 1986. Longleaf pine was never widespread in the Chesapeake region, since the species reaches its most northerly range only in the southernmost portion of the Bay watershed. However, remnants of longleaf pine forests still exist and are important to the region's biodiversity. Longleaf pine depends on wildfires to regenerate and is at risk in most of its range due to fire suppression.

Atlantic White Cedar

Approximately 98% of Atlantic white cedar stands have been lost. This forested wetland species can be found in peat bogs with numerous rare plants, and animal assemblages, especially insects. Atlantic white cedar is restricted to a narrow belt (30 to 120 miles) along the Atlantic Coast. Most stands in the Chesapeake region are on the Eastern Shore of Maryland. The few stands west of the Bay are genetically distinct and represent the western extent of the species in the mid-Atlantic.

Forested Wetlands

Wetlands overall have declined by almost 60%, translating into a loss of more than four million acres in the Bay watershed since 1780. New York and Maryland account for nearly two thirds of the total decline in wetlands in this region. Maryland has lost almost 75% of its wetlands since the last years of the American Revolution.[24]

Between 1982 and 1989, the National Wetlands Inventory (NWI) indicated that approximately 14,700 acres of forested wetlands were converted to other land uses—the greatest loss for any wetland type. Nearly 75% of these losses were in Virginia. Other hot spots occurred on Maryland's Eastern Shore, in western Delaware, and in northeastern Pennsylvania.[25] Timber harvests in forested wetlands, especially loblolly pine systems, do not result in a loss of wetlands, but rather represent a shift in the age and species structure, with effects on habitat and hydrology that are most often only temporary.

Forested wetlands now only make up 2% of all natural vegetation and are common in areas of the Bay watershed that have saturated soils.[26] In the Coastal Plain, forested wetlands are found in both freshwater tidal and non-tidal floodplains of rivers and streams and in upland areas with poor drainage. This unique habitat includes wetland species such as tupelo, baldcypress, and swamp oak. Within the Coastal Plain on the Delmarva Peninsula, patches of wet forestland over flat terrain are supported by seasonally high water tables that persist from late winter through late spring. Much of the historic wetland forests in areas such as the Delmarva have been drained and cleared for use as farmland. For example, an extensive network of maintained ditches on the Eastern Shore of Maryland and Virginia keeps once-forested wetlands

Clockwise from top left: Longleaf Pine Woodland, Atlantic White Cedar Forest (dark, coned-shaped tree crowns), Forested Wetland, and Red Spruce forest.

Photos by: Gary P. Fleming and Caren Caljouw © VA DCR Natural Heritage dry enough to produce crops such as soybeans. In the Piedmont, forested wetlands are typically found on broader stream valley floodplains like the Potomac, along narrower riparian areas following stream systems, and in springs and groundwater seepage areas. Forested wetlands in the Ridge and Valley and Appalachian Plateau occur along similar terrain and are found in association with headwater landscapes of various stream systems.

Red Spruce

Red spruce was once dominant in higher elevations, growing to diameters greater than five feet. Like other conifers, red spruce provides shelter for wildlife in winter and is used year-round for nesting and protection. West Virginia has lost up to 90% of its red spruce forests.[27] In the past 20 years, however, there has been no significant increase in mortality, and red spruce is starting to occur in lower elevations of the Appalachian Mountains. Still, global warming, acid rain, droughts, spruce budworm, windthrow, fire, and other forces threaten the continued presence of this tree in Chesapeake forests.

CHANGE IN UNDERSTORY SPECIES COMPOSITION

Plants form the base of the forest food web, which in the Chesapeake region includes more than 3,000 different plants and animals. Unlike in other areas, most understory plants in the mid-Atlantic are perennial. This means they are relatively long-lived with roots that may spread underground across wide areas, putting up new shoots from the same genetic individual. This act of "cloning" is common in forest species such as mayapple, trillium, pawpaw, trout lily, and many other wildflowers.

The root system and growth cycles of understory plants are especially sensitive to soil disturbance, compaction, and overbrowsing by deer. Forest harvesting practices such as clearcutting, land clearing, plowing, or recontouring the land can severely affect most of the understory plants, which may need decades to re-establish. Increased sunlight and the highly disturbed soil that follows these more intensive land use practices encourages the establishment of invasive species.

In large portions of Pennsylvania, Maryland, and Virginia, overbrowsing by white-tailed deer has essentially eliminated the tree seedling, sapling, and shrub layers, reducing

THE ROLE OF NUT-BEARING TREES

Nut bearing trees such as oak, American chestnut, American beech, and hickory depend on songbirds, small mammals, and even bears to disperse their seeds. A study on blue jays in Virginia noted that 50 birds transported 150,000 acorns in one month.[12] Animals are amazingly capable of retrieving most of their store of acorns, but, in large nut production years, they may not need their entire cache and unretreived acorns can add significantly to regeneration.

The relationship between nut bearing trees and animals is not one-sided, however. Nuts are a critical source of high-energy food.[13] The populations of small mammals, such as the white-footed mouse, rise and fall because of good and poor acorn production years. Numbers of hawks and owls, whose principal prey is small mammals, are in turn affected.[14] Black bear distributions also fluctuate with the availability of nuts. Acorns are the preferred food of bears and can be their only source of energy during winter.[15]

Large, nut-producing trees have been declining over the past 100 years. When the American chestnut was essentially eliminated from Chesapeake forests in the mid-20th century, wildlife lost a valuable food source. Chestnut trees with a diameter of 14 to 16 inches produced 300 to 900 nuts per tree, and larger trees could produce as many as 6,000 nuts.[16] Other nut-bearing trees such as hickory, chestnut oak, northern red oak, and white oak have gradually replaced American chestnut in portions of Chesapeake forests. While some oak species can produce more nuts than the American chestnut, they have less nutritional value and produce acorns less frequently. Thus, oak trees have not been able to fully replace the wildlife value of the chestnut.[17]

Oak, particularly white and northern red oak, is now the greatest acorn producer in Chesapeake forests. Forty-nine species of birds and mammals use oak nuts and foliage in the eastern United States. However, this important food source is in decline. Poor timber harvesting methods, gypsy moth infestations, and regeneration failure have contributed to the decline of oak throughout the Bay watershed.[18]

In contrast to the decline of oak, red maple is steadily increasing. While many wildlife species rely on acorns, very few use red maple seeds as a food source. Red maples are also used less by Neotropical migratory birds for sources of caterpillars. In addition, the smooth bark of maple provides less surface area and crevices for small insects to "hide" than the rough-barked oaks. Because of this, chickadees searching for food have been known to avoid smooth-barked trees like red maple.[19]

Photo: U.S. Forest Service

the vertical structure of forests. Pennsylvania has experienced the greatest effects with thousand of square miles of habitat damaged by deer. In a hemlock-beech forest in western Pennsylvania, deer had reduced plant species from 41 in 1928 to 21 in the mid-1990s. Areas providing sanctuary for wildflowers—many imperiled—were seen only in areas inaccessible to deer, such as the tops of boulders.

In heavily settled parts of Pennsylvania, where hunting pressure is light or nonexistent, it is not unusual to have more than 75 deer per square mile. A 10-year study by the U.S. Forest Service determined that at more than 20 deer per square mile, there is complete loss of cerulean warblers (on the Audubon WatchList as a species of global concern), yellow-billed cuckoos, indigo buntings, eastern wood pewees, and least flycatchers. At 64 deer per square mile, eastern phoebes and even robins disappear.[28] Some understory species, such as spicebush and pawpaw, are not preferred by deer and have become overabundant in the region. Native plant losses are four times greater in places that have little to no deer hunting.[29] Invasive species have also degraded the native layer of forest shrubs. The presence of these species depresses amphibian, small mammal, and bird populations and further limits forest regeneration.[30]


Photo: Will McWilliams

Vegetation flourishes on the other side of a deer fence.

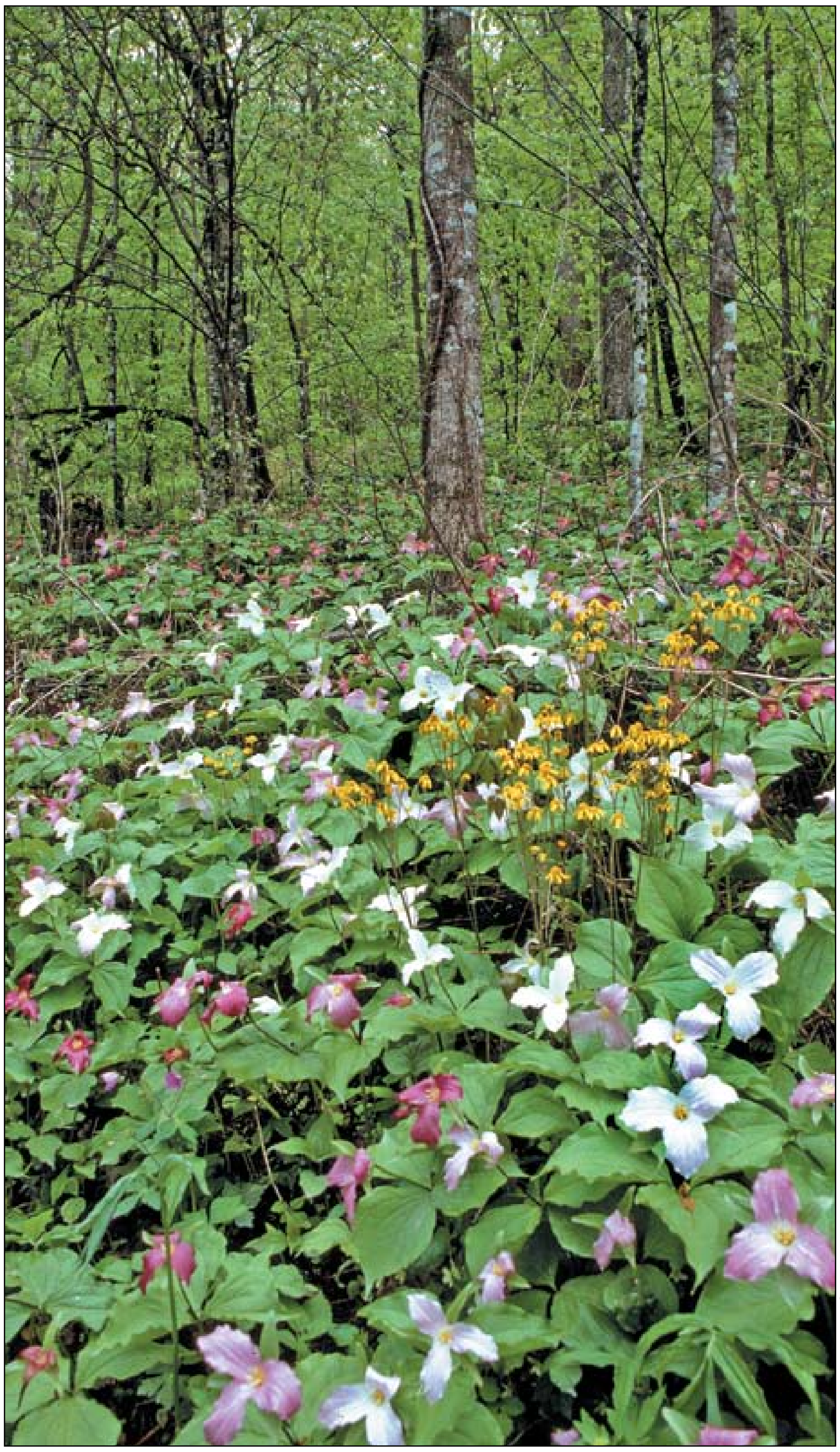


Photo: Gary P. Fleming © VA DCR Natural Heritage

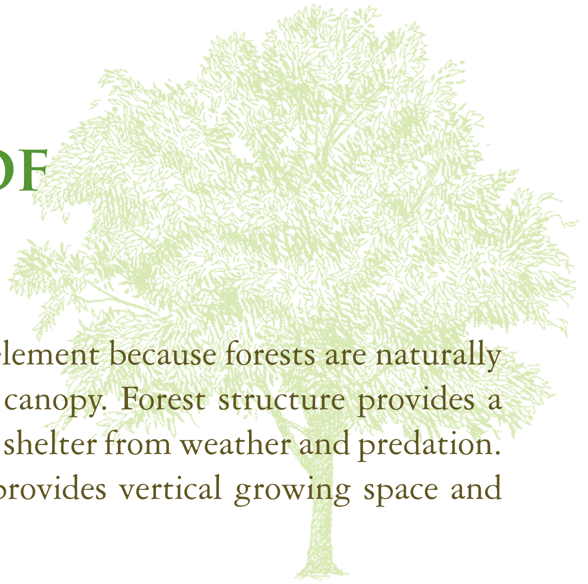
Large Flowered Trillium and Golden Ragwort in George Washington and Jefferson National Forests

THE OLDEST LIVING ORGANISM IN THE BAY WATERSHED

In a forest understory near the Juniata River in Perry County, Pennsylvania, is a clone-forming stand of the box-huckleberry shrub that measures more than a mile wide. Scientists agree that this sizable box-huckleberry patch appears to have originated some 8,000 to 13,000 years ago, eclipsing by far the age of the giant sequoias and bristle-cone pines in the western United States. This Pennsylvania box-huckleberry patch is the oldest known living thing in the Chesapeake Bay watershed and is one of the oldest plants on Earth.[31]


Photo: Larry Morse © LEM National Diversity

THE CHANGING STRUCTURE OF CHESAPEAKE FORESTS



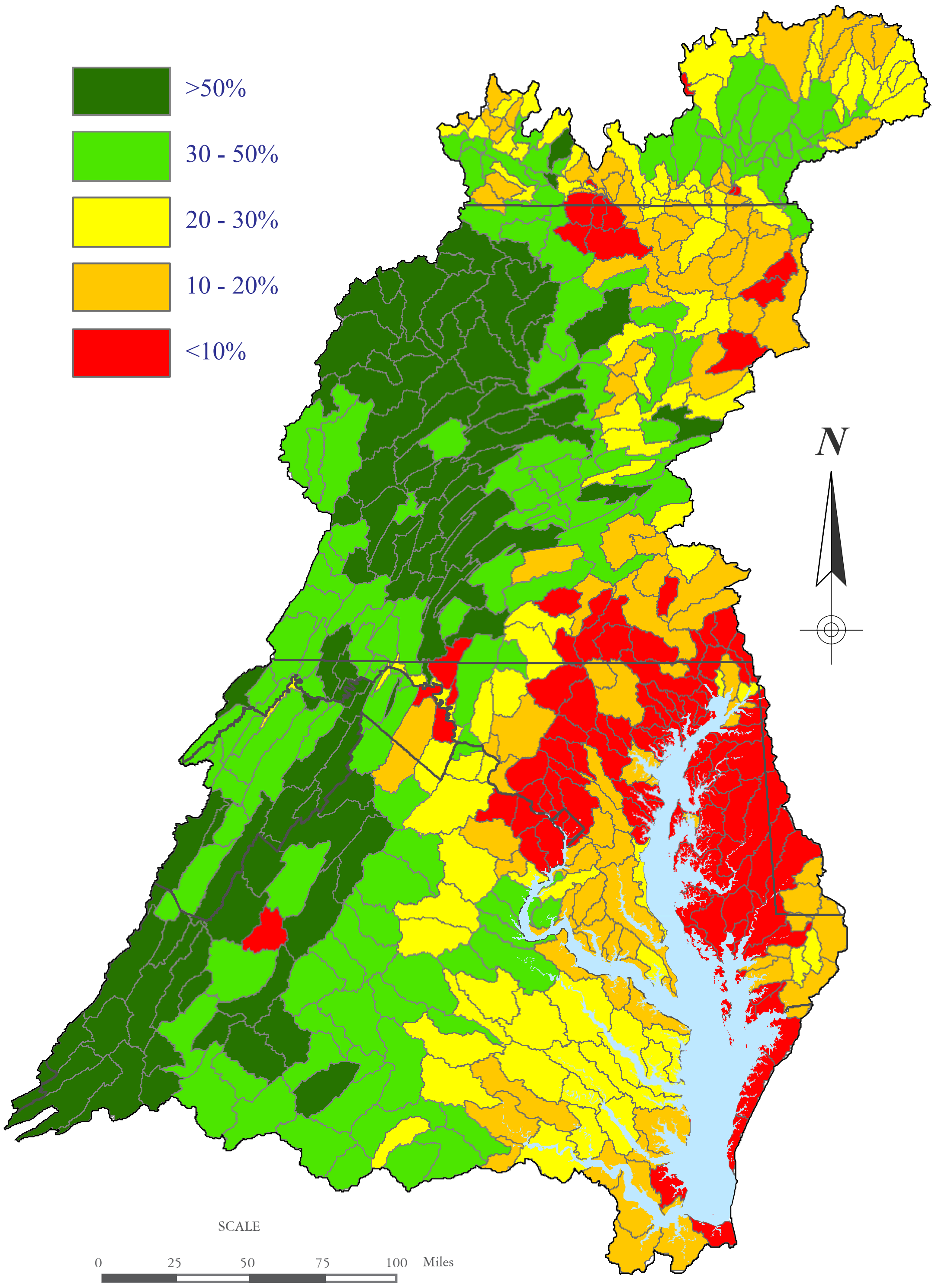
The physical structure of a forest is a critical habitat element because forests are naturally extensive and multi-layered—from the roots to the canopy. Forest structure provides a multitude of micro-niches, as well as nesting sites and shelter from weather and predation. For forest interior dwelling plants, forest structure provides vertical growing space and climate control.

LOSS OF INTERIOR FOREST HABITAT FROM FRAGMENTATION

The smaller size and lack of contiguity of today's forests makes them much less functional for some species of wildlife. Farms, roads, residential developments, and other human uses fragment forests into various-sized patches. Some species require the unique characteristics of "interior" forest—forest that is relatively mature and separated from other land use or forest types. Only 40% of Chesapeake forests provide interior habitat area (300 feet from a non-forest edge) for sensitive species like the scarlet tanager.[32] Interior forest habitat not only provides shelter from weather and predation, but also moderates temperature and light levels that are especially important to plants and wildlife in the summer. In addition, forest fragmentation isolates animal and plant populations by creating gaps in forest cover that are too wide or too dangerous to cross.

Infrastructure like roads and railroads confine larger, contiguous forest patches in areas with little agriculture or development. The majority of forest patches in the Bay watershed are less than 1,000 acres—an indicator of low amounts of interior forest.[33]

PERCENT OF WATERSHED FOREST WITH INTERIOR CONDITIONS, 2000



INTERPRETATION: Nearly all land animal and plant species evolved in forests with interior conditions, protected from the affects of extreme weater and predation where forestland abuts non-forestland. Some species have adapted to the loss of interior forests, but many have not and are threatened by its continued loss due to forest conservation and fragmentation.

SOURCE: U.S. EPA Region 3 2005

In addition to forest area and amount of interior habitat, adjacent land use plays an important role in the habitat suitability of forest fragments. A study on breeding bird communities in central Pennsylvania found that mature forest patches surrounded by agricultural landscapes had fewer forest-associated species and a greater number of species along the forest edge than similar forests surrounded by tree harvesting.[34]

Despite the decline of interior forests, there are still extensive forests with high ecological value in the Bay watershed. The Chesapeake Bay Program has identified the remaining high quality forestland that provides ample space for breeding and migration. The highest valued areas are:

- Large and intact, with interior conditions
- Habitat for rare, threatened, or endangered species or unique natural communities
- Highly diverse
- Aquatic or riparian habitats
- Remote from human disturbance such as roads

Based on current development patterns, 45% of the Bay watershed's network of forests and wetlands is vulnerable to development.

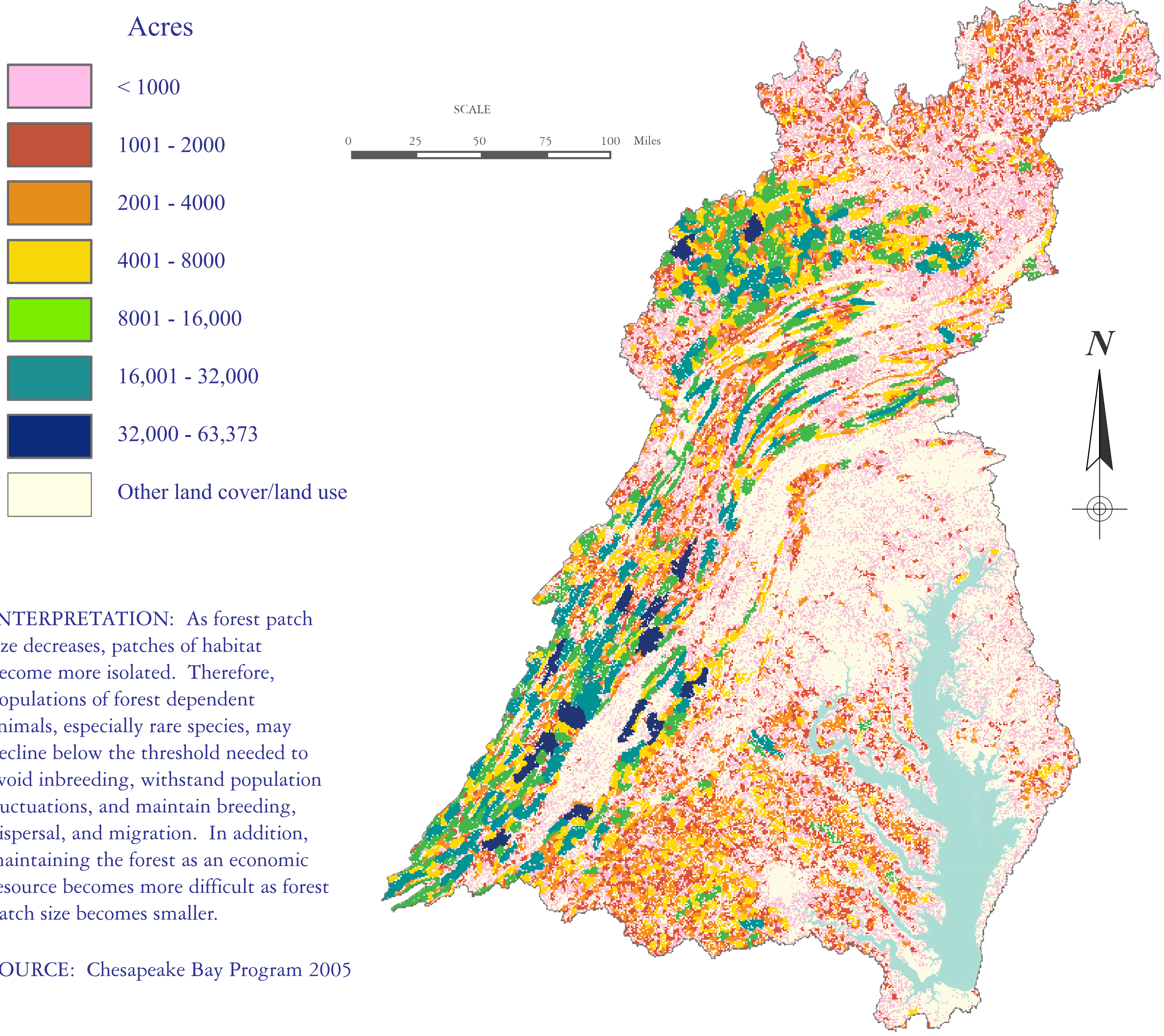
FORESTS OF SIMILAR AGE AND SIZE

Many Chesapeake forests we see today began growing on abandoned farmland and heavily logged forestland between 1900 and 1960. These forests are still growing and thanks to the region's highly productive soils and long growing seasons, they may be growing more quickly than forests in any other area of the country.[35,36] Forests in the 50 to 100 year age range dominate the Bay watershed, resulting in a relative scarcity of younger and older forests and the habitats they provide.[6]

The trees in Chesapeake forests are similarly sized. Almost 60% of the Bay watershed is dominated by stands of "large" trees—that is, hardwood and softwood trees at least 11 and 9 inches in diameter respectively. Over the past two decades, the volume of these growing trees has increased by 14%, with the greatest growth in trees 17 inches in diameter or larger.[6]

While larger trees continue to mature, newly

AVERAGE FOREST PATCH SIZE



INTERPRETATION: As forest patch size decreases, patches of habitat become more isolated. Therefore, populations of forest dependent animals, especially rare species, may decline below the threshold needed to avoid inbreeding, withstand population fluctuations, and maintain breeding, dispersal, and migration. In addition, maintaining the forest as an economic resource becomes more difficult as forest patch size becomes smaller.

SOURCE: Chesapeake Bay Program 2005

established seedling and sapling forests have declined. Trees below nine inches in diameter—those that most influence future forest composition—have declined by 8% over the past 20 years.[6] Forest understories are more often found barren of seedlings, when their maturity would suggest that they support new trees. In essence, the average forest age has increased not as much because there are a greater number of older trees, but because there are far fewer young ones.

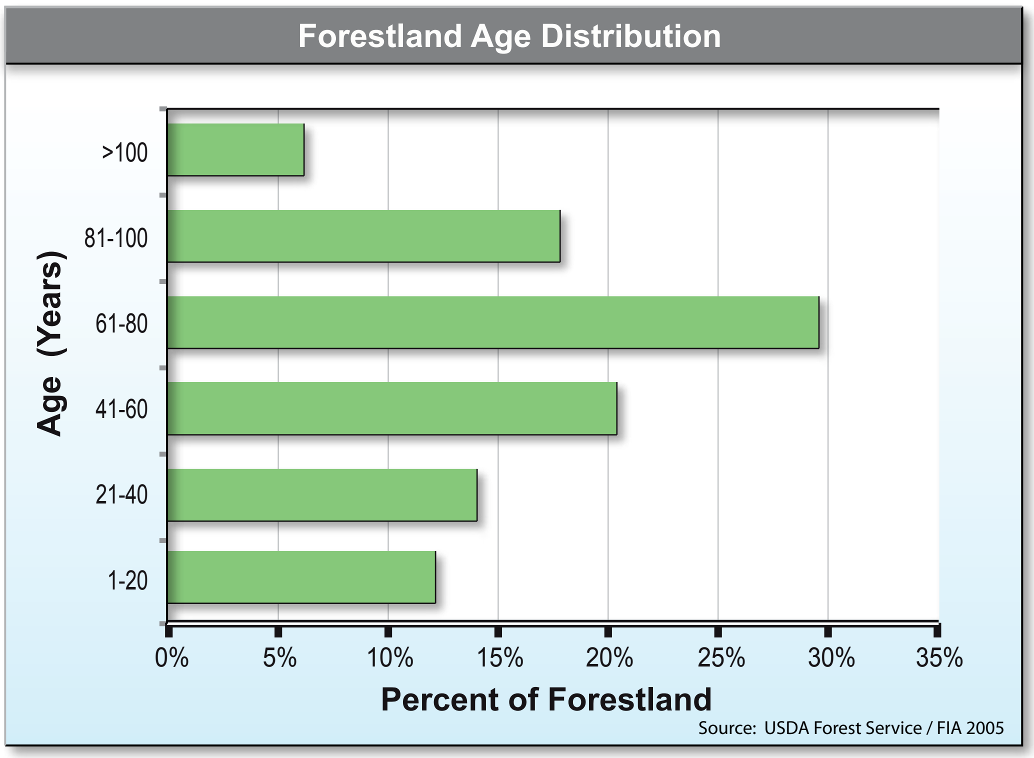
Early Successional Forests

Species dependent on early successional habitats are said to be the fastest declining group of wildlife in the northeast. While fire or browsing may have maintained some large early successional habitats in pre-European settlement forests, most occurred as small patches of trees, shrubs, and other plants that emerged as forest openings after disturbances. Currently, early successional forestland makes up about 10% of all forests in Pennsylvania, New York, and West Virginia. Historically, these headwater regions may have had less than 3% of the total early successional forest that existed 400 years ago. The coastal states of Delaware, Maryland, and Virginia currently have about 15% of their forests in early successional habitat, the same level that may have existed in pre-European settlement forests.[4,37]

As Chesapeake forests mature, many forest species like pileated woodpeckers and black bears are reclaiming past territories at the expense of early successional species. In Pennsylvania, at least four reptile, twenty bird, and three mammal species are likely to decline because of the continued loss of early successional habitat.[19]

Old Growth Forests

Given the human use of Chesapeake forests over the past 400 years, old-growth forests have been largely absent from this region for a long time. Today, it is thought that more than 99% of the original eastern deciduous old-growth ecosystem has been lost.[27] Old-growth forestland in the eastern United States covers approximately 2.2 million acres or 0.6% of all forest. The Bay watershed currently has approximately 42,000 acres of old-growth forest, representing 0.2% of all forestland.[38] The remaining areas of old-growth forest survive in small patches primarily in areas that humans found difficult to access, like remote areas and steep slopes.

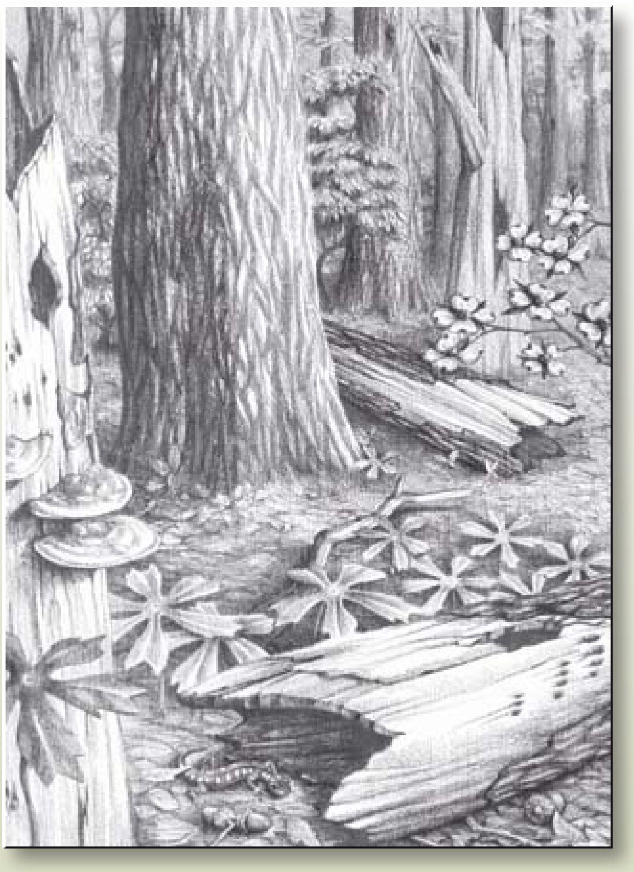


Source: USDA Forest Service / FIA 2005

Old-growth forests were heavily degraded during the mass conversion of forestland to agriculture and timber operations in the 19th century over most of the Bay watershed. Current forests are relatively young and even-aged and cannot yet provide the full range of habitats that a more structurally diverse, old-growth forest contains.

Like all forests in the Bay watershed, old-growth forests are not static. The forests and trees within and around them change continuously. This would be true even if human influence could be eliminated. Old-growth forests succumb to natural, disturbances and then regenerate over time.

Old Growth Forest Characteristics



Randomly-distributed gaps in forest canopy

High structural diversity; multiple layers of vegetation

Tree age diversity with a substantial number of old trees

Pit and mound topography from large trees uprooting

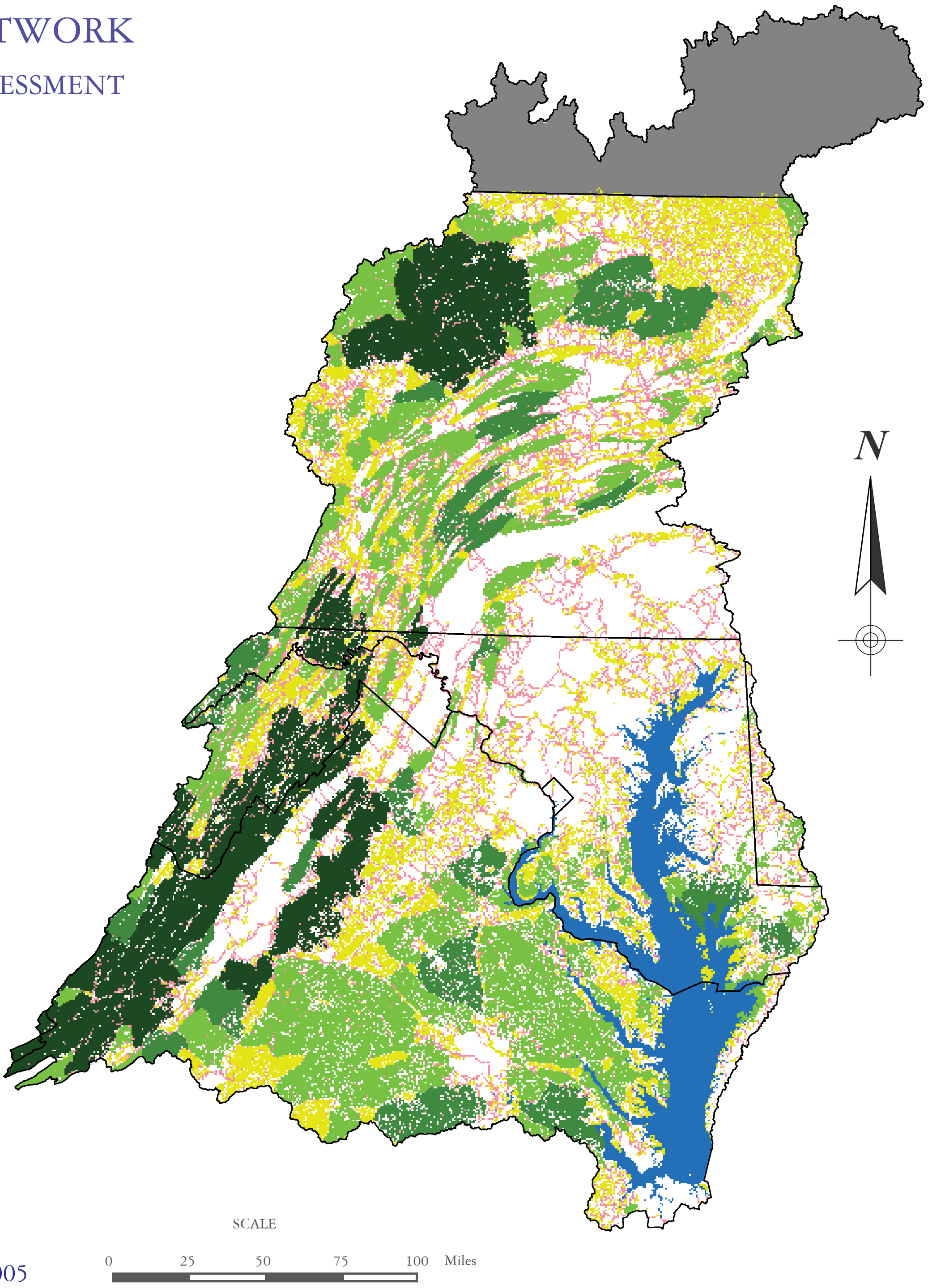
Dead wood of varying sizes and stages of decomposition

High diversity of plant and animal species

Ecological Network
Resource Lands Assessment

Relative Ecological Value

- ■ Top 25%
- ■ Upper middle 25%
- ■ Lower middle 25%
- ■ Bottom 25%
- ■ Corridor
- ■ New York State *- not included*
- ■ Chesapeake Bay



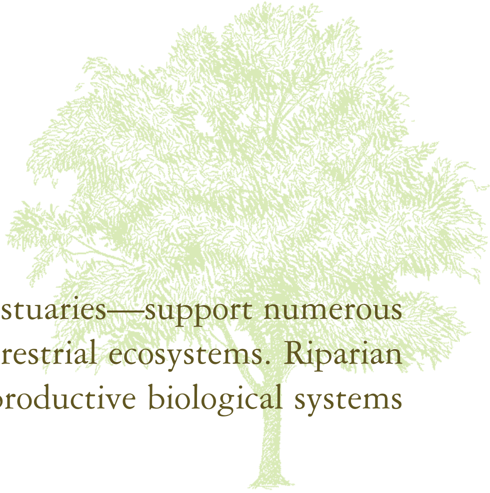
INTERPRETATION: The most important remaining habitats in the Chesapeake Bay watershed occur in large, intact, and remote areas that provide habitat for rare, threatened, or endangered species or unique natural communities. In addition, high valued habitats contain a large diversity of plants, animals, and physical conditions as well as aquatic or riparian habitats. Areas with lower habitat value at the Bay watershed scale can be of higher importance at a smaller scale.

SOURCE: Chesapeake Bay Program 2005

Snags and Fallen Trees

Standing dead trees (snags) and decomposing logs and stumps on the forest floor, known as coarse woody debris, are important to many ecological processes, including nutrient cycling, hydrology, plant growth, and provision of habitat. Snags provide habitat for cavity nesting animals such as woodpeckers, squirrels, and owls. Fallen logs protect seedlings from certain fungus in the soil, which cannot live on deadwood.[39] In the northern hardwoods of New England, one-third to one-half of native amphibians and mammals rely on logs at some stage in their life.[40] Biodiversity increases with the size of deadwood, because of the length of the decay process and the large number and types of habitats it provides. Many species of insects, small mammals, and birds can be found foraging and living among coarse woody debris in Chesapeake forests.

Photo: Clint Farlinger



RIPARIAN FORESTS

Riparian forests—those that border streams, lakes, and estuaries—support numerous plants and wildlife because they connect aquatic and terrestrial ecosystems. Riparian areas in the eastern United States are among the most productive biological systems in the world.[41]

THE RIPARIAN FOOD CHAIN

Tree material (such as leaf litter, fruit, and large wood) from the forest canopy provides the foundation of the freshwater aquatic food web. In the east, small headwater streams receive between 60 and 99% of their food base from the surrounding forest.[43] As water passes through the forest on its way to a stream, it picks up an enormous variety of useful organic molecules. When that water enters a stream, a special blend of dissolved organic matter is dispersed like tea from a tea bag. Bacteria and algae consume this "watershed tea" as well as detritus from leaves and twigs, utilizing their stored energy for growth. Aquatic insects feeding on these microscopic organisms are consumed by fish and so on along the food chain. Aquatic life native to this region evolved to utilize this unique mix of organic materials derived from trees. Without food from trees, many stream species simply cannot survive.

MAINTAINING AQUATIC HABITAT

Many species of fish need consistent streamflow to live and breed. For example, the endangered American shad, a Chesapeake icon, requires from one to three cubic feet of water per second. Forests can moderate streamflow by slowing water from rain events and maintaining ground water flows.

Streamside forests shade the water and maintain cooler water temperatures in the summer, especially on small streams. The leafy tree canopy also helps to moderate dramatic fluctuations in water temperature, further reducing stress on fish. As water temperature increases, streams have less ability to hold oxygen and undergo important ecological reactions. Agricultural or grass-lined streams average 10 degrees Fahrenheit warmer than a forested stream and are often unable to support the growth of diatoms, beneficial algae and aquatic insects and the fish that depend on them. A few degrees can have a major effect on water quality and the survival of aquatic organisms.

Most aquatic organisms in streams live on the streambed. Forested streams produce nearly double the effective stream bottom habitat of their non-forested counterparts. Therefore, a network of tree roots and gravel/cobble bottom can increase the overall habitat of a forested stream reach more than a thousand times when compared to the bare soil bottom in a grass-buffered stream. Branches and tree trunks add habitat components and help shape the physical character of the stream. This large woody debris plays an important role in creating habitat that is favorable for fish. Studies have shown that forested streams have more than six times the amount of large woody debris than grass buffered streams, even though the grass segments were immediately downstream of forested reaches.[44]

A GLOBALLY SIGNIFICANT DIVERSITY OF SALAMANDERS

The Appalachian Mountain forests, especially their southern extreme, are home to the most diverse salamander fauna in the world. With 168 species of salamanders, the United States ranks first internationally, followed by Mexico with 127 species. As a group, United States salamanders are threatened by habitat loss and degradation caused by land disturbance, loss of riparian areas and wetlands, development of habitat, logging, atmospheric pollution, and reduced water quality from agricultural, industrial, and residential runoff. Due to the broad ranges of some of these salamanders and their frequent occurrence in remote mountains, relatively few Appalachian species are threatened with extinction.[42]

Photo: Evan H.C. Grant

Forested riparian areas also improve aquatic habitat by reducing the amount of sediment and nutrients reaching streams. High levels of suspended sediment can abrade and clog gill tissues as well as bury fish eggs and habitat.[45]

SPECIAL AQUATIC HABITATS UNDER PRESSURE

Riparian Hemlock Forests

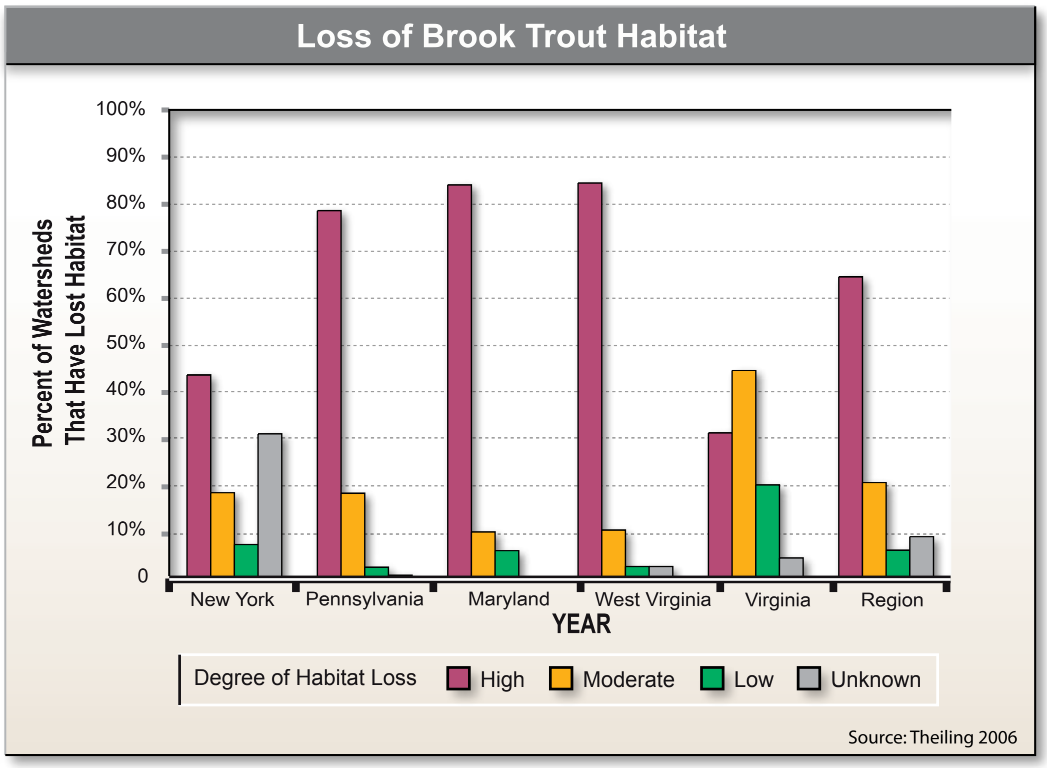
Eastern hemlock forests provide year-round habitat and are especially important to aquatic biodiversity. Their loss from Chesapeake forests, caused by the non-native hemlock wooly adelgid and the harvesting practice of high grading, could have significant ramifications. Streams flowing through hemlock forests can have higher invertebrate species richness and diversity than streams flowing through hardwood forests. The prized game fish, brook trout, is three times more likely to occur in hemlock streams than hardwood streams because of cooler stream temperatures in summer and warmer temperatures in winter.[46]

Forested Coldwater Streams

A loss of shade, habitat, bank-and-pool structure, and food production has led to a 30 to 50% loss of coldwater streams.[47] A recent sample of coldwater streams in Maryland revealed that 34% were severely degraded. The loss of this habitat has led to drastic declines in aquatic species like the brook trout.

Until the 19th and 20th centuries, brook trout populations thrived in the clean, clear, and cold streams that flowed through heavily forested regions throughout a large portion of the Bay watershed. However, much of the supporting habitat was destroyed at the turn of the 19th century by logging and agricultural practices. Agriculture and development continue to degrade riparian habitat today.

States in the Bay watershed have seen brook trout eliminated from nearly a third of subwatersheds in the species' historic range. Where populations still occur, supporting habitat in 65% of the streams is diminished and only 6% are in fully functioning condition.[48] Reproducing populations of brook trout are likely to disappear from subwatersheds when the percentage of human land uses like residential subdivisions is greater than 18%. Brook trout in Maryland are not present in streams where watersheds have more than 2% impervious cover.[49]


Loss of Brook Trout Habitat

Source: Theiling 2006


Photo: Ted Weber

Key Factors of Habitat Change

Overabundant Deer Populations

The white-tailed deer is a key threat to overall forest habitat quality in the Chesapeake Bay watershed. In many portions of the region, land use change and lack of management over the past 80 years have created forests where vegetation composition and structure are regulated by browsing patterns of white-tailed deer.[50] Increasing deer populations are also a public safety concern. Deer collisions with vehicles have increased greatly, and deer infested with Lyme disease-carrying ticks are abundant in forest fragments.[51]

Currently, hunting is the only viable option to control deer populations. The use of hunting is limited in rapidly growing suburban areas because of public safety concerns and the perception of inhumane treatment. Access for hunters is more restricted than ever because the greater number of private families owning Chesapeake forestland. Additionally, current hunting techniques are not always the most effective for controlling deer populations. Hunters tend to visit similar locations and rarely travel more than a third of a mile away from a road.[52]

Before European settlement, deer populations were probably as low as two deer per square mile over large sections of the mature deciduous forest.[53] Historic populations were limited by large predators like the gray wolf and from hunting by Native Americans. However, the abundance and nutritional value of food likely was the most important influence on population size for most deer herds. The white-tailed deer population severely declined throughout the eastern United States over the next 300 years, reaching an historic low by 1900 mostly from over-hunting in areas where deer remained a staple of the frontier diet. In Virginia, deer were effectively extirpated from most of the state except for a few sizable herds in northern Virginia and areas where hunting was minimal.

Deer numbers have since grown tremendously throughout the Bay watershed. In the Chesapeake region of Pennsylvania, deer density increased 80% between 1999 and 2003.[54] In Virginia, 30% of Chesapeake counties supported high densities of deer from 1994 to 2003.[55] While deer were historically a forest species, they are currently most abundant at the nexus of farmland (food source), forestland (protective cover), and areas with a high enough human population to preclude hunting. Female fawns are more likely to reproduce in farmland than in forestland because of the stability of food sources in agricultural areas.[56] Deer have also benefited from game management and forestry practices that promote preferred food sources such as shrubland and early succession forests.

Important Tree Species with Low Regeneration Rates in Pennsylvania

Black cherry
Oak
Sugar maple
Red maple
White pine
Eastern hemlock
Hickory
Yellow-Poplar
Ash
Black birch
Beech
Conifer
Basswood
Cucumbertree
Walnut
Butternut

Source: McWilliams 2005

Decimation of American Ginseng

The wild herb, ginseng, is an important economic and cultural forest plant in the eastern United States. Overabundant deer populations and illegal harvesting threaten ginseng across its range in the Chesapeake Bay watershed. Current ginseng populations must have at least 800 plants to have a 95% chance of surviving into the next century and sustaining the herb's value to Appalachian communities. However, over-browsing by white-tailed deer has limited the average population size to 93 plants in the Appalachian region. To ensure the long-term viability of ginseng populations, deer browsing levels would need to drop by 50% or more.[57]

Photo: USDA Agroforestry Center

RISING POPULATIONS OF INVASIVE SPECIES

Pests

Without effective restrictions or preventative measures, non-native and invasive forest pests and diseases will continue to dramatically alter forest conditions in the Bay watershed. Once non-native pests establish themselves, it is nearly impossible to remove them because they reproduce rapidly, disperse easily, and lack natural predators. This means that preventing the entry of new pests and rapidly attacking new outbreaks is paramount.

Major Insects and Diseases in the Chesapeake Bay Watershed

Nativity	Insect or Disease	Primary Tree Host(s)	Affects Low	 Med	 High
Exotic	Hemlock woolly adelgid	*Eastern hemlock*			⬆
	Beech bark disease	*American beech*			⬆
	Gypsy moth	*All oak and basswood*			~
	Chestnut Blight	*American chestnut*			▬
	Dutch elm disease	*American elm*		⏷	
Native	Southern pine beetle	*Loblolly and Virginia pine*			⬆
	Anthracnose	*American sycamore, ash and beech*		~	
	Looper complex/fall cankerworm	*Maple and oak*		~	
	Locust leaf miner	*Black locust*		~	
	Variable oak leaf caterpillar	*Oak and beech*	~		
Unknown	Dogwood anthracnose	*Flowering dogwood*			⬆
	Oak wilt	*Red oak*			⏏

⬆ Increasing ~ Variable ▬ Static
⏷ Static to Decreasing ⏏ Static to Increasing

Source: USDA Forest Service / FHM 2005, Asaro 2005, Yockey 2005

Some pests and diseases, such as chestnut blight, Dutch elm disease, beech bark disease, and gypsy moth have had long-term, devastating impacts on forest ecosystems. There are currently 12 major pests or associated diseases that are having widespread and serious effects.[58] These include:

- Gypsy moth - Despite the discovery of a pathogen that has reduced gypsy moth populations, the moth's range is expected to spread across the Bay watershed.[22,59] After repetitive years of defoliation, high densities of gypsy moth weaken and kill trees. The gypsy moth was first introduced in the United States to start a silk industry in 1869; since then, the moth has fed on the foliage of hundreds of tree species, especially oaks.[60]

- Hemlock woolly adelgid - Within decades, the Asian hemlock wooly adelgid is expected to eliminate most of the eastern hemlock forest ecosystem remaining in the Chesapeake region. Chemical insecticides, biological controls, and even harsh weather have proved ineffective in slowing the spread of the adelgid over the past half-century. Mixed hardwood species tend to grow in the openings created by the demise of hemlock groves, but this new forest does not support the same plant and wildlife communities as the deposed eastern hemlock.[61]

- Beech bark disease - There are currently no practical tools to prevent widespread defects and mortality in forests infected by the beech bark scale that causes the disease.[62] Over the past two decades, the number of American beech trees has declined by 11% in the northern Bay watershed.[5] As beech bark disease spreads, small mammal and other forest wildlife populations will continue to be affected by the loss of the once abundant and nutritious beechnut crop that is only produced by mature trees.[63]

- Southern pine beetle - The southern pine beetle has become a significant pest in the southern portion of the Bay watershed because of the intentional suppression of natural fire. Fire suppression and lack of thinning has created dense stands of loblolly pine trees in various stages of health—ideal conditions for the southern pine beetle. This beetle is native to the southern portion of the Bay watershed, but changes in the natural fire regime have limited the resilience of Chesapeake forests to the southern pine beetle.

The following pests have been discovered recently and underscore the constant and significant threat to Chesapeake forests:

- Emerald ash borer - White and green ashes are dominant trees in the Chesapeake's forests and a primary component of riparian forest buffers. There are over 470 million ash trees in the Bay watershed. Elm, walnut, and other trees in the Bay watershed are also susceptible to mortality because of the emerald ash borer.

- Sudden oak death - Though not currently known to affect eastern forests, sudden oak death is expected to spread to this area in the future. Since the mid-1990s, the fungus-like organism has caused substantial mortality in numerous oak species and other plants. Sudden oak death has been found in 18 states since 2000, including Maryland.[64]

- Asian longhorned beetle - This beetle will threaten many Chesapeake hardwood species including maple, birch, poplar, and sycamore. Approximately 70% of the trees in Pennsylvania and more than 50% in West Virginia are at risk to infestation.[65] Quarantines of infestations in New York, Chicago, and New Jersey are attempting to prevent the export of wood, tree debris, and nursery products that could be infected with the beetle.[66]

Plants

Invasive trees, shrubs, vines, and grasses have become so common that some are now permanent components of many Chesapeake forest ecosystems. Invasive plants, often non-native, grow and reproduce rapidly, killing and out-competing native species in the process.

Climate causing change is causing vines to grow faster than their tree hosts. They lower the quality of food sources and shelter for wildlife, eliminate host plants of native insects, and compete with native plants for pollinators.

The most successful invasive plants lack natural herbivores, spread underground, produce large numbers of durable seeds, and disperse seeds in multiple ways. Some invasives also produce chemicals that kill nearby native vegetation to create their own space to grow. They are often very attractive plants, which leads to intentional plantings by amateur and professional gardeners. In addition, the disturbed habitats that invasives thrive in continue to spread with human activity.

While only 5% of all plants in the eastern United States are non-native and invasive, and only a small portion invade forests,[67] some of these plants can cause significant problems. Particularly invasive plants that have made Chesapeake forests their home include:

- Tree of heaven (Ailanthus) - This tree grows rapidly in a variety of conditions and, consequently, is able to form dense stands that displace native plants by blocking sunlight and capturing available nutrients and water. The tree of heaven also produces chemicals that kill or prevent other plants from growing nearby.

- Japanese barberry - The bright red, oblong berries of this shrub have become a familiar sight in Chesapeake forests, where large clusters of the plant out-compete native vegetation. Birds and wildlife quickly spread the attractive and edible seeds.

- Oriental bittersweet - This vine kills other plants by blocking light, girdling plant tissues, and covering then even toppling trees with its immense weight.

- Japanese stilt grass - This grass covers extensive areas and replaces native species, including those that occur in forest interiors.[68]

Major Invasive Plants

Trees

Norway maple* (*Acer platanoides* L.)
Siberian elm* (*Ulmus pumila* L.)
Tree of heaven (*Ailanthus altissima*)
Princess tree (*Paulownia tomentosa* Thunb.)

Vines

Oriental bittersweet* (*Celastrus orbiculatus* Thunb.)
Japanese honeysuckle* (*Lonicera japonica* Thunb.)
Mile-a-minute* (*Polygonum perfoliatum* L.)
English ivy* (*Hedera helix* L.)
Kudzu (*Pueraria montana var. lobata* Willd.)
Exotic wisterias (*Wisteria floribunda* (Willd.) DC. , *W. sinensis* (Sims) DC.)
Periwinkle (*Vinca major* L. , *V. minor* L.)
Japanese hops (*Humulus japonicus* Sieb. & Zucc.)

Shrubs

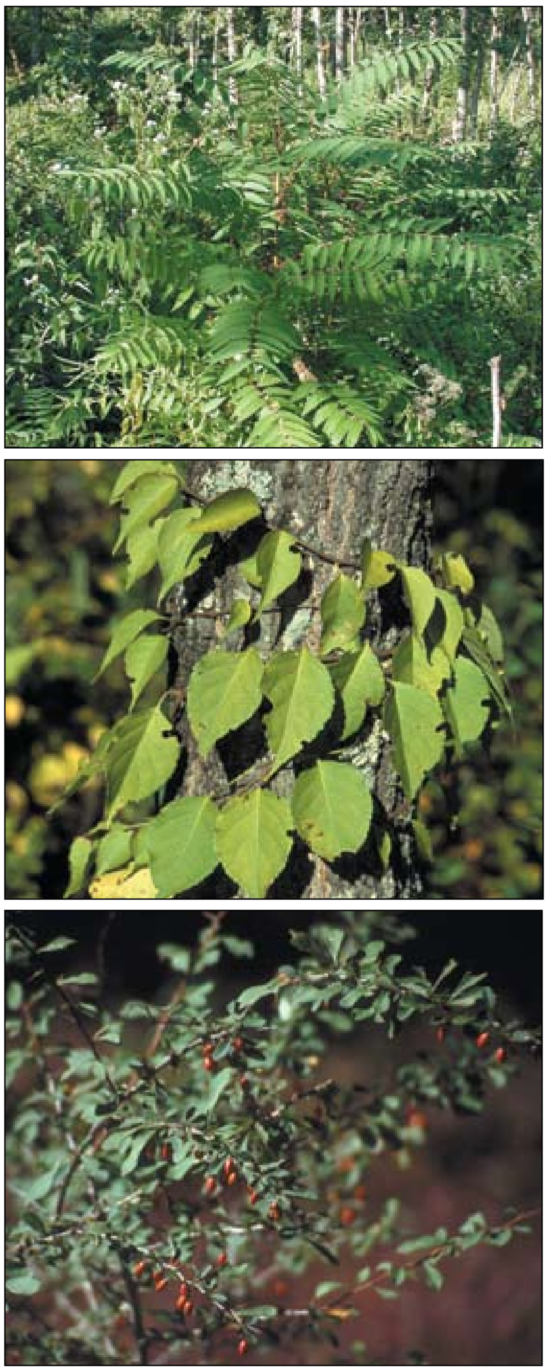
Japanese barberry* (*Berberis thunbergii* DC.)
Chinese privet* (*Ligustrum sinense* Lour.)
Multiflora rose* (*Rosa multiflora* Thunb.)
Winged euonymus* (*Euonymus alta*)
Exotic bush honeysuckles (*Lonicera* spp.)
Wineberry (*Rubus phoenicolasius* Maxim.)
Common reed (*Phragmites australis* Cav.)
Autumn olive (*Elaeagnus umbellata* Thunb.)
Japanese spiraea (*Spiraea bumalda* Burven)

Grasses and Herbs

Japanese stiltgrass* (*Microstegium vimineum* (Trin.) Camus)
Reed canary grass* (*Phalaris arundinacea* L.)
Chinese silver grass (*Miscanthus sinensis* Anderss.)
Johnson grass (*Sorghum halepense* (L.) Pers.)
Garlic mustard* (*Alliaria petiolata* (Bieb.) Cavara & Grande)
Japanese knotweed* (*Polygonum cuspidatum* Sieb. & Zucc.)
Dame's Rocket (*Hesperis matronalis*)
Purple loosestrife (*Lythrum salicaria* L.)
Pale yellow iris (*Iris pseudacorus* L.)
Canada thistle (*Cirsium arvense* (L.) Scop.)
Exotic Bamboos (*Bambusa, Phyllstachys* and *Pseudosasa* spp.)

* Invades forest interiors

SOURCE: Chesapeake Bay Program 2005



Photos: Chris Evans UGA

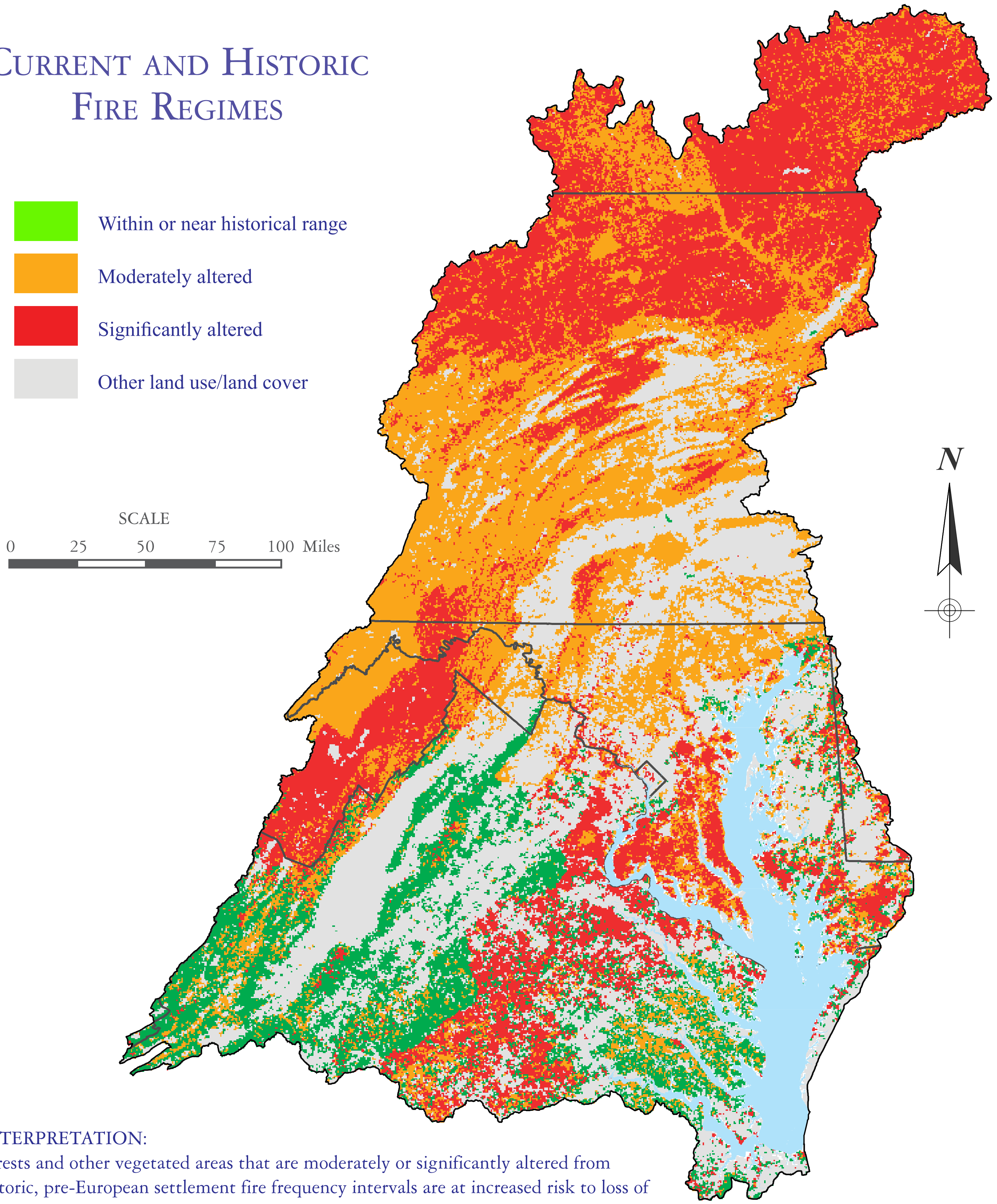
top to bottom: Tree of heaven, Oriental bittersweet and Japanese barberry.

Effects of Suppressing Fire

More than 80% of Chesapeake forests have seen changes in condition, species diversity, and increased risk to catastrophic wildfires because of the suppression of natural, low-intensity fires.[69] Fire is important to forest ecosystems for several reasons. It promotes mineral cycling, creates habitat for many animal species, and exposes the mineral soil for seed germination. However, in the early 1900s, widespread and destructive high-intensity wildfires created by poor land management led to the establishment of fire control as one of the dominant forest management practices of the 20th century.

Over the past century, species whose numbers were traditionally controlled by fire—like red maple, tulip poplar, sugar maple, and American beech—have increased, while slow growing, fire resistant species like white and red oak and pine have decreased.[7] The prolonged absence of natural fire has also allowed the density of trees and shrubs to increase substantially, which further increases the likelihood of severe wildfires. Road access and rapid detection and suppression capabilities have made large wildfires a less serious problem for Chesapeake forests. However, expanding rural and suburban development has introduced new ignition sources and created increased risk for some local forests and residents.[70,71] When they occur, high-intensity wildfires can have serious impacts on local forests and communities.

Current and Historic Fire Regimes



INTERPRETATION:
Forests and other vegetated areas that are moderately or significantly altered from historic, pre-European settlement fire frequency intervals are at increased risk to loss of biodiversity and other forest components. 83% of vegetation is either moderately or significantly altered and covers the majority of the Bay watershed.

SOURCE: Schmidt et al. 2002

FOREST COMMUNITIES THAT DEPEND ON FIRE

Photo: Sandra Y. Erdle © VA DCR Natural Heritage

Perscribed Fire to Restore Pine/Scrub Oak Forest in Virginia Coastal Plain

Several types of pine forest, open woodlands on serpentine bedrock, and assorted dry forests of Appalachian ridges all depend on fire to maintain their integrity. Often, fire-created openings are soon filled with abundant grasses and wildflowers that arise from decades-old underground seeds. They flourish briefly, producing new seeds that lie dormant until the next fire. Meanwhile, new tree shoots arise from seed or, more often, from undamaged underground parts of the original trees. As the new trees grow, they shade out the sun-loving plants, and a new forest cycle begins. If fire is suppressed, fire-intolerant trees eventually dominate the land, shrubs grow tall, and dead wood accumulates, conditions that can increase the intensity of future fires.

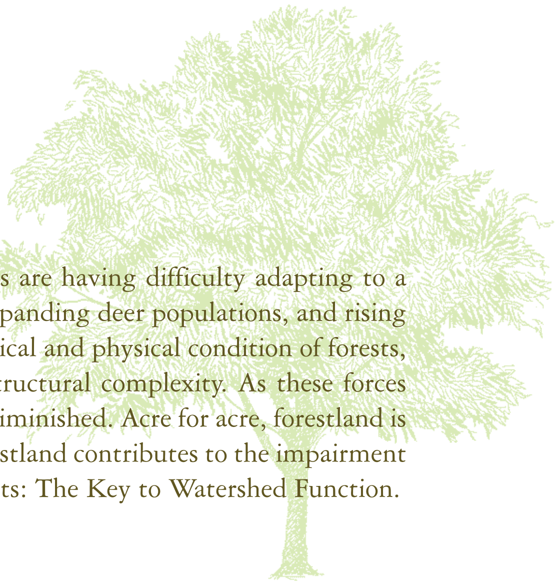
Some of the rarest plants in the Chesapeake region grow in areas of recurrent fire. The serpentine barrens, on peculiar bedrock of the Piedmont (especially between Baltimore and Philadelphia), have abundant stands of unusual species. Examples include the blackjack oak; various grasses characteristic of Midwestern prairies; a fern more common in Canada; the sandplain gerardia, a rare wildflower; and the serpentine chickweed and Reed's moss—plants that occur nowhere else on Earth.

In the sandstone ridgetops of the Appalachians, fire maintains sandy openings in pine forests. These openings generate an assemblage of strange plants. Some, such as the turkey-beard and the sand-heather, are characteristic of coastal habitats, while others, such as the silvery nailwort, are characteristic of Appalachian mountaintops. One of these wildflowers, the white-flowered alumroot, grows in only a few dozen locations worldwide—most of which are on a few mountain ridges in the Potomac River headwaters of the Chesapeake Bay watershed.[72]

INDICATORS FOR SUSTAINABLE CHESAPEAKE FORESTS

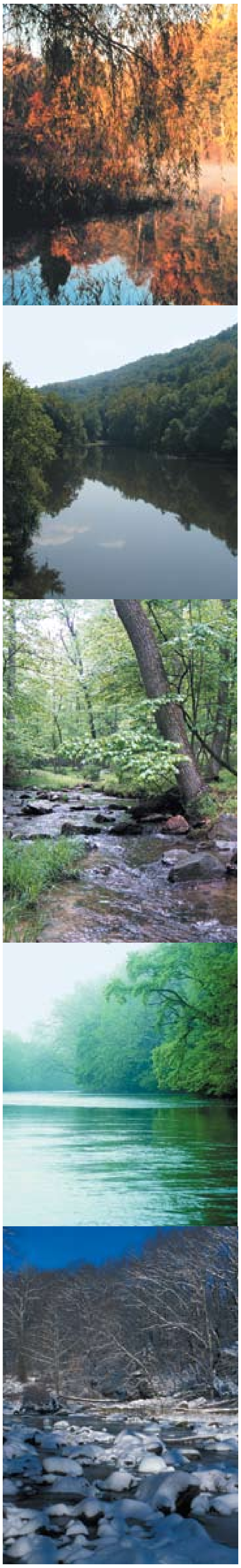
To ensure the rich diversity of Chesapeake forests is present for future generations, the following indicators can be used to track biological conditions over time:

- Area of forest types
- Forest size class and age group
- Area of forestland affected by insects, diseases, plants, and deer



CHAPTER IN PERSPECTIVE

Healthy forests are in a continual state of flux. However, Chesapeake forests are having difficulty adapting to a new suite and frequency of forces of change such as rapid land use change, expanding deer populations, and rising numbers of invasive plants and pests. These forces have influenced the biological and physical condition of forests, altering the natural diversity of plant and animal life and decreasing the structural complexity. As these forces degrade forest health, the total ecological value of Chesapeake forests is also diminished. Acre for acre, forestland is the most beneficial land use for protecting water quality, and every loss of forestland contributes to the impairment of the Chesapeake Bay. This connection is explored in the next chapter, Forests: The Key to Watershed Function.



Chapter 4:

The Key to Watershed Function

KEY FINDINGS

- Forests act as a living sponge by storing, cleaning, and slowly releasing the majority of the water that maintains stream flow and replenishes groundwater.

- Forests are the most beneficial land use for promoting and maintaining clean water. While forests cover 58% of the Chesapeake Bay watershed, they contribute less than 15% of total nitrogen and 2% of total phosphorus loads to the Bay.

- The health of a watershed is directly tied to the amount of forest and tree canopy cover, the quantity of intact riparian forests, and the health, condition, and distribution of its forested lands.

- Forests protect local waterways by retaining more than 85% of the nitrogen deposited on them from the air. If nitrogen deposition continues to rise, this retention rate could decline to 23% by the end of the century.

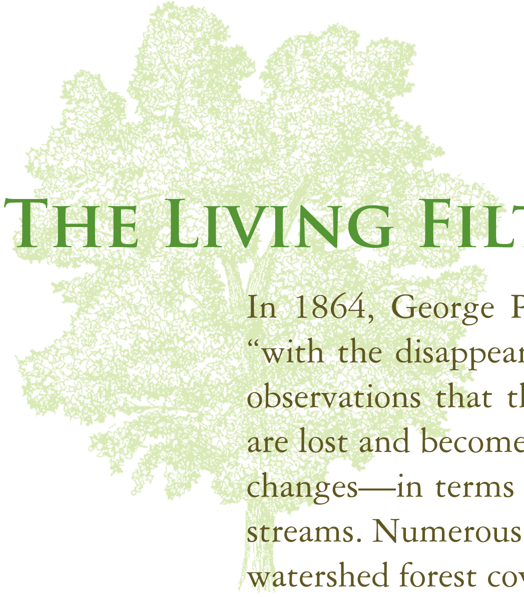
- Forestland loss disproportionately increases nutrient pollution to the Bay. Reducing forest area in a watershed by 10% leads to as much as a 40% increase in nitrogen loads to the water.

- Urban and rural forests are critical to reducing stormwater runoff from small storms–storing and filtering up to six times more rainfall than grass and 20 times more than a parking lot.

- Riparian forests are essential for healthy aquatic habitat and water quality, and currently buffer 60% of the streams and rivers in the Bay watershed. To achieve water quality, habitat, and watershed function goals in the Bay watershed, at least 30,000 miles of additional riparian forest buffers will be needed.

- Losses of forestland increase the cost of clean drinking water for more than 10 million residents in the Bay watershed.

- Over 5.5 million acres or 31% of the most valuable forests identified are at high risk to development.



THE LIVING FILTER

In 1864, George Perkins Marsh wrote in his landmark book *Man and Nature* that, "with the disappearance of the forest, all is changed."[1] Science has confirmed Marsh's observations that the loss of forestland can have far-reaching implications. As forests are lost and become fragmented by other land uses, the function of watersheds likewise changes—in terms of water yield, timing of runoff, soil erosion, and supply of food to streams. Numerous studies have observed declines in water quality and stream health as watershed forest cover dropped below a range of 65 to 75%.[2]

In general, forests in a watershed improve the water quality and health of the aquatic ecosystem and moderate stream flow. Forest cover in a watershed, however, is neither uniformly distributed nor always concentrated in areas that control pollution most effectively.[3] Although the loss of forests in one area may be offset by gains in other parts of the watershed, the result is not necessarily equal in terms of ecological value or impact on the Bay.

EFFECTS OF LAND USE

If we assume that regional trends hold true for the Bay watershed, approximately two-thirds of the water that maintains our streams and replenishes our groundwater comes from forested lands.[4] This is especially significant because forests normally yield water of exceptionally high quality. Compared with other land uses, forests also have more steady water yields throughout the year.[5] In watersheds dominated by agricultural or urban land, remaining forests cushion or dilute the impacts of these other land uses, while supporting ecological functions that maintain productive streams.[6]

Lower quality water increasingly flows through the watershed as forests are converted to other uses.[7] Especially on a rainy day, the results become apparent as water rushes off hard surfaces such as roads and parking lots. Even as we spend millions of dollars annually on best management practices to control polluted runoff, nothing yet devised works like an intact forest.

The capacity of forests to absorb and store runoff can be almost 20 times higher than a parking lot and up to six times higher than a turf lawn.[8] A study of the Gwynns Falls watershed in Baltimore, Maryland, indicated that heavily forested areas reduced total runoff by as much as 26% and increased the low-flow volume of streams by up to 13%.[9]

Forests and Water Storage

The flow of streams throughout the year depends in large part on the storage capacity of the watershed. Impervious surfaces stop precipitation from infiltrating into the soil. Instead, the rainwater washes rapidly into stream channels. This increases both erosion in the stream channel and the level of pollutants that are transported from rooftops, lawns, and streets to streams during rain events. This same process, which floods the stream during

VITAL SIGNS OF A HEALTHY WATERSHED

A healthy watershed can be measured by its ability to:

- Intercept and store rainfall
- Recharge groundwater supplies
- Protect soil loss and erosion
- Sustain and regulate stream flows
- Sequester and recycle nutrients
- Support natural riparian and floodplain functions
- Meet the habitat needs of natural aquatic species

Photo: Mary Hollinger NOAA

The extent and health of forests will ultimately determine how well a watershed can provide these functions. The critical measures of a watershed's forests include:

- The total amount of forestland or percentage of a watershed that is forested
- The extent to which critical landscapes remain forested (riparian corridors and wetlands, steep slopes, erodible soils, and groundwater recharge areas)
- The health and condition of remaining forests, including their degree of fragmentation
- The nature of ownership and land stewardship

rainfall, leaves the stream dry during other times of the year. Rain that would otherwise infiltrate the soil to recharge groundwater has simply washed away, leaving streams without sustenance during drier times.

Because so little overland flow occurs naturally in a forest, almost any conversion to other land uses, especially impervious cover, produces proportionally larger peak flows. Models used to examine the effects of impervious cover have clearly demonstrated the importance of forests. One study looked at a 4% increase in impervious cover on a 100-acre grass watershed. The outcome indicated more than a 50% increase in the magnitude of a two-year flood and a 65% increase in the magnitude of a 100-year flood. Increased flooding was insignificant when the same imperviousness was introduced to a fully forested area. These studies show how well forests can help to moderate the harmful impacts of development. Current research points to both the importance of retaining forests and reducing impervious cover in urbanizing watersheds.[10]

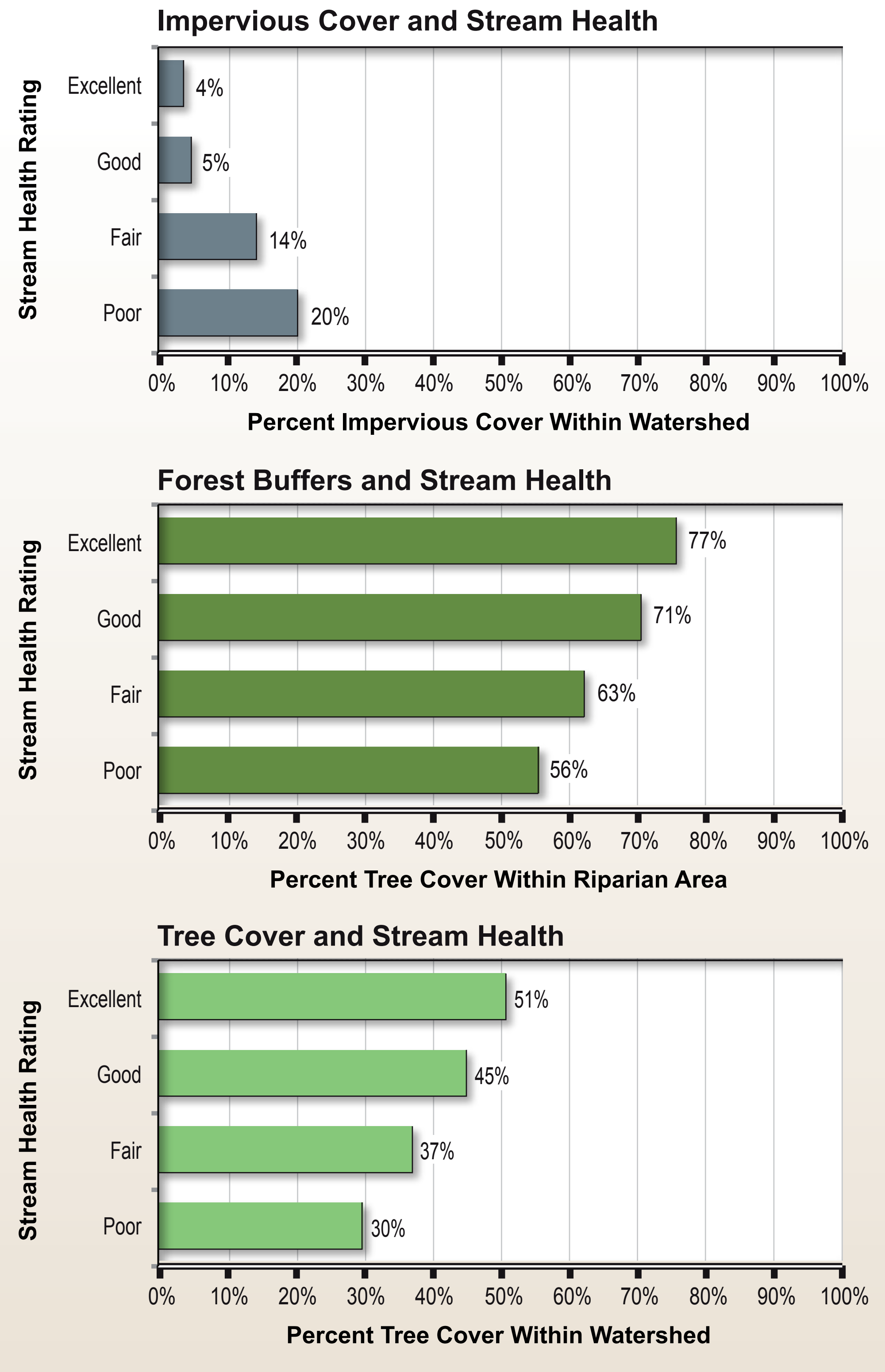
Studies conducted by the Smithsonian Environmental Research Center also tied changes in stream flow and water quality to land use. They found that an increase in agricultural land use and impervious area was a stronger determinant for water quality than the percentage forestland alone.[11,12] There are clearly limits to what forest cover alone can achieve. However, mounting evidence indicates that forest conservation should be a valued component of growth management strategies.

Forests and Stream Health

The conversion of forests to impervious surfaces is particularly damaging to streams and the life within them. In general, negative effects on stream conditions can begin at impervious levels as low as 5% and become dramatic at approximately 25%. This impact is largely due to changes in stream flow, which have pronounced and sometimes devastating effects on stream stability and the aquatic life in the stream.[13]

Small watersheds with high percentages of forest and tree cover are more likely to have "excellent to good" stream health than watersheds with higher percentages of impervious cover.[14] In addition, streams with intact riparian forest corridors seem better able to sustain the health of their biological communities, even when forest is lost to impervious cover. A recent study suggests that streams with an "excellent to good" rating for biological integrity would be most commonly achieved in watersheds with less than 10% impervious cover, at least 60% of streams with forested buffers, and greater than 45% forest cover. While other factors play a role, the nature of land use in a watershed, along with the extent and condition of forested stream corridors, greatly affect stream flow and nitrogen, phosphorus, and sediment loadings to streams.[15]

Land Cover and Stream Health



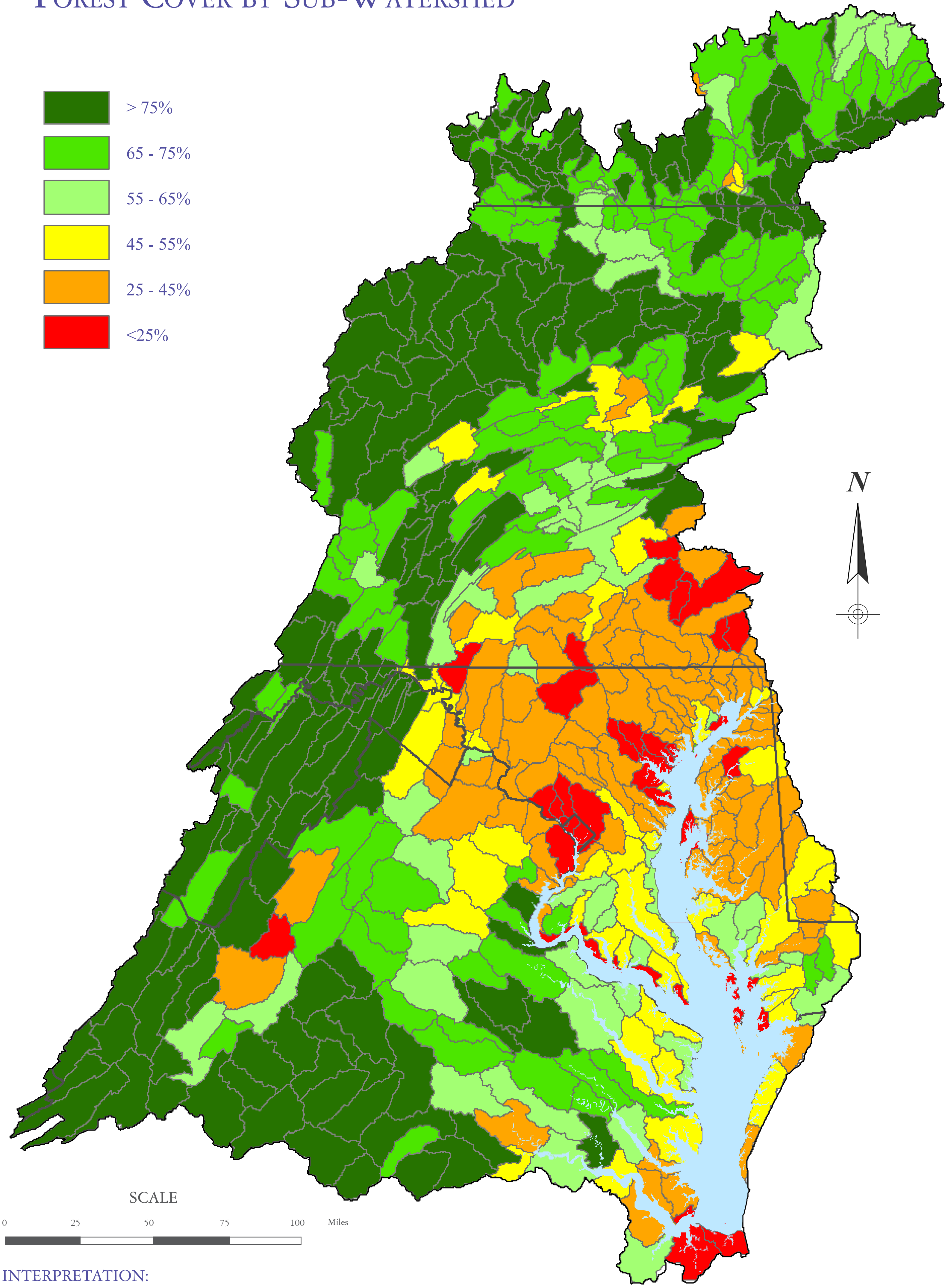
Impervious Cover and Stream Health

Forest Buffers and Stream Health

Tree Cover and Stream Health

Source: Goetz et al. 2003

Forest Cover by Sub-Watershed



INTERPRETATION:
As forests are lost and become more fragmented by other land uses, the function of watersheds is degraded. In general, watershed health begins to decline as forest cover drops below 65-75% of a watershed.

SOURCE: MA RESAC 2000

Urban Tree Canopy

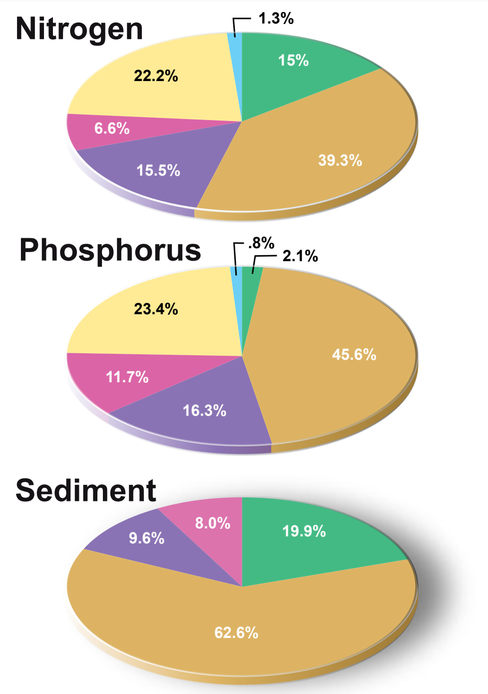
An urban tree canopy is the layer of trees and branches that shade the ground. It is often measured when viewed from above as percent tree canopy cover. A tree canopy that overhangs impervious areas not only cools these surfaces but also captures and holds rainfall, reducing runoff from rainstorms. It is especially effective during small storms, which wash off the majority of pollutants from streets, parking lots, and other developed areas. In already developed areas, the effects of urban tree canopies on storm water runoff and water quality have not been investigated in detail. New hydrologic models, currently under development, should provide significant insight to this area of research.[i]

WATER QUALITY FUNCTIONS

Nutrients and other pollutants travel to streams through both surface and ground water. Forests act as pumps, taking up water and nutrients through their root system, storing them in the biomass of the tree and releasing moisture into the air. In this way, forests are a long-term nutrient storage reserve. Nutrients are circulated in forest ecosystems through a series of physical, chemical, and biological processes. Each year, this nutrient cycle adds about two tons of leaves and organic debris or "litter" to each acre of the forest floor. The resulting organic layer shields the soil and creates an environment that fosters water infiltration and biological activity. Through a process called "denitrification," bacteria in wet forest soils convert nitrate into a nitrogen gas, which is released into the air instead of being introduced to local streams.

Decades of research have established two fundamental principles. The first is that forests retain nutrients and sediment much more effectively than all other land uses in the Chesapeake Bay watershed. The second principle is that the distribution of forests in a watershed, especially their distance from streams and nutrient sources, determines how well forests keep nutrients and sediments out of rivers, streams, and the Bay itself.[18,19,20]

Nitrogen, Phosphorus, and Sediment Loads to the Chesapeake Bay, 2003



		Nitrogen Million lbs.	Phosphorus Million lbs.	Sediment Million Tons
Forest	🟩	41.2	.4	1
Agriculture	🟨	108.2	8.8	3.1
Urban	🟪	42.7	3.2	.5
Mixed Open	🟥	18.2	2.3	.4
Point Source	🟨	61.2	4.5	0
Atmosphere	🟦	3.5	.2	0
Totals		**275.1**	**19.3**	**5.0**

Source: Chesapeake Bay Program 2003

DEVELOPMENT DENSITY AND WATERSHED IMPERVIOUSNESS

Even small amounts of impervious surface can degrade water quality. Because of this, some communities have limited the amount of impervious cover that can be used on a building site. Zoning often limits housing density to one unit per one, two, or even five acres. This approach attempts to minimize hard surfaces and preserve absorbent ones.

However, low building densities can increase imperviousness at the watershed level and lead to worse overall water quality. How does this occur? Low-density development requires more land and infrastructure than would be needed for a similarly sized development in a more compact area.[16] In the Chesapeake Bay watershed, a study compared compact and dispersed developments on similarly sized tracts of land. Compact development consumed one-third as much land as dispersed development and included about half the amount of impervious surfaces. As a result, the compact development pattern had 43% less runoff.[17]

Local governments concerned about the effects of development on water quality and stream health should consider setting goals for forest cover and thresholds for impervious surfaces. With a goal in place, municipalities could achieve a mix of land uses while evaluating the cumulative effects on forest cover and stormwater runoff.[8]

Photo: Howard County, Maryland

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[i] For example, RHESSys model (http://geography.sdsu.edu/Research/Projects/RHESSYS/) or the UFORE-Hydromodel (http://www.fs.fed.us/ne/syracuse/Tools/UFORE.htm)

Non-Point Source Pollutant Loadings to the Chesapeake Bay, 2003

River Basin	% Forest Cover	Nitrogen Load to Bay (percent)	Nitrogen Load From Forests (lbs/acre/year)	Phosphorous Load to Bay (percent)	Phosphorous Load From Forests (lbs/acre/year)	Sediment Load to Bay (percent)	Sediment Load From Forests (lbs/acre/year)
Susquehanna	63.0	49.0%	12.7% (2.4)	21.1%	1.0% (<.1)	21.2%	4.1% (<.1)
Potomac	51.7	19.1%	2.7% (1.5)	23.3%	0.5% (<.1)	34.7%	4.0% (<.1)
James	61.6	10.2%	1.9% (1.5)	27.9%	0.8% (<.1)	23.5%	8.6% (<.1)
Eastern Shore MD	44.1	9.9%	0.7% (1.5)	11.4%	0.2% (<.1)	5.6%	0.5% (<.1)
Rappahannock	52.9	3.4%	0.6% (1.2)	5.9%	0.1% (<.1)	6.6%	1.4% (<.1)
York	63.4	3.0%	0.6% (1.1)	4.0%	0.1% (<.1)	2.5%	0.7% (<.1)
Western Shore MD	38.3	3.2%	0.2% (1.1)	3.7%	<.1% (.1)	2.7%	0.3% (<.1)
Patuxent	43.6	1.5%	0.1% (1.1)	1.4%	<.1% (<.1)	2.7%	0.3% (<.1)
Eastern Shore VA	43.1	0.8%	0.1% (1.0)	1.2%	<.1% (<.1)	0.4%	<.1% (.11)
Totals		100%	19.6% (12.4)	100%	2.7% (.30)	100%	19.9% (.43)

Source: Chesapeake Bay Program 2005

Even though forests account for 58% of the land area in the Bay watershed, they contribute only about 15% of the total load of nitrogen and 2% of the phosphorus load to the Bay.[21] Likewise, river basins with the highest percentage of forest cover have the lowest annual sediment yields in the Bay region.[22]

Forestland in the Susquehanna River basin is particularly valuable for the bay. Nearly half of all nitrogen pollution from non-point sources (excludes atmospheric deposition and point sources like sewage treatment plants) originates from this portion of the Bay watershed. As other land uses replace forestland, the amount of nitrogen entering the Bay will likely increase with great effect on water quality.

NITROGEN: A PRINCIPAL PROBLEM FOR THE BAY

While excess phosphorus is a more serious issue in fresh water streams and lakes, nitrogen has the greatest effect on estuarine systems, like the Bay, that are naturally nitrogen limited. Nitrogen is the most abundant nutrient on earth and is essential to the growth of all living things. It is in the air we breathe and the rocks and soils under our feet. However, it is also at the heart of problems with the Bay's health. Under natural conditions, most nitrogen is tied up as organic nitrogen, mineral soil, or in the air as a gas. But, fertilizers, air pollution, animal waste, sewage treatment, and other land use activities can introduce more inorganic and dissolved forms of nitrogen, including nitrate and ammonium, that are far more water soluble and easily enter local waterways. The release of nitrogen from forests to streams depends on a number of factors including amount of nitrogen deposited through the air, climate change, forest loss, and forest type:

Air Deposition

A quarter of the nitrogen entering the Bay is directly deposited from the air. Nitrogen oxide, formed by fuel combustion, reacts with other substances in the air and falls to earth as rain, fog, snow, or dry particles.[23] When nitrogen oxides and other pollutants interact with water, they form "acid rain" which carries nitrogen back to the surface.

Chesapeake forests generally retain 88% of the nitrogen they receive, making them an efficient buffer for air deposition. In watersheds where forests grow rapidly, biological demand for nitrogen is often sufficient to retain virtually all atmospherically deposited and mineralized nitrogen during the growing season.

However, prolonged exposure to acid rain can make forest soils acidic. This in turn can kill trees, stunt their growth and productivity, and thereby increase pollutant loads to streams. Highly acidic soils can also release aluminum into nearby streams, which can be toxic to plant or animal life. Over the past 20 years, the Bay watershed has received some of the highest amounts of acid rain in the continental United States. Between 1994 and 2001, the average amount of acidic nitrogen deposited on Chesapeake forests fell well within the range that is detrimental to forest ecosystem health.[19,24] Larger amounts of nitrogen deposition occur in higher elevations and the western highlands of the Bay watershed. High nitrogen rates continue to affect Chesapeake forests, particularly because the largest source of nitrogen oxides—automobiles—is expected to increase. Pollutants originating from industries outside of the Bay watershed exacerbate the problem. In fact, roughly half the air pollution deposited in the Bay originates outside of the watershed.[25]

Chesapeake Bay Program Water Quality Goals

	Current Nutrient Loads	Chesapeake 2000 Goals	If All Watershed Land Use Was Forest
Nitrogen (million pounds per year)	275	175	60.6
Phosphorus (million pounds per year)	19	13	1.1
Sediment (million tons per year)	5	4	1.5

Source: Chesapeake Bay Program 2005

After decades of nitrogen depositon, the soils of many Chesapeake forests store an overabundance of nitrogen. These saturated soils tend to leach nitrogen into waterways. While none of the forested watersheds in the Chesapeake region appear to be at an advanced stage of nitrogen saturation, increasing evidence shows that too much acid rain may be acidifying soils and reducing the degree to which forests will be able to retain nitrogen in the future.[26]

If nitrogen deposition rates stay at current levels, the ability of Chesapeake forests to retain nitrogen could decrease from its current high rate of 88% to only 47%. This change would represent a four-fold increase in nitrogen exported to streams from forests.

WATER QUALITY GOALS OF THE CHESAPEAKE BAY PROGRAM

The Chesapeake Bay Program has set a goal to reduce current nitrogen and phosphorous loadings to 175 and 12.8 millions of pounds per year respectively by 2010. In addition, sediment loadings are to be lowered to 4.2 million tons. Can the conservation and restoration of forests affect the success of Bay restoration efforts?

If forestland extended across most of the Bay watershed as it did at the time of European settlement, the Chesapeake Bay Program's goals would be surpassed by a wide margin. Of course, restoring this much forestland in the Bay watershed is unrealistic if we are to maintain our economy and communities. However, looking at this baseline provides a view of the water quality changes brought about by human settlement and our use of the watershed. According to the Chesapeake Bay Program watershed model, a forested watershed would produce 1,700% less phosphorus, 450% less nitrogen, and 300% less sediment than current loadings.[21]

If nitrogen deposition from the air is allowed to continue to rise uncontrolled, the retention rate of forests could drop to 23% and the amount of nitrogen in streams would be 13 times higher.

This scenario is particularly troubling for the Bay. When multiplied by the large acreage of forestland in the Bay watershed, even small losses in a forest's ability to retain nitrogen could pose serious challenges to meeting and maintaining nutrient reduction goals—making the connection between air pollution and water quality very real. This is especially true in the high elevation streams of Pennsylvania and New York.[27]

Climate Change

Climate change creates uncertainty for Chesapeake forests. Over the next 30 years, forests may experience decreased growth rates, higher average annual temperatures, less rainfall during the growing season, shifts in species composition, and more disturbances such as hurricanes, fire, or insects. All of these changes may affect nitrogen yields, but the precise changes are unknown.[3]

Forest Loss and Disturbance

Forest conservation, restoration, and management all have great potential to influence the future health of the Bay. Relatively small changes in forest cover, plus or minus 10% can increase or decrease nitrogen loss from forests by 40%.[28] Retaining existing forests, expanding forests in critical areas, and managing forests to improve their growth and nitrogen retention should be an essential part of nutrient reduction strategies for the Bay.

Forests are naturally resilient in the face of disturbances. High winds, fires, hurricanes, and other natural events have shaped the distribution and composition of Chesapeake forests for millennia. Over the past few hundred years, humans have drastically changed the degree and frequency of disturbances. However, not all disturbances are equal in their impacts on forests. After a timber harvest, small to large forests can return to their original function in terms of nutrient retention and sediment production within three to five years, while a forest cleared for farming or construction may not recover for centuries, if it recovers at all.

Forest Type

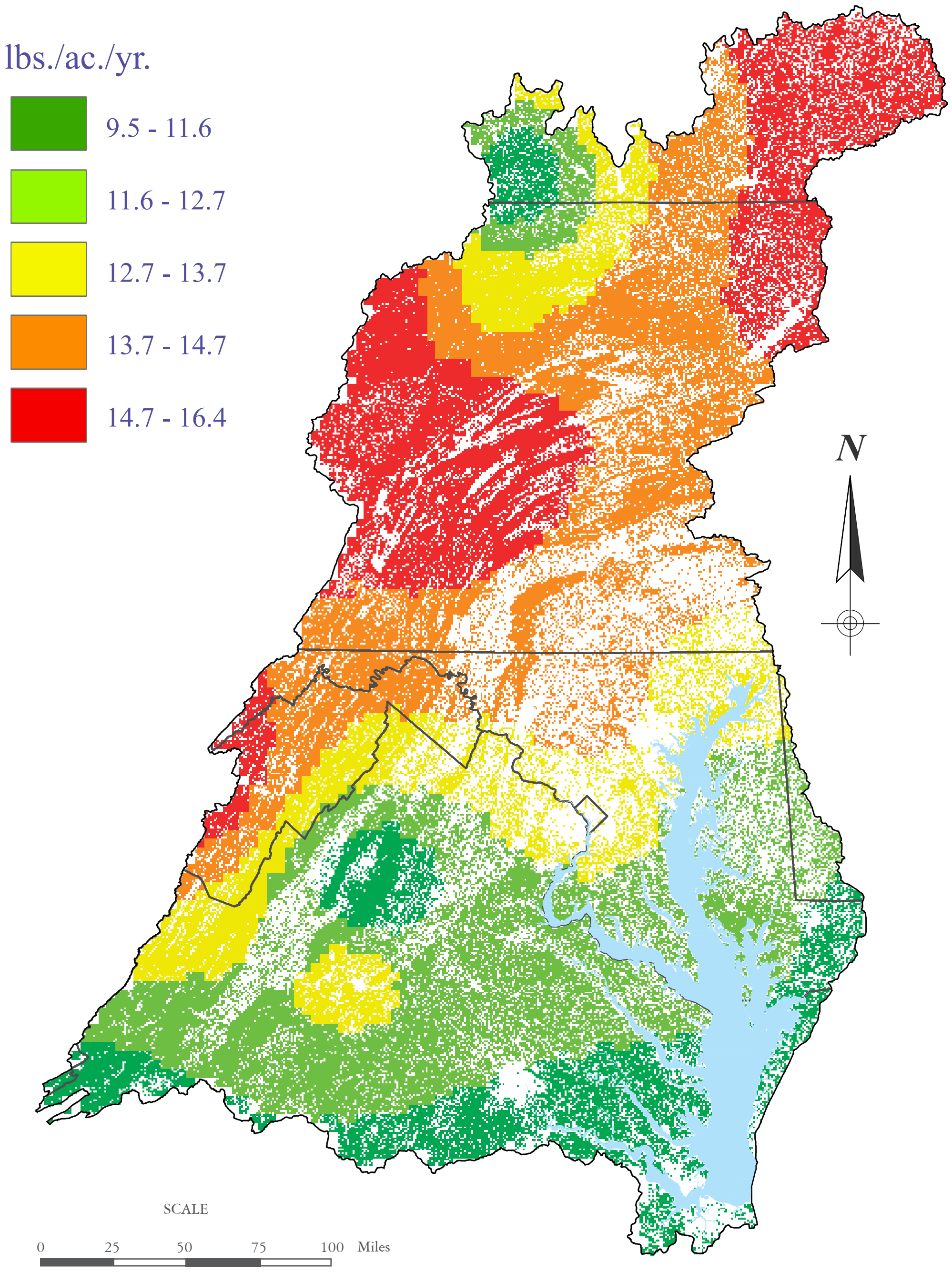
The natural character of Chesapeake forests favors nitrogen retention. An oak/hickory forest, the most abundant forest type in the watershed, retains an average of 90% of atmospheric deposition, while the smallest forest type, spruce/fir, retains 78%.[27] Coniferous forests in general use less nitrogen than deciduous forests; this is determined more by the soils where conifers grow than the nature of the tree itself. There are important exceptions, such as Eastern hemlock forests, which are highly efficient at retaining nitrogen because of their distinct microclimates.[29] Hemlock in the Chesapeake region is experiencing a dramatic decline due to the exotic hemlock wooly adelgid. Hardwood forests are also periodically affected by insect outbreaks, such as the gypsy moth, which can generate pulses of nitrogen output.

Nutrient Export Rates From Mid-Atlantic Forests

Watershed	Air Deposition (lbs./ac./yr.)	Retention (%)	Mean Stream Export (lbs./ac./yr.)
Rhode River, MD[1]	10.53	85	1.58
Baldwin Creek, PA[1]	13.83	87	1.95
Delaware Bay[2]	11.29	86	1.63
Delaware Bay[3]	11.29	77	2.64
Chesapeake Bay[3]	11.52	82	2.03
Chesapeake Bay[4]	11.52	89	1.24
Chesapeake Bay[5]	8.95	88	1.10

1: Gardner et al. 1994 2: Stacey et al. 2000 3: Alexander et al 2000 (SPARROW model)
4: Chesapeake Bay Program 2003 (Watershed model) 5: Pan et al 2004 (PnET-CN)

Air Depositon of Nitrogen



INTERPRETATION:
Long-term air deposition of nitrogen in the range of 4 to 18 lbs./ac. is known to be detrimental to forest ecosystem health in the Bay watershed. The entire watershed averaged over 9.5 lbs./ac./yr. from 1994 - 2001 with the highest rates present in the northern and western portions of the Bay watershed.

SOURCE: Coulston et al. 2003

RIPARIAN FORESTS: THE LINK BETWEEN LAND AND WATER

Four centuries ago, when Europeans arrived on the shores of the Chesapeake Bay and explored its watershed, nearly every stream flowed beneath a canopy of trees. The shorelines were rimmed with forests and fallen woody debris.

Humans have been influencing the quality of the forested riparian zones in the Chesapeake Bay watershed for thousands of years. Most Native American settlements were near riparian areas because of the relatively flat land, fishing opportunities, and transportation routes. The drastic decline in forest area over the past 400 years has been mirrored by similar losses of riparian forests. Too many people do not realize the importance of these streamside forests. As they disappear, the quality and productivity of streams, rivers, and the Bay itself have declined, and wildlife habitats have been eliminated.

Riparian forests also serve as the "last line of defense" for streams. While there are other forms of vegetative buffers, forested riparian buffers provide long-term nutrient storage better than either grasses or shrubs. The most common and natural riparian area has a combination of trees, shrubs, and herbaceous vegetation.

Over 200,000 miles of interconnected streams, rivers, and their associated riparian areas serve as the "circulatory system" for the Bay. Although riparian forests comprise only about 5% of the total land area, they are disproportionately important to the healthy function of watersheds. Because of their position in the landscape, riparian forests interact with the flow of surface and groundwater from upland areas and play an important role in filtering runoff, reducing nutrient pollution, and moderating stream temperature.

Conserved and managed as buffers, riparian vegetation can reduce the effects of upslope land-use activities. If they are forested, these buffers can also provide a wealth of ecological benefits for fish and wildlife, both onsite and downstream. The protection and restoration of riparian forests is an essential cornerstone to long-term restoration efforts in the Bay watershed.

Photo: Heather Richards

FUNCTIONS AND BENEFITS

Moderating Water Temperature

Leafy tree canopies produce shaded streams that maintain cooler, temperatures, especially in small streams. Cooler water reduces stress on fish and other creatures and holds more oxygen, encouraging the growth of diatoms, beneficial algae, and aquatic insects. In addition to more moderate temperatures in warm summer months, stream shading reduces daily temperature fluctuations. Continuity of these shaded streams is also important as a few degrees can have a major effect on water quality and the survival of aquatic organisms. Elevated stream temperatures can also serve to accentuate negative effects of pollutants in the stream.

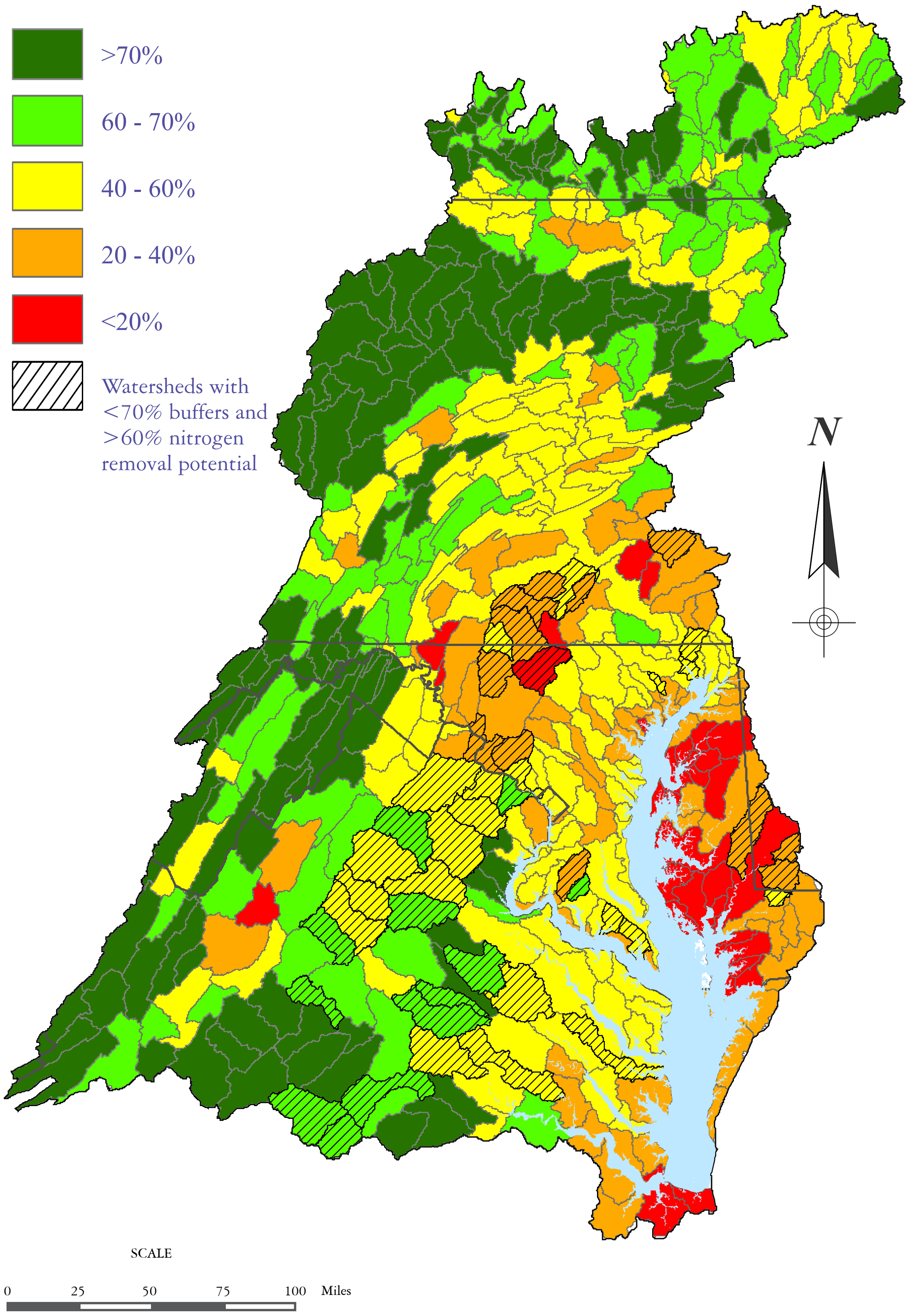
Protecting Stream Banks and Stabilizing Floodplains

Healthy riparian forests help stabilize stream banks and reduce erosion. The network of roots holds soil in place, while both branches and roots help protect banks by reducing stream flow velocity during floods. Floodplain forests can also lessen the effects of flooding downstream by retaining and temporarily storing flood waters.

RIPARIAN FORESTS

Because of their position in the landscape, riparian forests can serve as buffers between land uses in upland areas and waters that eventually enter the Bay. A riparian forest buffer is defined as: an area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water and is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, and to supply food, cover, and thermal protection to fish and other wildlife.

Riparian Forest Cover by Sub-watershed



INTERPRETATION: Although riparian forests comprise only 5% of the land area in the Bay watershed, they are disproportionately important to the health of the watershed. For maximum benefits, riparian forests should cover over 70% of a watershed. Riparian forests are not always concentrated in areas that are most effective for reducing water pollution. Those watersheds that have less than 70% riparian forests and are capable of reducing greater than 60% of nitrogen flowing through them represent areas with high restoration value.

SOURCE: Chesapeake Bay Program 2005

Chesapeake Bay Forest Buffer Goals

Since 1996, the Chesapeake Bay Program and its partners have been actively pursuing the restoration and protection of riparian forest buffers in the Bay watershed. Working across state boundaries, this effort has set aggressive restoration goals, developed innovative programs and landowner incentives, conducted training and outreach, and built local community partnerships.

In December 2003, the Chesapeake Bay Executive Council expanded and strengthened the riparian forest buffer goals and defined a long-term vision for forest buffers in the Bay watershed. The new goals were expanded beyond the original directive to include the following:

- Restore at least 10,000 miles of riparian forest buffers by 2010
- Ensure that at least 70% of stream banks and shorelines in the Bay watershed are buffered
- Advance efforts to conserve existing forest buffers
- Work with a minimum of five jurisdictions per state to promote urban forests and increase tree canopy

To reach the long-term goal of 70% coverage in the Bay watershed, over 30,000 miles of new riparian forest buffers must be restored. The Conservation Reserve Enhancement Program (CREP), a federal-state program that provides financial incentives for restoring forest buffers on agricultural lands, has supported much of the current progress. In the future, more innovative and incentive-driven practices will be needed to accomplish the riparian forest buffer goals for the Bay watershed. The maintenance and conservation of current forested buffers is also an integral part of the initiative and will continue to be a focus of those leading the efforts.

Photo: David Winston

Filtering Pollution

The potential of riparian buffers to remove nutrients and sediment has been documented since the late 1970s.[20] While all forests filter sediment and runoff, riparian forests are particularly effective at capturing and transforming nitrogen and other pollutants into less harmful forms, mostly due to the high level of chemical and biological activity in the organic, carbon-rich soil.

Not only do forest buffers prevent non-point source pollutants from entering small streams, they also enhance the in-stream processing of both non-point and point source pollutants, thereby reducing their impact on downstream rivers and estuaries. Fallen woody debris and tree roots slow stream flow, which significantly increases the possibility of pollutant removal. In fact, deforested streams are able to process only one-tenth to half the amount of nitrogen as forested streams. The effectiveness of buffers in reducing in-stream pollutants depends on the width of the buffer, the soils and vegetation, and the contributions of pollutants from upland land use activities.

Buffers also help to prevent common pesticides, such as atrazine, as well as insecticides from reaching streams. Once in the water, degradation of these chemicals has been found to be higher in forested rather than non-forested streams. Although sunlight plays a significant role in pesticide degradation, the increased area of stream bottom, riffles, and woody debris in forested reaches seem able to compensate for lower sunlight.[30]

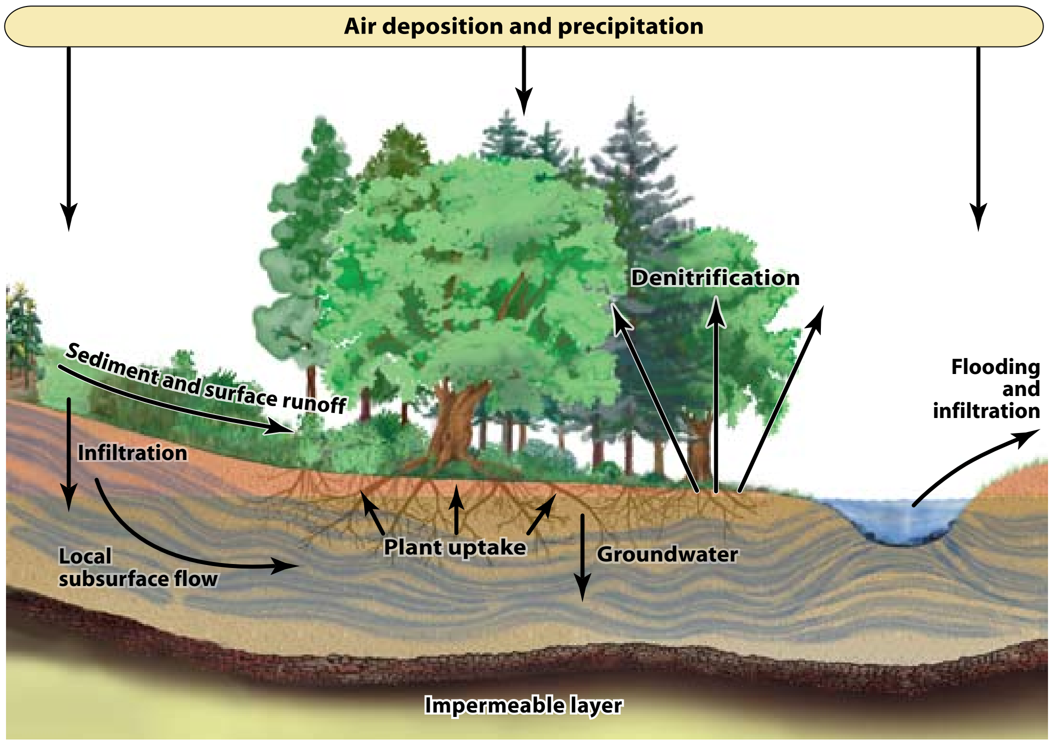
The effectiveness of buffers in some areas can be restricted by watershed and site conditions as well as past land use. For example, urban stream channels often erode as runoff increases, short circuiting the functional interaction between streams and riparian vegetation. Other means of concentrating flow, from stormwater pipes in urban areas to drain tiles on farms, prevent riparian areas from effectively filtering water before it reaches the stream.

Recent attention has also been drawn to legacy sediments in some portions of the watershed where sediment was deposited in the floodplain from soil erosion on farm fields or stored behind historic mill dams. Some of this sediment has been present for hundreds of years. In Lancaster, Pennsylvania alone, for example, there were over 450 mills built between 1700 and 1900—equaling roughly one mill dam for every two miles of stream.[31] Forests that reclaimed these legacy sediments sometimes grew on artificially high banks, 3 to 20 feet above the original floodplain. The roots of these perched forests can be separated from the primary source of nitrogen and have more trouble preventing it from reaching streams.[32]

Sustaining Aquatic Habitats

Mats of fallen leaves form the food base for aquatic insects and beneficial bacteria. Furthermore, as water passes through the forest on its way to a stream, it picks up an enormous variety of useful organic molecules. When that water enters a stream, a special blend of dissolved organic matter is dispersed like tea from a tea bag. Without riparian forests, the aquatic food web is dysfunctional.

Nutrient Flows Through a Riparian Buffer



Status and Trends of Riparian Forest Buffers

Currently, riparian forests buffer nearly 60% of streams in the Bay watershed. West Virginia has the greatest percentage of buffered streams in the watershed, at close to 70%. Most Bay states have approximately 50% of their stream miles bordered by riparian forests of 100 feet in width.[33] However, at smaller scales, developed watersheds are known to have as little as 15% riparian cover along streams.[34]

The overall loss of forested riparian buffers in the Bay watershed has been substantial over the past few hundred years. Forest corridors that were once thousands of feet wide have often been reduced to narrow strips of trees. Forested wetlands or bottomland hardwood forests have been particularly affected by land cover change.

The status and trends of buffers is often controlled by the implementation of riparian buffer ordinances by local jurisdictions. Ordinances are designed to protect streamside forests during the development process and likely have had an influence on retaining riparian forests in urbanizing areas. Individual local governments create and adopt these development regulations. In Virginia, many local buffer ordinances were developed in response to implementation of the Chesapeake Bay Act. In Maryland, an evaluation of the Maryland Critical Area Program found a low rate of loss of resource lands and, therefore, suggested that the Critical Area Criteria are making a difference.[35] The Forest Conservation Act in Maryland is also a landmark development law that requires conservation of forests and mitigation of forest loss within a hierarchy that recommends that riparian forests be the highest priority for protection.

Even where local buffer ordinances exist, development continues to "chip away" at remaining forests along vulnerable streams. Buffers continue to be developed into

RIPARIAN BUFFER RESEARCH

In 1993, Bern Sweeney of the Stroud Water Research Center suggested "one of the biggest factors contributing to the decline in water and habitat quality in aquatic ecosystems of eastern North America was the removal of forest ecosystems adjacent to the streams and rivers comprising the Atlantic drainage." He and his colleagues have demonstrated this fact and more. Research at Stroud has shown that reforesting riparian areas not only helps keep pollutants out of streams, but also significantly increases a stream's ability to process pollutants already in its waters.[30] Dr. Sweeney offers the following insights on riparian forest buffers and their restoration:

- A combination of native tree species is best. They adapt better to regional conditions, and do a better job of supporting the growth and survival of stream invertebrates, which are the primary food for fish. The leaves from non-native plants are even toxic to some stream organisms.

- Forested streams have a greater abundance and diversity of macroinvertebrates because they provide more benthic habitat area and food supply.

- Forested streams have 200 to 500% more organic matter per unit of channel length than deforested streams. The value of this organic matter is often underestimated or overlooked. A natural stream flowing through a mature forest in the Chesapeake Bay watershed needs an average of approximately 0.75 pounds of leaves for every square yard of stream bottom and at least 8 to10 species of trees to support natural levels of stream life.

- Forested streams tend to be wider and shallower than grassed streams. Increased channel width plays a critical role in nutrient processing by providing significantly greater surface area for biological activity. The stream bottom in a forested area can process 10 to 40 times more in-stream nutrients than a grass-bordered stream. Restoring forests can reduce the transport of nitrogen downstream to large rivers and estuaries.

- Proactive reforestation is usually necessary because foreign invasive plants hinder natural reforestation; intense grazing by deer, rabbits, and voles; and the lack of mature forests nearby to provide a seed source. Without proactive reforestation, aggressive non-native plants can dominate streamsides for more than 40 years following their abandonment from farming.


Photo: Heather Richards

Riparian Buffer on Previously Disturbed Land

recreation sites, storm water retention ponds, lawns, and other land uses.[36]

DRINKING WATER SUPPLIES

In much of the Bay watershed, there is a direct connection between the forest and the faucet. Forests protect watersheds and drinking water better than any other land cover. They safeguard more than 3,000 surface water sources across the northeastern United States, providing water supply for more than 70 million Americans. While protecting water quality, these lands are often managed for timber, wildlife, recreation, and other purposes that help conserve them as open space.

Approximately 75% of people in the Bay watershed rely on surface water supplies for their clean drinking water. However, the public and policymakers alike often overlook the fact that safe, clean, and cheap water begins with the management and conservation of forested watersheds. Although non-point source pollution from agriculture remains the largest threat to water supplies, pollution related to development is the fastest growing threat.[37] Sprawling development, particularly when it replaces forests and wetlands, greatly increases the impact of pollution by removing natural barriers that filter pollutants and retain water. While droughts were historically the domain of the Western United States water shortages have begun to take center stage in the humid East. In 1998, when the Washington, D.C. area faced an unusually dry summer, local water authorities withdrew nearly 70% of the Potomac River's flow to supply water to area residents.

Many local water supplies that were established in the country, far outside of town centers, are now being rapidly encroached upon by development. Of the watersheds supplying drinking water to Bay communities, 60% are losing forestland. A recent survey of water suppliers conducted by the Trust for Public Lands and the American Water Works Association showed that treatment costs for drinking water go up when the amount of forest goes down.

With the exception of a few rivers, most sources of drinking water in the watershed have already been tapped. There are few, if any, ecologically or economically viable ways to augment most water supplies aside from water conservation, reuse, and greater depletion of groundwater. While water is a renewable natural resource, this geographic limitation should remind us that, for all practical purposes, water supplies are finite and irreplaceable. As a result, source water protection programs are showing renewed focus on forest conservation, ecosystem restoration, and stormwater management in water supply watersheds.[38]

CRITICAL FORESTS FOR WATER QUALITY

While all forestland enhances watershed health and water quality, some forests are particularly effective at delivering these benefits. The loss of high priority forests could severely compromise or degrade water quality and watershed functions.[2]

The Chesapeake Bay Program conducted a Resource Lands Assessment to identify these high-value forests in the Bay watershed. The water quality protection model ranked forests by their ability to store precipitation, retain and assimilate nutrients, moderate runoff, protect soils, and maintain important critical landscape functions such as those of riparian areas. Forests that scored high among these physical and biological factors were presumed to best protect water quality.

The following characteristics of soil and vegetation at a particular site as well as the characteristics of the watersheds within which they occur were used as parameters:

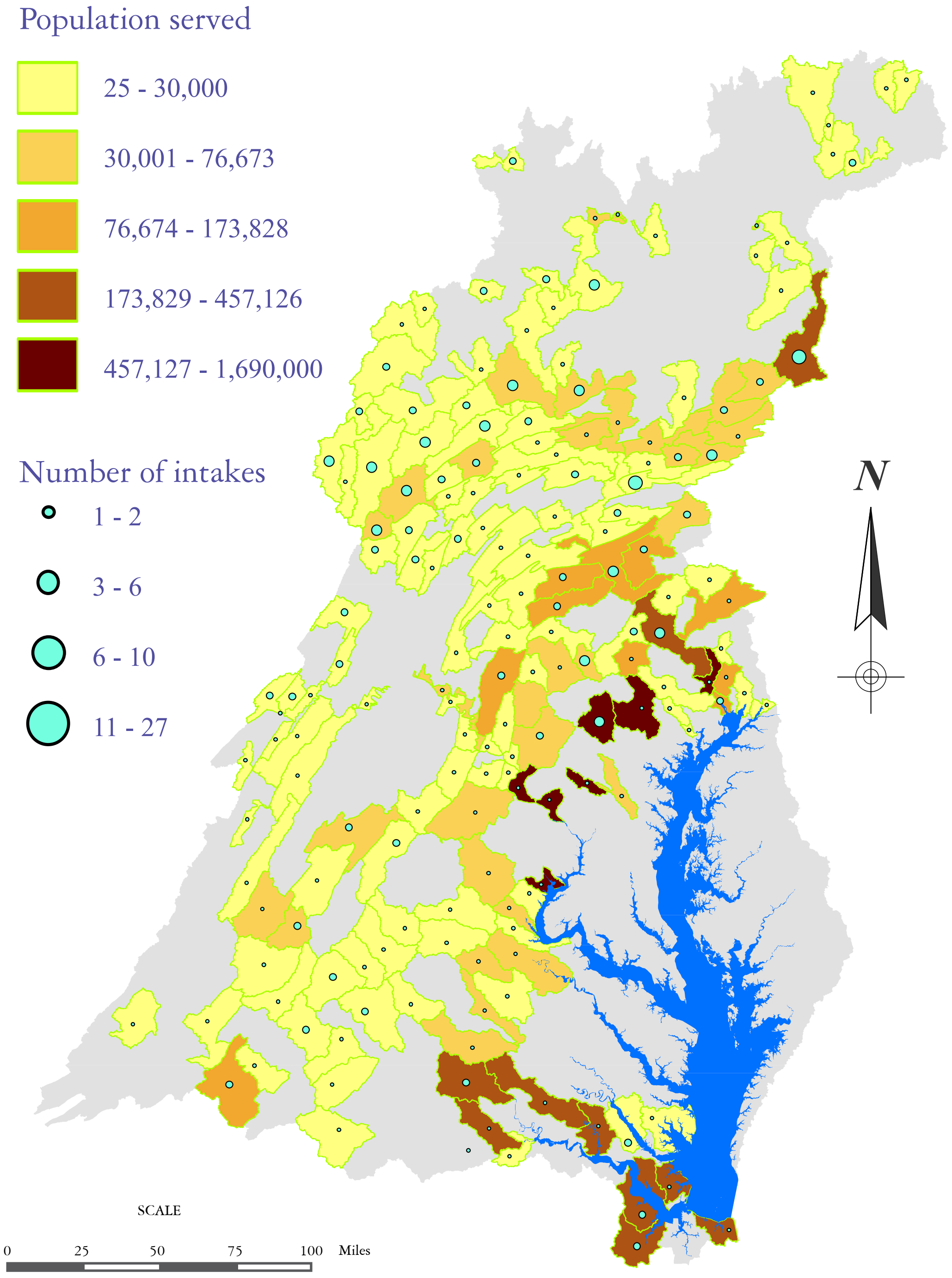
Site
- Proximity to water
- Erodible soils
- Forest productivity
- Slope
- Wetland function
- Fragmentation/patch size

Watershed
- Percent of watershed forested
- Stream density of watershed
- Percent watershed imperviousness
- Current water quality
- Drinking water supply
- Floodplains
- Hydrogeomorphic region

Based on this analysis, regional conservation and restoration efforts to protect water quality should be enhanced in southern and southeastern Virginia, the Appalachian Plateau of western Pennsylvania, the Appalachian ridges, and scattered portions of the Piedmont and Coastal Plain. To determine the value of forests on a smaller scale, communities are encouraged to use the model to rank their local forests.

Based on current development patterns, 31% of the forests that are most valuable for water quality protection are threatened. For more information, see Chapter 7.

DRINKING WATER SUPPLIES

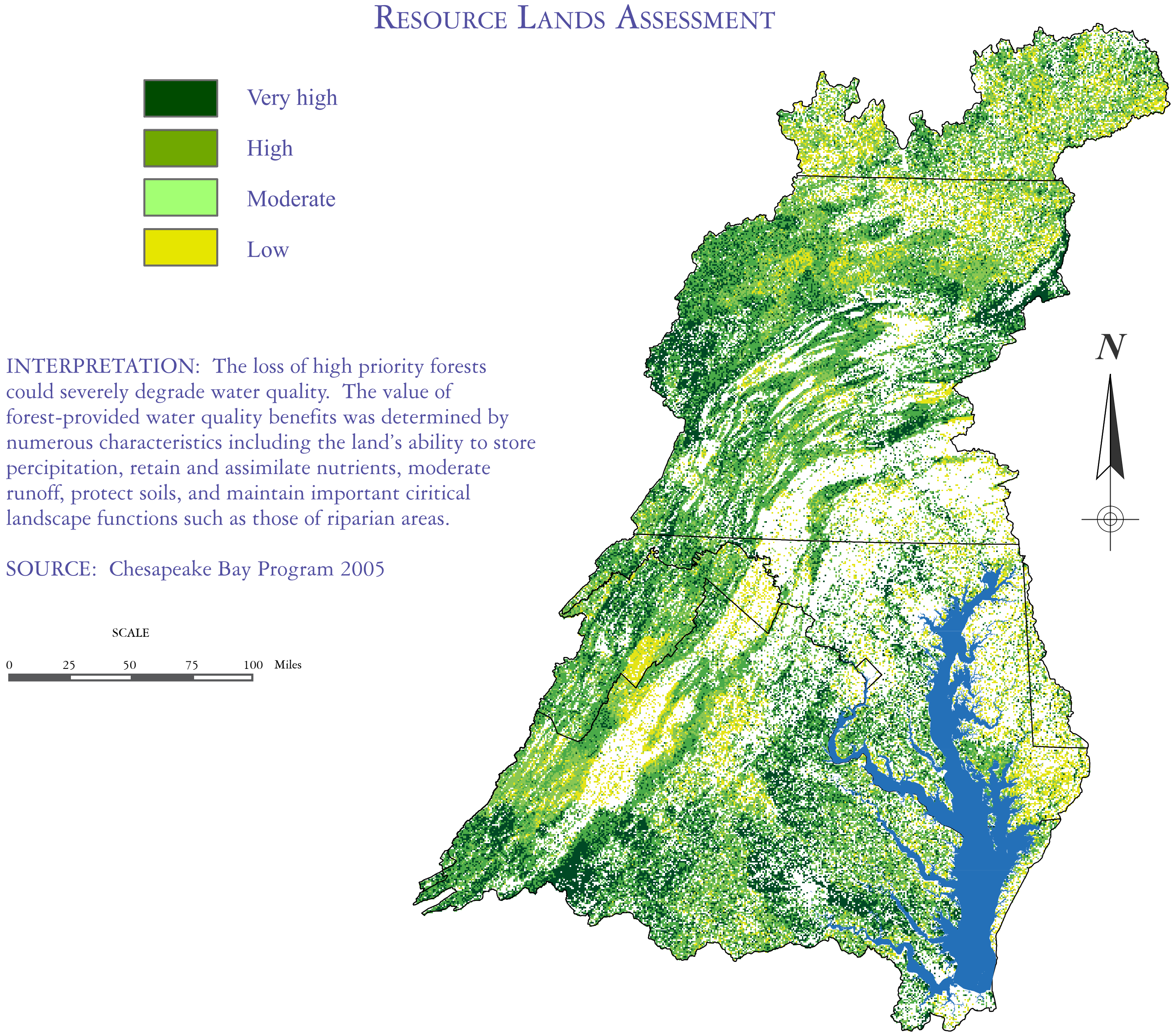


INTERPRETATION: Approximately 75% of people rely on surface water supplies for clean drinking water. Of the watersheds supplying drinking water, 60% are losing forestland. Becaues of this, drinking water quality will likely be degraded and treamtment costs will rise.

SOURCE: Chesapeake Bay Program 2005

FORESTLAND IMPORTANT TO WATER QUALITY

RESOURCE LANDS ASSESSMENT



INTERPRETATION: The loss of high priority forests could severely degrade water quality. The value of forest-provided water quality benefits was determined by numerous characteristics including the land's ability to store percipitation, retain and assimilate nutrients, moderate runoff, protect soils, and maintain important ciritical landscape functions such as those of riparian areas.

SOURCE: Chesapeake Bay Program 2005

INDICATORS FOR SUSTAINABLE CHESAPEAKE FORESTS

The following indicators can be used to track the ability of forests to maintain watershed function:

- Area and percent of impervious surface by watershed
- Percent of stream and shoreline miles that are buffered by at least 100 feet of forestland by watershed
- Area and percent of forestland by watershed

CHAPTER IN PERSPECTIVE

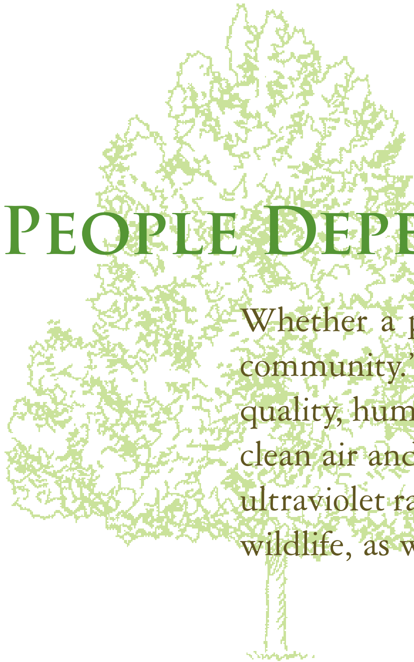
Forests and watershed health are closely linked. As forests are lost, less water is stored in our watersheds, less groundwater recharge takes place, and more nutrients are likely to make it to rivers, streams, and the Chesapeake Bay. Yet, most people still take for granted the important benefits provided by forests in discussions about non-point pollution control or stream health. Acre for acre, forests are the most beneficial land use for water quality and every loss of forestland contributes to increased nutrient loading to the Bay. However, forests and their stewardship are not only integral to improving the health of the Bay. They are also critical to the daily lives of every Bay watershed resident. The ability of forests and trees to protect public health and contribute to the overall quality of life in the Bay watershed is discussed in the next chapter, Forests for People.

Chapter 5:

Forests for People

Key Findings

- Over the past century, the amount of forestland per person dropped 40% decreasing the ability of forests to provide the economic, social, and environmental benefits that residents depend on.
- Forests provide many benefits that enhance the physical and mental health of people.
- While urban forests represent only 5% of all forestland, they directly improve air quality, enhance community livability, and provide recreational opportunities for more than 80% of watershed residents.
- Tree cover affects community stability and desirability. Studies show that when neighborhood tree cover drops below 15%, more than half of all residents consider moving.



PEOPLE DEPEND ON FORESTS

Whether a person lives in a rural, suburban, or urban area, they are part of a "forest community." Forests provide vital benefits for all people by affecting environmental quality, human health, and quality of life. Services that people receive from trees include clean air and water, reduced energy use in buildings, carbon storage, protection against ultraviolet radiation, and cooler air temperatures. Trees provide opportunities for viewing wildlife, as well as aesthetics.

Reductions in ecosystem health translate directly to declines in public health and quality of life. This is an important consideration for the expanding population of the Bay watershed, where 100 acres of forest are lost each day. The area of forest per person or "forest population density" has dropped steadily since the early 1900s. In Maryland, Pennsylvania, and Virginia, the forest population density fell 40% between 1907 and 2002. As a result, residents have a relatively smaller area of forest to use for drinking water, wood, air pollution control, and many other daily needs than what was available to people in the early 1900s. In Maryland, the amount of forest per person declined by 70% despite an increase in forest area because of a large gain in the population (>300%).[1,2]

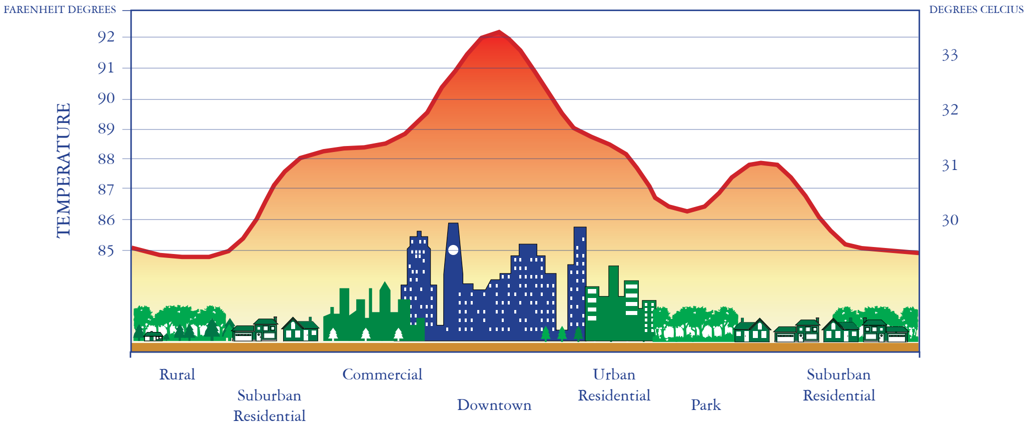
AIR QUALITY BENEFITS

There is a direct relationship between forest area and air quality in the Bay watershed. Forests and tree canopies improve local and regional air quality by altering atmospheric conditions by reducing air temperatures and other microclimatic effects, removing air pollutants, and conserving energy.[4] Atmospheric pollutants like ozone, particulate matter, nitrogen dioxide, and sulfur dioxide can induce asthma and a variety of other respiratory problems. Fine particles of dust, smoke, and ash are thought to cause lung cancer.[5] Improving air quality can substantially improve public health. For example, for each decrease of particulate matter of one microgram per cubic meter of air, death rates from cardiovascular disease, respiratory illness, and lung cancer decrease by 3%; extending the lives of 75,000 people in the United States each year.[6]

URBAN FORESTS: THE FORESTS WHERE WE LIVE

Urban forests are especially important to the health and quality of life of Bay watershed residents as more than 80% of people live in urban areas. Urban forests are a combination of parkland, street trees, residential trees, and other vegetation found in towns and cities. While different in composition and structure from their rural counterparts, urban forests provide substantial benefits to communities, including recreational opportunities, temperature reduction, and air pollutant removal. The average urban area in the Bay watershed has 35% of its area covered by forests equaling approximately 1.2 million acres of urban forests in the Bay watershed.[3]

Photo: Eric Sprague



Urban Heat Island Profile

Temperature Reduction

Many unhealthy pollutants and ozone-forming chemicals develop in high concentrations during summer days in the Chesapeake region as exhaust from increased automobile traffic is subjected to hot temperatures. Trees are able to counter-act the decline in air quality by cooling the surrounding environment with shade and releasing water to the atmosphere through transpiration. As trees and other natural vegetation are replaced with pavement and buildings, "heat islands" are created that can produce air temperatures 2 to 10 degrees Fahrenheit warmer than nearby rural areas. These elevated temperatures affect communities by increasing peak energy demand, air conditioning costs, air pollution levels, and heat-related illness.[7]

Removal of Air Pollutants

The 1.2 million acres of urban forest in the Chesapeake region removes approximately 42,700 metric tons of pollutants annually. Sulfur dioxide and nitrogen oxide, two major components of acid rain, are among the pollutants removed by the Bay watershed's urban forests.

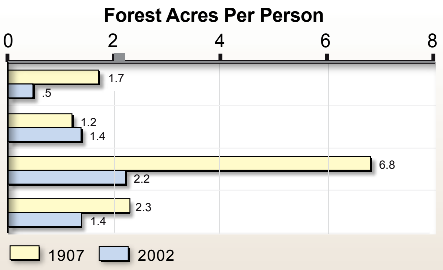
Pollution removal rates differ among cities based on a variety of factors, such as the amount and type of air pollution, length of the leaf season, and precipitation. Urban tree canopies in Baltimore, Maryland, and Washington, D.C., absorbed and intercepted more than 500 and nearly 400 metric tons of air pollution respectively in 2000. The urban tree canopy in Washington, D.C., covers less than a third of the city, yet removes an amount of particulate matter (10 microns) each year equal to more than 300,000 automobiles, or 60% of all cars in the city. Areas in cities that have a complete tree canopy, like Rock Creek Park in Washington, D.C., have shown short-term air quality improvements as high as 14% for sulfur dioxide, 13% for ozone, 9% for particulate matter, and 6% for nitrogen dioxide.[3]

Energy Effects on Buildings

Trees save heating and cooling costs. Properly placed trees shade buildings in the summer and block winter winds. When buildings use less energy, pollutant emissions from power plants also are reduced. Shaded houses can have 20 to 25% lower annual energy costs than the same house without trees.[8] In Washington, D.C., the urban tree canopy saves city residents approximately $2.6 million dollars per year.[9] Establishing 100 million mature trees around residences in the United States could save about $2 billion annually in reduced energy costs.[10]

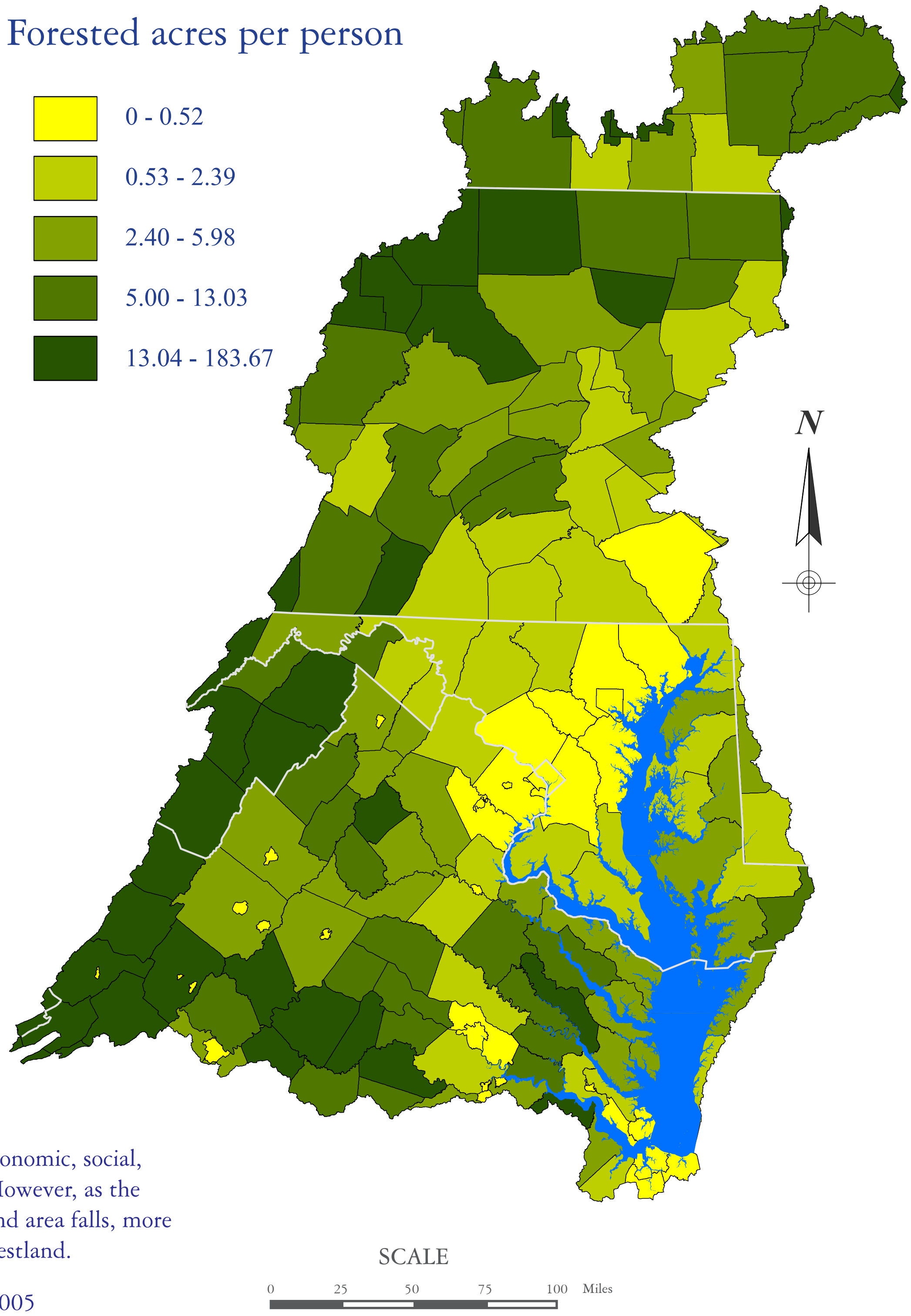
Forest Population Density

State	Forest Area (million acres)		Population (millions)	
	1907	2002	1907	2002
Maryland	2.2	2.6	1.3	5.5
Pennsylvania	9.2	16.9	7.7	12.3
Virginia	14.0	16.1	2.1	7.3
Region	25.4	35.5	11.0	25.1



Source: U.S. Census 2005 and USDA Forest Service 2002

FOREST POPULATION DENSITY

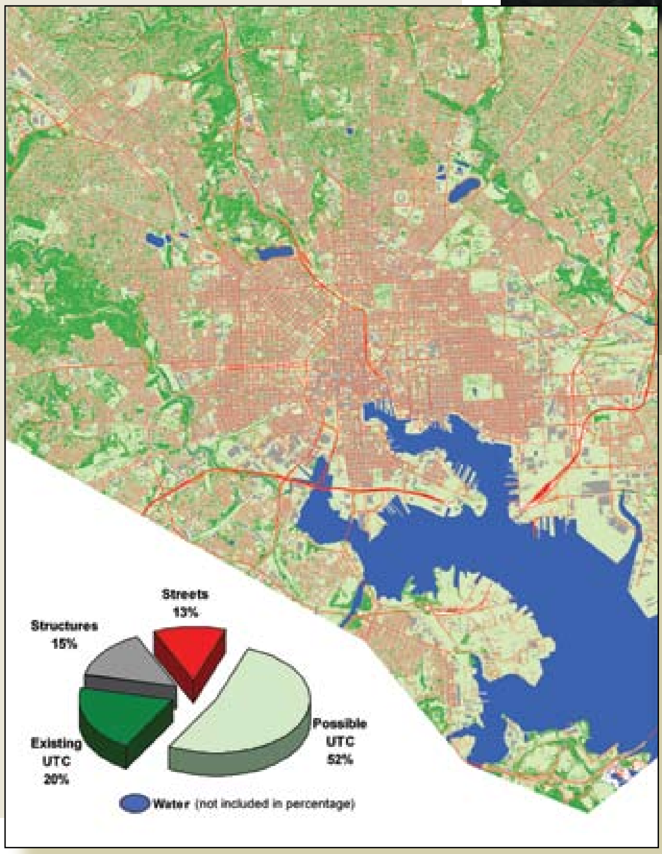


INTERPRETATION:
Chesapeake Forests provide numerous economic, social, and environmental benefits to people. However, as the population continues to rise and forestland area falls, more people depend on smaller portions of forestland.

SOURCE: USDA Forest Service / FIA 2005

URBAN TREE CANOPY GOAL IN BALTIMORE MARYLAND

On March 30, 2006, Baltimore, Maryland, became the first city in the Chesapeake Bay watershed to adopt an urban tree canopy goal. Under this initiative, Baltimore will seek to double its existing tree cover from just under the current 20% to 40% by 2030. Baltimore is the first of many communities that are expected to set tree canopy goals under the Chesapeake Executive Council's Expanded Riparian Forest Buffer Directive. This directive asks that five communities each in Maryland, Virginia, Pennsylvania, and Washington, D.C., serve as models for the rest of the Bay watershed by adopting goals to increase tree cover.



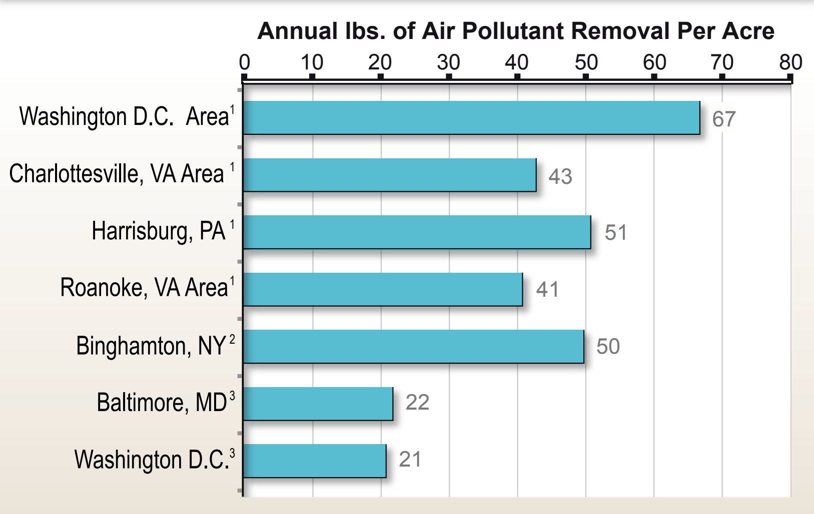
Air Quality Benefits of Urban Forests, Washington, D.C.

Emissions Filtered	Urban Forest Removes Pollution Equivalent to the Emissions of	
Pollutant	**Automobiles**	**Single Family Homes**
Particulate Matter (10 microns)	315,200	30,400
Sulfur Dioxide	82,400	1,400
Carbon	9,700	49,000
Nitrogen Dioxide	3,500	2,300
Carbon Monoxide	78	300

Source: Nowak et al. In Review

Photo: David Winston

Air Quality Benefits of Urban Forests in Major Metro Areas



Source: 1. American Forests 2002, 2. American Forests 2004, 3. USDA Forest Service, UFORE 1999

CULTURAL BENEFITS

Recreation

Forest recreation, such as wildlife watching, hunting, hiking, and camping, is very popular in the Chesapeake Bay watershed. Visits to national forests and wildlife refuges have risen dramatically.[11] In 2001, greater than 2.5 million and 12.5 million people hunted or viewed wildlife in the Bay region, respectively.[12] Nearly five million people annually visit the two national forests in the Bay watershed, the George Washington-Jefferson and Monongahela forests. The majority of these visitors come to view wildlife and scenery.[13] Greater than 1 million people also visit the heavily forested Shenandoah National Park.[14]

Urban forests are valued for recreation and provide opportunities for daily exercise. Washington, D.C., and Baltimore, Maryland, are among the top five "large" cities in park availability, with 13 and 9 acres of parkland per 1000 persons, respectively.[15] This is an important public benefit, when only 25% of Americans are getting the exercise they need. Lack of exercise is a leading contributor in the current obesity epidemic and is a factor in more than 200,000 deaths a year.[16]

Private forests are also highly regarded for their cultural benefits. Many private forest landowners enjoy viewing wildlife, hunting, and ATV travel as means of recreation. Most own forests, though, to enjoy the solitude and peacefulness of the woods. These objectives are important, as families and individuals own 64% of Chesapeake forests.[17]

Quality of Life

Trees provide myriad benefits that affect quality of life for individuals and communities. These benefits range from providing pleasant surroundings and a more meaningful connection between people and the natural environment to improving health. Residents in the Chesapeake region have become increasingly aware of these benefits, as shown by the $2 billion made available for conservation on election days between 1996 and 2005.[19] In addition, approximately one-third of Chesapeake forests are protected[i] from conversion to other land uses. Pennsylvania has the largest area and percentage of protected forestland. Maryland and Delaware have approximately 30% of all forestland protected from development.[20]

A study in Baltimore, Maryland, revealed that as the percent of tree canopy cover increases, residents are more satisfied with their community. The study also showed that when neighborhood forest cover is below 15%, more than half of the residents consider moving away. Therefore, increasing forest cover in urban neighborhoods makes existing communities more desirable and can be an important tool for encouraging revitalization and helping to reduce sprawl.[21]

Photo: Middleton Evans / Chesapeake Bay Gateways Network

The American Elm

The American elm was once a prominent and much loved urban tree in the Chesapeake Bay watershed. American elms are large trees that often reach 100 feet in height and four feet in diameter. These stately trees were planted heavily in urban areas because of their superior shade.

In 1930, the European elm bark beetle and its associated fungus, known as Dutch elm disease, arrived in the United States on a shipment of logs from Asia. First discovered in Ohio, the disease spread quickly and reached the Bay watershed. By 1960, the American elm was no longer prominent in Chesapeake communities. During the past 75 years, approximately 100 million American elms have perished.[18]

Researchers have been working to develop disease resistant elm varieties and hybrids. Over the past few years, numerous types of disease-resistant American elm trees have become available to the public and been planted around the Bay watershed.

Photo: Shannon Sprague

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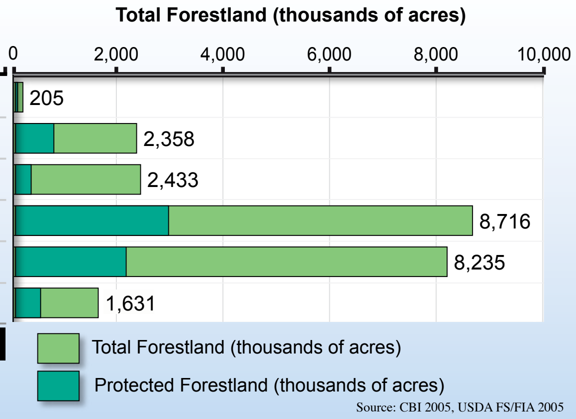
[i] National, state, or local designations (such as national forests) or legal restrictions (such as conservation easements) that preclude land conversion.

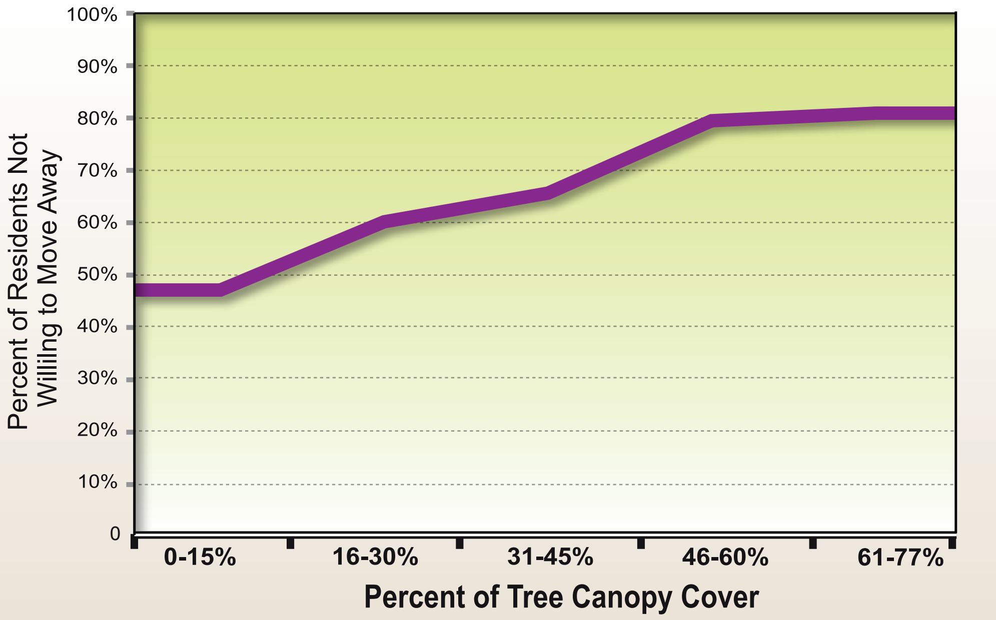
Protected Forestland in the Chesapeake Bay Watershed

State	Percent of Total Forestland Protected	Protected Forestland (thousands of acres)	Total Forestland (thousands of acres)
Delaware	19%	39	205
Maryland	31%	724	2,358
New York	12%	295	2,433
Pennsylvania	33%	2,896	8,716
Virginia	25%	2,093	8,235
West Virginia	29%	474	1,631
Total	**28%**	**6,521**	



Source: CBI 2005, USDA FS/FIA 2005

Neighborhood Satisfaction and Tree Canopy Cover



Source: Grove et al. 2004

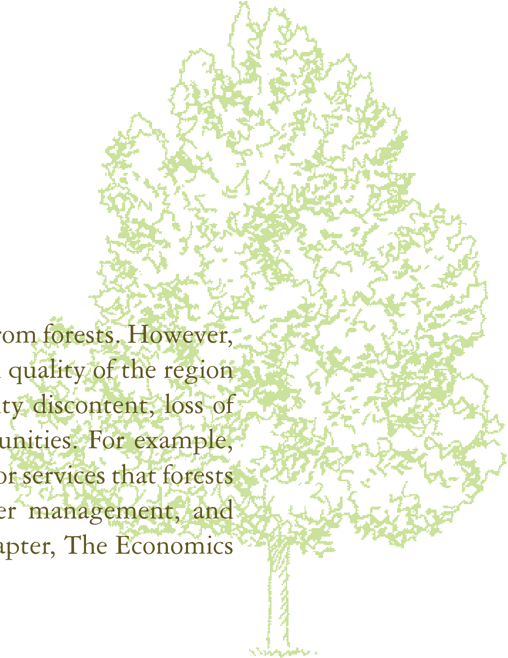
Other benefits of urban forests and trees include:

- Noise reduction - Wide belts (98 feet) of tall dense trees combined with soft ground surfaces can reduce apparent loudness by 50% or more.[22] In narrow planting spaces (less than 10 feet wide), dense belts of vegetation can achieve reductions of three to five decibels by combining one row of shrubs with one row of trees behind it.[23]
- Work productivity - Desk workers without views of nature claim 23% more sick time, while those with natural views demonstrate greater job satisfaction, less frustration, more enthusiasm, and better overall health.[24] Nearby nature, even when viewed from an office window, can provide substantial psychological benefits that affect job satisfaction and a person's well being.[25]
- Patient recovery - Hospital patients with views of trees and other greenery recover more quickly, with fewer complications and less pain medication after surgery than patients without views of nature.[26]
- Reduced stress - Experiences in urban parks have been shown to change moods and reduce stress.[27] Reduced driver aggression and stress recovery have also been associated with treed thoroughfares.[28,29]
- Improved business - Consumer behavior responds favorably to streetscape greening. Consumers pay more money for parking in treed areas, spend more time shopping there, and pay up to 50% more for certain goods—suggesting a basis for partnerships between the business community and urban forest planners.[30,31]
- Emotional experiences - Urban trees and forests provide significant emotional and spiritual experiences that are important in people's lives and can foster a strong attachment to particular places and trees.[32]
- Increased property values - A survey of sales of single-family homes in Athens, Georgia, indicated that landscaping with trees was associated with an increase in sales prices of 3.5 to 4.5%.[33] In addition, builders have estimated that homes on wooded lots sell on average for 7% more than equivalent houses on open lots.[34] Research in Baton Rouge, Louisiana, indicates that mature trees contributed about 2% of the home market.[35]
- Improved community and public safety Urban trees and forests contribute to stronger ties among neighbors, greater sense of safety and adjustment, more use of neighborhood common spaces, healthier patterns of children's play, and fewer property and violent crimes.[36]

INDICATORS FOR SUSTAINABLE CHESAPEAKE FORESTS

The following indicators could be used to track the ability of forests to improve human health and quality of life:

- Number of communities that have adopted a tree canopy goal
- Acres of forestland per person
- Acres and percent of total forestland that is protected



CHAPTER IN PERSPECTIVE

Rural, suburban, and urban residents of the Chesapeake Bay watershed all benefit from forests. However, as forests are lost or degraded, the public health, quality of life, and environmental quality of the region declines. Negative effects of tree cover loss include rising asthma rates, community discontent, loss of jobs and income, increase in taxes, and decline in the fiscal health of Bay communities. For example, communities are forced to spend millions of dollars on technological replacements for services that forests provided naturally—such as air pollution control, flood mitigation, storm water management, and drinking water filtration. The economic value of forests is explored in the next chapter, The Economics of Chesapeake Forests.

Chapter 6:

The Economics of Chesapeake Forests

KEY FINDINGS

- Each year, forests in the Chesapeake Bay watershed provide at least $24 billion just from the ecological services carbon sequestration, flood control, wildlife habitat, and recreation. The value of these are rarely accounted for in private and public decision-making or in developing incentives for retaining and managing forestland.

- Residential development requires four times more community expenditures than forestland, making forest conservation a long-term economic advantage for local communities.

- Each Bay watershed resident uses an amount of forest products equivalent to harvesting more than two acres of forest each year, but 65% of this supply comes from forests outside the Bay watershed.

- Sustainably-managed forests provide both invaluable ecological services and important economic returns to communities in the Bay watershed.

- The forest products industry provides 140,000 jobs, $6 billion in income, and a total industry output of $22 billion to the Bay watershed economy each year.

- While large-scale commercial forestry in the Bay watershed will become increasingly concentrated in rural western Pennsylvania, southern Virginia, and western and southeastern Maryland, there are growing opportunities for small-scale forest management throughout the region.

- Waning owner interest, decreasing parcel size, and expanding development is shrinking the land base of the forest products industry.

ECOSYSTEM SERVICES: “GETTING MORE THAN YOU PAY FOR”

Forests are the largest portion of the Chesapeake Bay watershed’s green infrastructure—the natural life support system that sustains the environment and contributes to public health and quality of life. Whether in a city or rural area, ecosystem services or “ecoservices” are highly valued benefits constantly supplied by green infrastructure. Ecosystems services are so fundamental to life that they are easy to take for granted and so large in scale that it is hard to imagine that human activities could destroy them. Even though these services are inherently renewable, they require that we protect natural system productivity and diversity. Some of the most significant ecological services provided by forests include:

- Cleaning the air
- Filtering and cooling water
- Storing and cycling nutrients
- Conserving and renewing soils and soil fertility
- Habitat for pollinators
- Regulating climate
- Maintaining habitat and biodiversity
- Lowering residential and commercial energy use
- Protecting areas against storm and flood damage
- Maintaining hydrologic function[1]

QUANTIFYING THE VALUE OF FOREST ECOSYSTEM SERVICES

Just as we expect economic capital to provide steady financial returns, natural capital provides steady environmental and economic returns in the form of ecosystem services for free. For example, forests provide services that the public spends millions of dollars on to reproduce. Air pollution control, flood mitigation, storm water management, and drinking water filtration are among these ecological services.

However, the public does not pay for most ecological services, so places little economic value on them. Instead, decision-makers tend to emphasize the value of forests only for human goods such as wood or paper products, which have been traded on the public market for centuries—resulting in dollar values that are both established and well understood. Many ecosystem services are beyond price, providing a source of cultural identity, of kinship with life, of learning, of evolutionary processes, and of soil, air, water, and biodiversity that have no engineered substitutes.

While very few ecosystem service valuations have been conducted in the Mid-Atlantic, studies from outside the region have shown that ecoservices provide enormous cost savings to the public and highlight the potential benefits of forest conservation. Healthy natural lands like forests show a net gain in cost-benefit analyses. Natural areas that are relatively free from disturbance can produce 100 times the benefits that could be derived from converting the same landscape to another use. A seminal study estimated the value of 17 basic ecoservices such as water supply, climate regulation, and erosion control. An estimate of the total annual global value was between $18 and $61 trillion, with a rough average of $38 trillion, similar to the size of the global gross national product.[2] In addition, The Wilderness Society has estimated that the annual value of ecoservices from temperate and boreal forests in the

Ecosystem Services Provided by Forest Cover

Ecological Service	Location	Annual Value Per Acre of Tree Cover
Air Pollutant Removal	*Washington D.C. Area*[1]	**$261**
	Charlottesville, VA Area[1]	**$261**
	Harrisburg, PA[1]	**$405**
	Binghamton, NY[2]	**$269**
	Roanoke, VA Area[1]	**$265**
	Washington D.C.[3]	**$174**
Biodiversity	*Maryland*[4]	**$305**
Carbon Sequestration	*Chesapeake Bay Watershed*[5]	**$5-$57**
Recreation	*Chesapeake Bay Watershed*[6]	**$131**
Energy Savings	*Washington D.C.*[3]	**$231**
Stormwater Control (one-time savings)	*Washington D.C. Area*[1]	**$25,031**
	Charlottesville, VA Area[1]	**$4,602**
	Harrisburg, PA[1]	**$3,527**
	Binghamton, NY[2]	**$10,088**
	Roanoke, VA Area[1]	**$11,406**

Sources: 1. American Forests 2002, 2. American Forests 2004, 3. USDA FS / UFORE 2004, 4. Pimentel 1998
5. Birdsey 2005 / Chicago Climate Exchange 2006 / European Climate Exchange, 6. USFWS 2001

United States is approximately $75 billion (in 2001 dollars). Climate regulation, food production, and waste treatment accounted for approximately 75% of this total.[3]

VALUE OF ECOSERVICES PROVIDED BY CHESAPEAKE FORESTS

Based on a study published by the Audubon Society, which considered only carbon sequestration, flood control, wildlife habitat, and recreation, the annual ecoservice value of Chesapeake forests ranges from $10 to $48 billion, with a conservative estimate of $24 billion per year.[4] Since this analysis does not include water quality, air quality, water storage, and other valuable services, this range is a considerable understatement of the total value of Chesapeake forests.

Furthermore, while residential, commercial, and industrial areas require public services, natural areas require little other than protection. Natural areas even reduce costs of public services like stormwater treatment facilities. Studies in 33 Bay watershed communities show that for every dollar of tax revenue raised by residential development, the median cost to support it is $1.23. In contrast, the median cost of forest and farmland is $0.32 per dollar of community revenue.[5]

Drinking water supply, carbon sequestration, and recreation are some of the most prominent and quantifiable ecoservices of Chesapeake forests and are highlighted as examples.

Clean Drinking Water

For most of the last 50 years, advancements in science and technology effectively treated most known contaminants in drinking water sources—providing United States citizens with some of the safest drinking water in the world. As a result, many communities have neglected policies that protect source water and instead rely on water treatment systems to deliver clean drinking water. Many of these systems now require upgrades to handle new standards and threats. There is evidence that some water supplies that require extensive treatment may pose public health risks. Recent findings are suggesting that chlorination and other chemical processes used in water treatment are not benign and could lead to potential health problems. The Environmental Protection Agency, in 1998, estimated that necessary upgrades to the nation's water treatment systems would cost more than $158 billion. Some cities, notably New York and Boston, with assertive forest protection programs are providing quality water with minimal filtration and treatment.

It is also clear that the more water sources are affected by impervious surfaces, production agriculture, and other intensive land uses, the harder and costlier it is to filter or treat drinking water.

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 go up when the amount of forestland and wetlands goes down. Approximately 50% of the variation in operating treatment costs could be explained by the percentage of forest cover in the drinking water source area alone.[6]

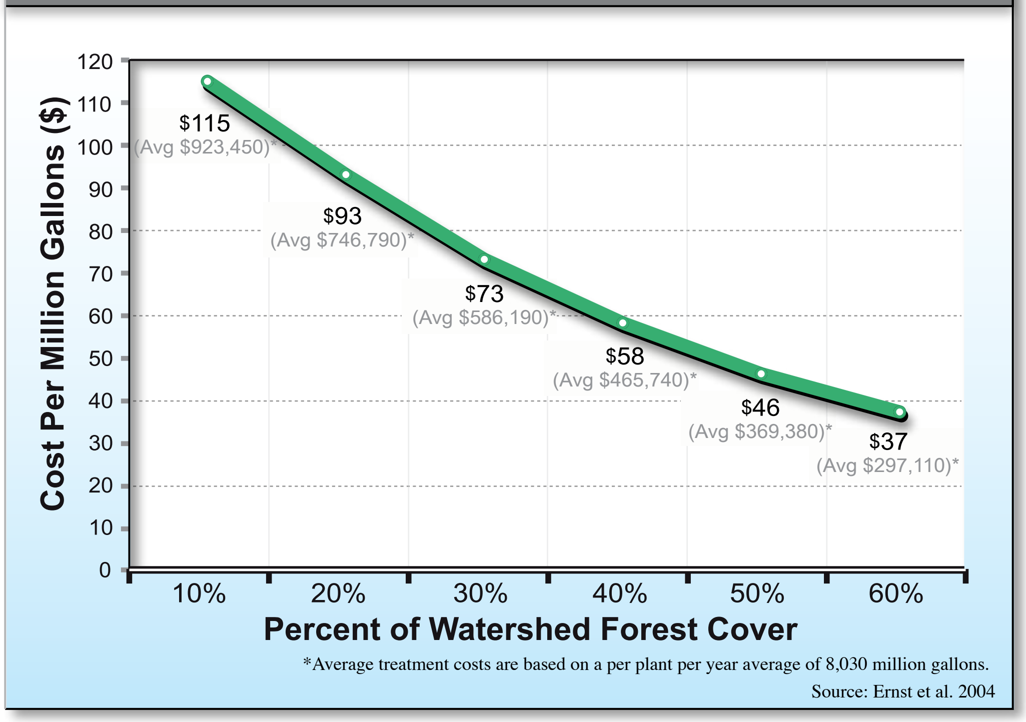
Carbon Sequestration

Internationally, industries and governments are growing more concerned about increasing levels of carbon dioxide and other greenhouse gases contributing to climate change. Globally, the average surface air temperature is expected to rise between 1°C and 3.5°C by the year 2100.[7] Forests are a critical component to mitigating climate change because they store carbon.

The economic value of Chesapeake forests for sequestering carbon could be immense. Based on the current value of United States carbon credits, the net value of publicly owned forests for carbon sequestration would be approximately $25 million dollars per year. Using European prices, their value would be approximately $310 million per year. European market prices are currently higher than in the United States because of Europe's involvement in the Kyoto Protocol and use of carbon dioxide emission caps for industries. Using management to increase carbon storage potential and expand forest conservation on private forestland could increase the value to the Bay watershed by $81 million. The value could approach $1 billion if we could attain the European market value.[8]

This impressive value is possible because Chesapeake forests are currently storing a net 17 million metric tons of carbon annually. Between 1990 and 2000, carbon stored in the Bay watershed accounted for 11% of the contemporary increase for the whole United States on just 3% of the land base. This means that Chesapeake forests may be more productive than any other area in the country.[9] There are approximately 2 billion metric tons of carbon stored in the soil, plants, trees, forest floor, and dead woody material of Chesapeake forests.

Relationship Between Forest Cover and Water Treatment Costs



*Average treatment costs are based on a per plant per year average of 8,030 million gallons.

Source: Ernst et al. 2004

Photo: Lisa Gutierrez

Urban forests and soils also store large amounts of carbon, offering potentially large economic benefits. It is estimated that the urban forests in Baltimore, Maryland, and Washington, D.C., together store 22,500 tons of carbon annually.[10]

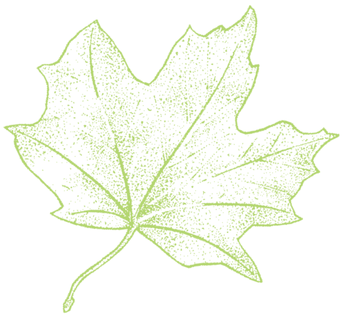
However, deforestation is threatening the carbon storage potential of Chesapeake forests. Forest loss led to a decline in storage of about 1.6 million metric tons of carbon per year between 1990 and 2000. This rate of loss is lowering the carbon sequestration value of forests by $10 million annually and by much more using the European market value.[8] The loss of forest to development also limits the overall amount of forestland that can be managed to increase carbon storage in the future.[9]

Also, carbon stored in living trees, shrubs, grasses, and other live vegetation (known as "biomass") in Chesapeake forests has potential to provide an alternate and renewable fuel source for industries, universities, governments, and other groups. Today, wood and wood waste (such as bark, sawdust, and wood chips) provides only about 2% of the energy used in the United States.

Recreation

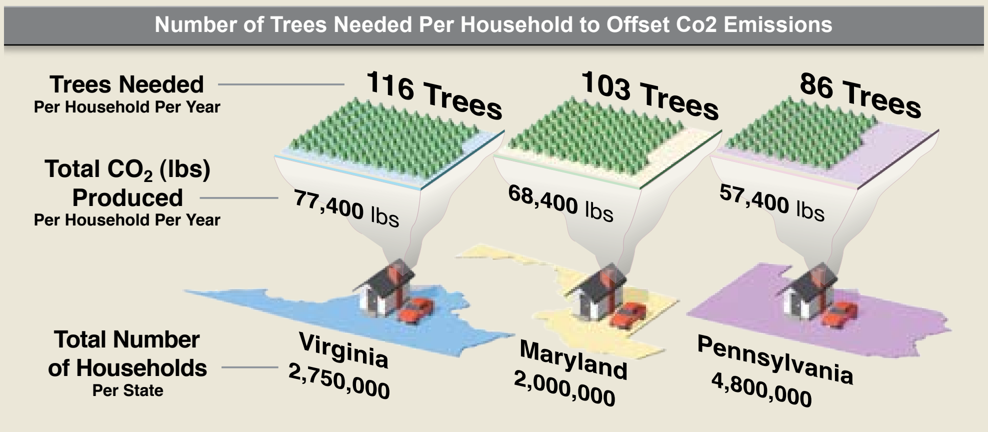
Forest-related recreation generates income through entrance fees and by creating demand for equipment like camping, hunting, and fishing gear, and trip services like gas, food, and lodging. More than 15 million people fished, hunted, or viewed wildlife in the Chesapeake region's forests in 2001 and contributed approximately $3 billion to the regional economy.[12]

Surveys indicate that urban residents are willing to pay an additional $1.60 per visit to a site that is "mostly wooded, some open grassy areas under trees" rather than "mowed grass, very few trees anywhere."[13] Trees in urban parks and recreation areas add a value exceeding $2 billion per year for outdoor leisure and recreation experiences in the United States.[14]



YOUR HOUSEHOLD CARBON DIET

American Forests developed a climate change calculator, which estimates the number of new trees that need to be planted each year to offset a household's annual carbon emissions. Using data on average household and population size, energy use, garbage production, and travel behavior from a variety of sources, the calculator indicates that each household in the Chesapeake Bay watershed needs to plant between 86 and 103 trees each year in order to support its carbon "diet" and be "carbon neutral."[11]



Source: http://www.americanforests.org/resources/ccc/

THE FOREST PRODUCTS INDUSTRY

PUBLIC PERCEPTION VS. CONSUMPTION

Photos: Don Outen and Eric Sprague

Which forest was recently logged? Answer: The one on the left.

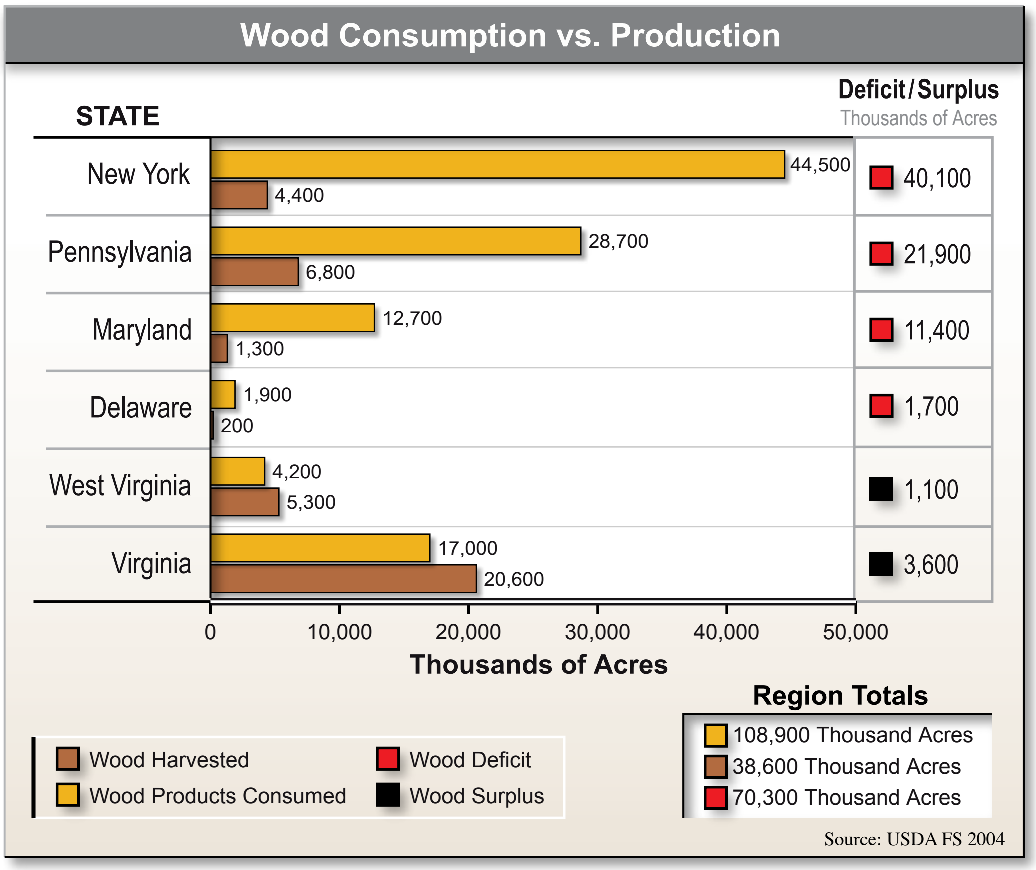
Crop and livestock production are often the most noticeable industries taking place on the land. However, since the Chesapeake Bay watershed was first settled, people have depended on its forests to produce food, fuel, shelter, and other commercial products.[15]

The highly publicized political battles over logging and the spotted owl in the western United States have led many people to view tree harvesting as an environmentally damaging use of the land. When done poorly, this is certainly the case.

One problematic practice used for centuries and still used today on private land is to "cut the best, and leave the rest"—known as high grading. Professionals discourage removing all of the biggest, best, and most valuable trees. This method leaves only less fit or poorer quality trees to regenerate the forest. High grading not only reduces future economic return, but also reduces the overall health of the forest stand and eliminates wildlife food sources and important habitat features.

However, economic motivations can be compatible with maintaining healthy forest ecosystems. Sustainable forest management considers the future health of the entire forest ecosystem, including wildlife, soil, and water resources as well as the valuable timber trees.

While the public perception of tree harvesting may have cooled in parts of the Bay watershed, the consumption of wood products has not. The average person in the Bay watershed uses an amount of forest products equivalent to the clearing of more than two acres of forest per year—2.5 times the European and 3.4 times the world averages.[16] The demand for forest products by residents in the Chesapeake region is three times the annual yield from forests in Maryland, Virginia, and Pennsylvania. Therefore, Bay watershed states rely on over 9 million acres of non-Chesapeake timberland to meet their annual needs.[17]



Source: USDA FS 2004

Importing so much wood passes the burden of sustainable management to other regions such as Canada's Boreal Forest and the subtropical forests of Central and South America. These regions are often not subject to the same level of environmental and labor regulations that commercial and family forest landowners in the Bay watershed must follow.[18] Increasing the regional production of wood products, while reducing overall consumption would allow Chesapeake forest owners to maintain their land through new sources of income and would enhance the sustainability of forests and the environment in the Bay watershed and around the globe.

VALUE OF THE FOREST PRODUCTS INDUSTRY

According to output from the economic model IMPLAN, the forest products industry in the Bay watershed directly employs approximately 140,000 people and supplies $6 billion in labor and proprietor income with a total industry output (sales) of more than $22 billion to the Bay watershed economy each year.[i] Half of the total economic output is derived from secondary wood manufacturing—the production of goods like furniture, containers, and toys. Nearly 40% is

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[i] Economic data was compiled using the IMPLAN categories "output" and "employment." Income was calculated using the sum of "employee compensation" and "proprietors income."

[ii] New York, Delaware, West Virginia, and Washington, D.C. were not included

generated from primary manufacturing—the processing of logs and related products into lumber, veneer and plywood, pulp, and other products. The remainder comes from direct timber management and harvesting activities. Although the forest products industry represents just 2% of total sales and 1% of all employment across the Bay watershed, the industry is particularly valuable to many local economies and private forest owners.[19]

THE MANY USES OF WOOD

Most people are conscious of their every day use of many wood products like furniture, paper, chopsticks, and packaging. However, wood is also used in countless other commonly used products like concrete, rubber, paint, food preservatives, adhesives, photographic film, make-up, rayon fabrics, gum, and soap.

Regional Profiles

The Chesapeake Bay Program has identified the locations of economically important forestland across the Bay watershed.[ii] The analysis considered not only the potential economic gain from forest harvest operations, but also the long-term economic sustainability of forest management and the local importance of the timber and wood products industry. Local data helped to characterize site conditions such as slope, tree species, forest density, and soil productivity. Regional factors focused on forest fragmentation, population density, and historic timber harvests. In general, highly ranked forests contain commercially valuable species, productive soils, few management constraints (such as steep slopes and wetlands), large areas, a low surrounding population density, and a significant forest products industry in the area.[20]

Economic Impact of Chesapeake Forestry

	Workers Employed	Income (million dollars)	Sales (million dollars)
Chesapeake Bay Watershed	139,438	5,610	22,614

Source: IMPLAN 2001

Pennsylvania

The highest valued forest in Pennsylvania occurs in the western portions of the Appalachian Plateau, and the Ridge and Valley regions. These areas have relatively high proportions of forestland to other land cover types and are dominated by economically valuable species like black cherry and oak species. These regions also contain the largest average size of forest tracts and the lowest human population density in the commonwealth.

Over half of Pennsylvania's timberland is located inside the Bay watershed and accounts for more than 40% of the commonwealth's net timber growth and removal.[21] The forest products industry is the fourth largest manufacturing sector in the state. The portion of the industry in the Bay watershed employs more than 60,000 people contributing more than $2 billion in income and around $10 billion in total sales annually to the economy.[19] Nationally, Pennsylvania is the number one producer of hardwood lumber and has the largest amount of hardwood timberland.[22]

The Pennsylvania Chesapeake forest products industry represents 6% of all sales of manufacturing goods and 4% of all employment in rural counties.[iii] Rural, low-income Sullivan County derives 6% of all jobs and 17% of all sales from the Chesapeake forest products industry in the commonwealth. The industry is also important to the central Appalachian counties of Wyoming, Clinton, and Snyder, where it makes up more than 20% of all sales and 4% of jobs.[19]

Virginia

Virginia's highest economically valued forest is located in the south-central and southeastern portions of the commonwealth. These regions have large amounts of commercially valuable oak, pine, and in particular loblolly pine. These regions have been long-valued for their timber production and have low population densities, allowing the industry to remain viable.

Similar to Pennsylvania, Virginia's portion of the Bay watershed is valuable to its overall forest products industry. Around half of Virginia's timberland, live tree volume, lumber volume, and net tree growth and removal occur in the Bay watershed.[21] Across the commonwealth, the forest products industry ranks first in manufacturing jobs. The Virginia Chesapeake forest products industry accounts for approximately 36,000 of the 405,000 statewide manufacturing jobs in Virginia.[23] The industry also provides more than $1 billion in income and $7 billion in sales annually to the Virginian economy.[19]

Many counties are dependent on their local timber industry for employment and economic well being. For example, the Chesapeake

Economic Impact of Chesapeake Forestry by State

STATE	Workers Employed	Income (million dollars)	Sales (million dollars)
Delaware	4,300	100	600
Maryland	16,300	600	2,400
New York	10,300	300	1,500
Pennsylvania	66,200	2,300	9,700
Virginia	36,300	1,400	6,600
Washington D.C.	200	10	20
West Virginia	6,000	100	700

Source: IMPLAN 2001

[iii] Counties not present in a United States census-defined 2000 Metropolitan Area.

forest products industry in Virginia provides 5% of the total income and jobs in the low-income rural Nottoway County. Fifteen percent of jobs in Charlotte County depend on the Chesapeake industry.[19]

Maryland

The most economically valuable forestland in Maryland occurs in the far western panhandle and the lower Eastern Shore. The western forests are dominated by oak and hickory, while pine is more prevalent on the Eastern Shore. These two high-value zones also occur far enough away from the heavily developed central portions of the state for a thriving timber industry to remain viable. Only a small portion of western Garrett County and the coastal Eastern Shore are outside of the Bay watershed. Therefore, Chesapeake forests in Maryland are especially important to the future of the state's forest products industry. Timberland area, live tree volume, lumber volume, and net tree growth in Maryland's Bay watershed area all represent more than 80% of the state's total resource.[21]

Jobs in the forest product industry account for 9% of Maryland's total manufacturing employment.[24] Every job directly involved in wood harvesting or production supports two additional jobs in value-added services such as furniture production.[25] In addition, Maryland's forest products industry generates eight times the economic output and five times the direct employment of the well-known seafood industry.[19]

While all manufacturing industries make up a small percentage of the state's economy, forest product industries are important to many rural economies.[24] The forest products industry is the fifth largest manufacturing industry statewide, but it ranks first in western Maryland and second on the Eastern Shore. The forest products industry is particularly valuable to rural, low income Garrett County, where the industry makes up 20% of all jobs and economic output.[19]

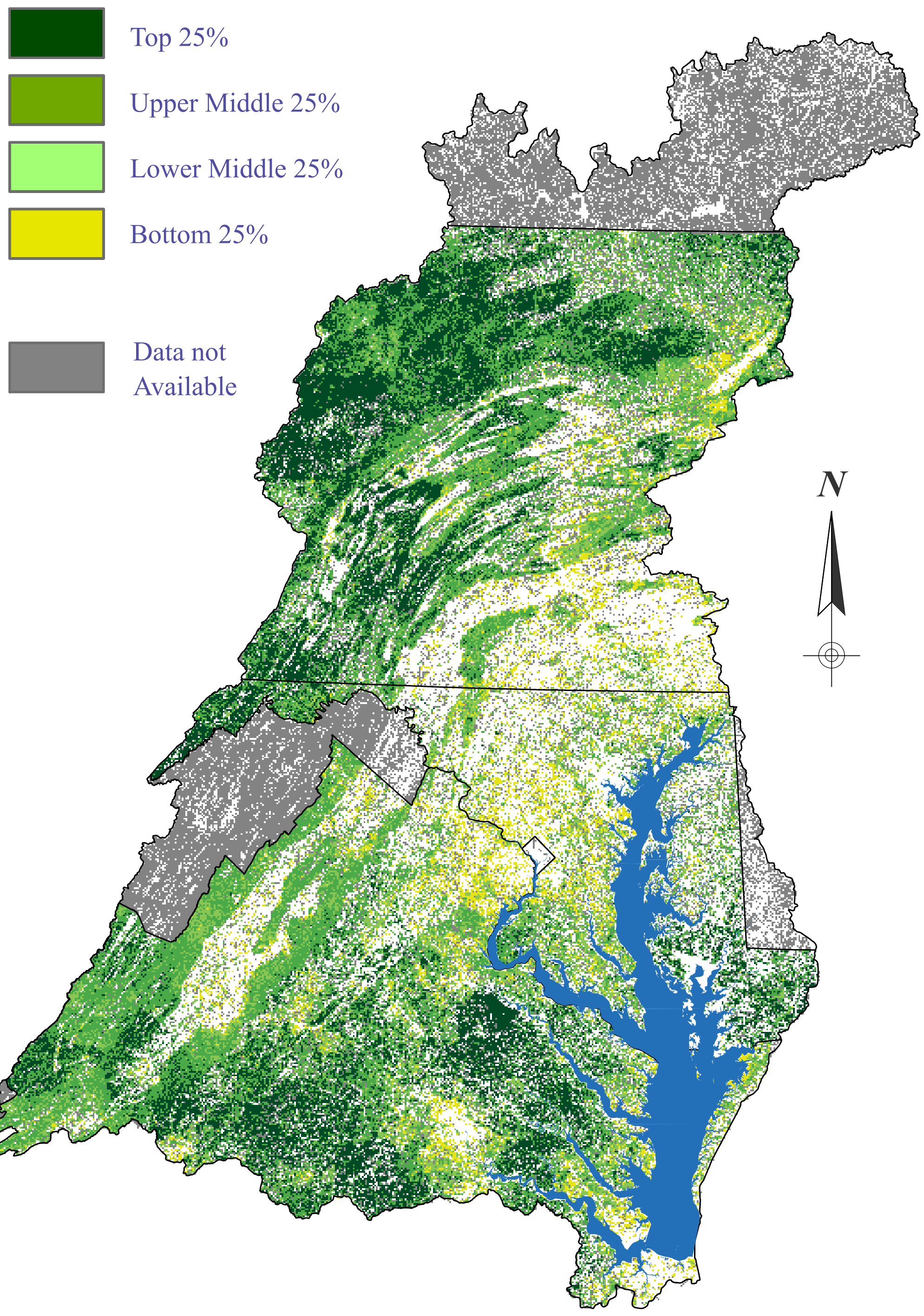
Changes Affecting the Forest Products Industry

A growing number of forces are reducing the viability of the forest products industry. As forest parcel size, owner interest in management, and the amount of industry-owned lands decrease, management costs rise and revenue possibilities dwindle. Sawmills soon become too expensive to run and close down forcing loggers to travel farther to deliver wood, increasing costs still further. Additionally, the costs of paperwork, permit processing, and management plans are fixed and do not decrease greatly as the size of forest blocks decrease.

The ability of states in the Chesapeake Bay watershed to sustain a wood-based manufacturing economy is declining. Innovations that are tailored to small land owners, the use of forest enhancement practices such as thinning, and the support of small diameter and traditionally low value

Economically Valuable Forests

Resource Lands Assessment



INTERPRETATION: Economically valuable forestland has long-term economic potential and is an important source of income and jobs for local communities. In general, highly ranked forests are those that contain commercially valuable species, productive soils, few management constraints (such as steep slopes and wetlands), large areas, low surrounding population density, and a significant forest products industry and infrastructure in the area.

SOURCE: Chesapeake Bay Program 2005

species like red maple may be required to maintain this industry.[24]

Less Forest to Manage

Land can only be managed for sustainable forestry as long as it remains forest. After a century of expansion and growth, the amount of forestland in the Bay watershed is declining.[26] Between 1982 and 1997, development accounted for approximately 70% of the loss, but agriculture and other land uses also played a considerable role.[27]

At the same time, nearly 900,000 acres of fallow cropland and pastureland reverted to forestland. Those lands left to revert to forestland are often of lower soil quality or degraded by decades of tillage and chemical use, meaning that the ability of the forest to reach its full potential has probably also declined. In addition, the vegetation that initially reclaims abandoned farmland, including invasive species, often has lower economic value.[28]

More Owners and Smaller Parcels

The consulting firm U.S. Forest Capital estimates that half of all American timberland has changed hands in the past decade. In the Chesapeake Bay watershed, the number of family forest owners has risen by nearly 25% over the past ten years—an average of 23,000 new forestland owners each year. In addition, the average size of forested landholdings decreased from 21 to 16 acres per family forest owner. This trend, known as "parcelization," is likely to continue in the future, especially because more than 70% of family forestland owners are more than 55 years old.[29]

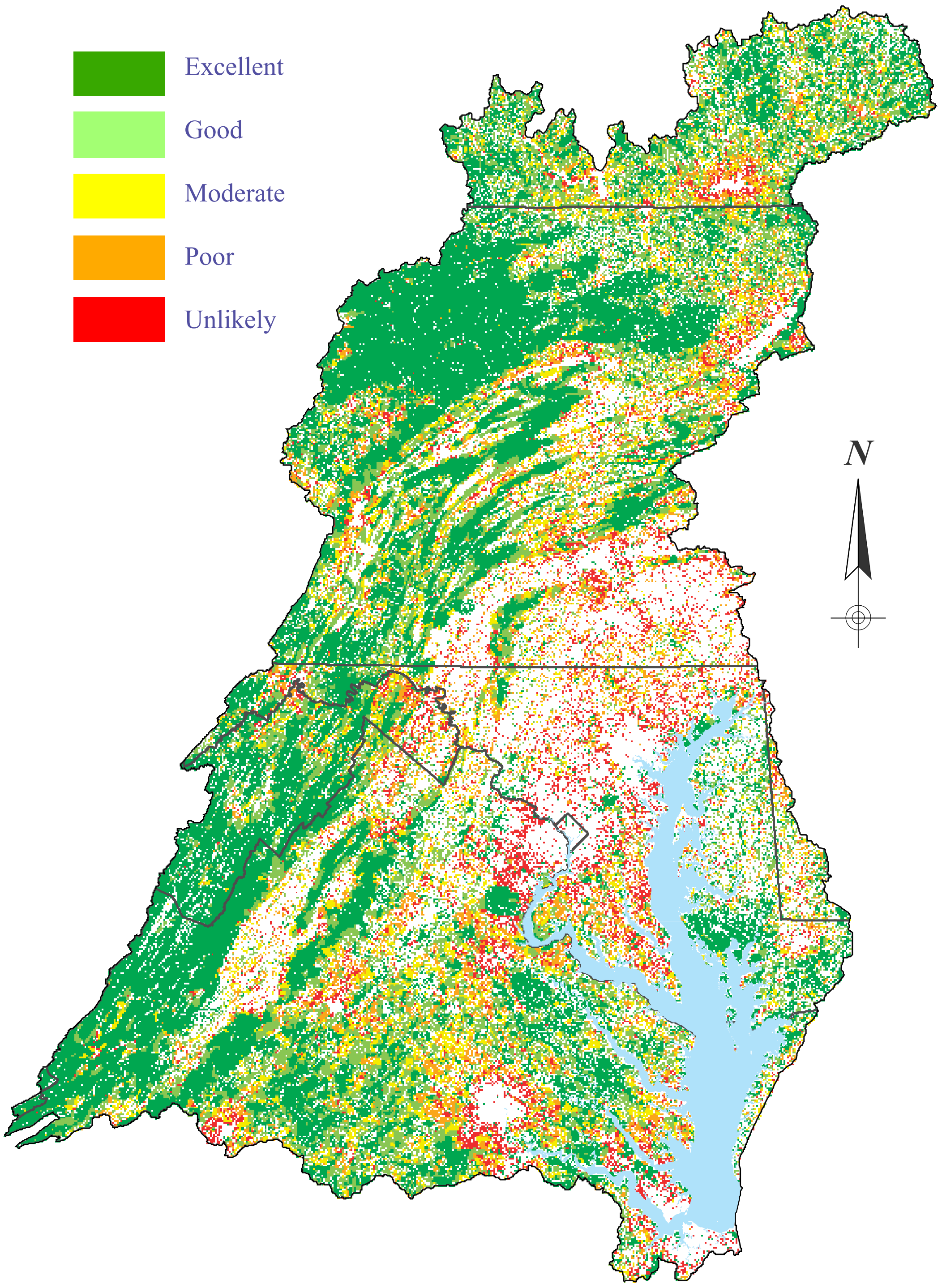
Forest management objectives may change significantly once land has been parcelized. This is certainly true in the Bay watershed, where family forestland owners are increasingly interested in aesthetics and privacy and less interested in timber production. Land investment now ranks as a more important objective than timber harvesting.[29] These parcelized forests are in effect becoming personal green spaces maintained as amenities, rather than working forests.[28]

For new forest owners who are still interested in growing wood products, parcelization may mean that the size of their holdings is too small to make logging economically viable. When the size of a forest property drops below 50 acres, the average per-acre cost of preparing for a timber sale, harvesting the trees, and growing a new forest often goes up, making owners less likely to manage their land for timber.[30] This has important implications for Chesapeake forests, where 41% of forestland and 94% of all owners involve parcels of less than 50 acres.[29]

Expanding Development

As development expands (particularly low-density, automobile-dependent sprawl), the economic viability of forestry decreases. This is due to the direct loss of forests to make room for homes, roads, and stores, and the

Potential for Forest Harvesting



INTERPRETATION: As population decreases, the likelihood of timber management incteases: 25% at 70 people per square mile, 50% at 45 people per square mile, and 75% at 20 people per square mile. Less than 20% of Chesapeake counties have a 50% probability of supporting a viable timber industry because high development pressure will push out the needed forestry infrastructure.

SOURCE: United States Census Bureau 2000 and MA RESAC 2000

SUSTAINABLE FORESTRY: MARYLAND'S CHESAPEAKE FOREST LANDS

In 1998, the Chesapeake Forest Products Corporation (CF) determined that its 278,000 acres of forestland, stretching across the Delmarva Peninsula in Delaware, Maryland, and Virginia, were no longer essential to its business. In April of 1999, the corporation disclosed a plan to sell the land to the Hancock Timber Resource Group (HTRG), an investment management firm that holds millions of acres of timberland across North America and abroad. Along with a change in ownership, the long-term fate of the forest was uncertain, given its location for second home development.

In Maryland, more than 58,000 acres of CF lands were located on the Eastern Shore, widely distributed over five counties, and 460 separate tracts. Collectively, the tracts represented the largest singly owned property in Maryland. In addition to supporting a forest-based economy of importance to the entire state, these lands contained more than 11,000 acres of unmodified wetlands, habitat for game species and migratory birds, endangered and threatened species, and watersheds identified as critical to maintaining water quality in the Chesapeake Bay.

The HTRG consulted with The Conservation Fund (Fund) to investigate the acquisition of these sensitive lands. The Fund wanted to secure the forest's long-term ecological and economic benefits and called for a sustainably managed forest to support the local economy and provide revenue for on-site restoration projects. At the same time, the Fund worked closely with the Maryland Department of Natural Resources (MD DNR) and the Richard King Mellon Foundation (RKMF) to structure an offer and transfer the land to state ownership.

The deal closed in September 1999, providing for:

- 28,237 acres to the state of Maryland, including the most environmentally sensitive land and land adjoining existing state property, for $16.5 million
- 29,935 acres to the RKMF for $16.5 million, to be transferred to the state of Maryland after the Fund and its partners developed a sustainable forestry management plan

A short time after the sale was executed, a consensus emerged to create a management plan for sustainable forestry practices. The plan aimed to meet environmental and socio-economic goals, while providing a land management model for the public and private sectors. The Fund worked closely with The Sampson Group of Alexandria, Virginia, to develop the initial plan.

Photo: Ted Weber

When the plan was complete, the Fund signed a three-year contract with Vision Forestry, LLC, to manage the 29,000 acres held by the RKMF, which then donated the land to the state. The donation was made with the following agreements:

- The land will remain in perpetual public ownership.
- The land will be subject to a sustainable forest management plan, long-term supply agreement, and management agreement.
- Timber revenue will be used for management, restoration, and enhancement of forest resources, and will be shared with local counties.

In January of 2005, the MD DNR Forest Service completed a sustainable forest management plan for all 58,000 acres, now known collectively as the Chesapeake Forest Lands. The plan called for significant changes from the prior corporate operations, including:

- Moving from industrial forest management to multi-purpose public ownership and management
- Deploying "adaptive management" principles to sustain the health and productivity of the forest using state-of-the-art science and monitoring
- Using less intensive methods of forest regeneration and longer pine plantation rotations
- Executing a comprehensive assortment of restoration actions to improve water quality and to restore wetlands and wildlife habitat, particularly for the Delmarva fox squirrel
- Achieving greater access for public recreation, especially hunting
- Placing special emphasis on riparian buffer zones, including variable width buffers and management prescriptions
- Obtaining dual certification as a sustainable forest by the Sustainable Forestry Initiative and the Forest Stewardship Council
- Using an annual work plan to guide all aspects of forest management operations, including cost efficiency and conservation concerns.

The Chesapeake Forest Lands received dual certification in 2005. The MD DNR hopes to impress both industry skeptics and environmental groups by demonstrating that the forest can simultaneously become a self-sufficient business enterprise, a publicly accessible recreational asset, and a model habitat management area. This bold initiative will allow future generations to enjoy both the economic and environmental heritage that the forest has to offer.

Trends in the forest products industry have contributed to the parcelization of forestland as the transfers of corporate-owned forestland to other ownerships have increased dramatically.[31] Nationally, at least 25 million acres have dropped out of commercial forest ownership since the 1980s. In 2003 alone, 4.5 million acres of major United States timber holdings changed hands.[24] By 2010, an additional 12 to 15 million acres could be transferred out of industry ownership.

While some of these transfers are made to public interests or other forest products companies, most are sold to investment organizations such as pension funds, insurance companies, and banks. The main goal of these companies is to secure the highest rate of return for their investors—making them less likely to use capital for sustainable forest management.[32] If the selling spree of commercial forestland continues, many fear that these areas could be cut up into much smaller parcels in which condominiums and summer homes would replace trees.

As ownership among investment organizations continues to rise, new partnerships will be needed to decrease the chance of forest conversion and fragmentation.[33] Chesapeake Forest Products Corporation, once a stalwart of the Maryland and Virginia timber industry, liquidated its land holdings in 1999. In this case, a consortium of private, state, and federal interests were able to work quickly to raise the funds needed to retain these lands as forest, ensuring future protection for the Nanticoke River and Eastern Shore streams.

loss of investment in timber production as landowners anticipate continued growth and changes in land use. In addition, forest managers encounter increased local opposition to practices such as thinning and prescribed fire.

A groundbreaking study of these interactions in Virginia revealed that nearly 20% of all forestland in the commonwealth is in effect removed from commercial forestry because surrounding areas are too densely populated. The probability of timber management is nearly zero when population density exceeds 150 people per square mile because development pressure and social preference pushes out the needed forestry resources and infrastructure. As population decreases, the likelihood of timber management increases: 25% at 70 people per square mile, 50% at 45 people per square mile, and 75% at 20 people per square mile.[34] Based on these thresholds, less than 20% of counties in the Bay watershed have a high probability of supporting a viable timber industry.[35]

Increasing Land Values

Parcelization and expanding development generates land values that are significantly higher than timber values. Commercial timberland normally sells for much less than the land's value as residential sites, second homes, or recreational areas.[36] This is particularly true for forest properties around the recreational and scenic assets of the Bay. In these places, the financial pressure to sell major portions of forestland will likely be too great for landowners to resist. Whether they are families seeking retirement security or companies seeking profitable returns, the result is the same for forest management. Public investment can compete with these rising land values but as time goes on, even the government and major non-profits will be unable to compete with rising development pressures and land values.

Estate Tax

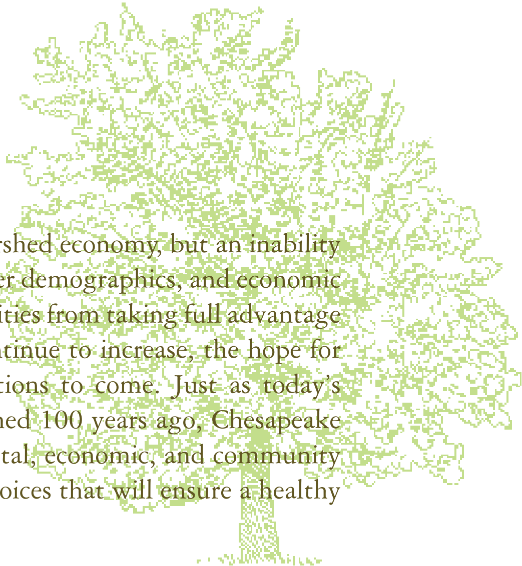
The federal estate tax often forces the sale of forest properties, which increases the risk of conversion to development. Estates valued at more than $1.5 million face taxes upon the death of the property owner. The estate tax is particularly worrisome in the Bay watershed because family owners make up 64% of all forest owners and individuals over 65 years old own over 40% forestland.[29] Corporations, which do not pay estate taxes, own only a small percentage of all forests. Current legislation is reducing the tax over time, but it is unknown if the changes will become permanent.

INDICATORS FOR SUSTAINABLE CHESAPEAKE FORESTS

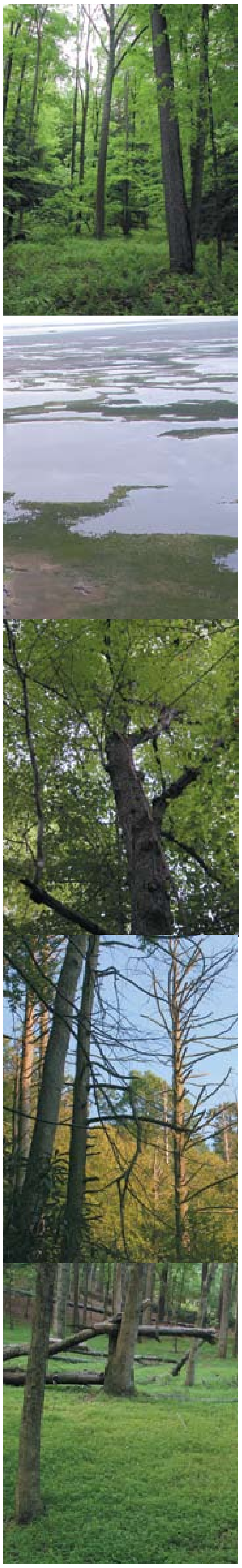
The following indicators could be used to track the economic sustainability of Chesapeake forests:

- Area and percent of forestland in watersheds with drinking water sources
- Ratio of timberland needed to meet local consumption of wood products to area of land harvested regionally
- Relative contribution of the forest products industry to the overall economy

CHAPTER IN PERSPECTIVE



Forests provide billions of dollars each year to the Chesapeake Bay watershed economy, but an inability to account for ecological services in the market place, changing landowner demographics, and economic restructuring in the forest products industry are restricting Bay communities from taking full advantage of their value. If the many forces of change discussed in this report continue to increase, the hope for economically and ecologically sustainable forests will fade for generations to come. Just as today's forests are substantially different from those present in the Bay watershed 100 years ago, Chesapeake forests 30 years from now could offer significantly different environmental, economic, and community values. However, Bay leaders can learn from past mistakes and make choices that will ensure a healthy "next forest" and Bay watershed.



Chapter 7:

The Next Forest

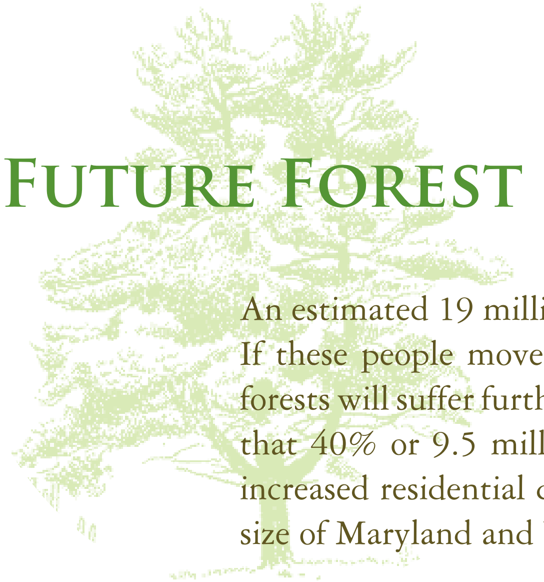
The last 100 years have been a time of dramatic change for Chesapeake forests. Concern about the widespread loss and degradation of forestland at the turn of the 19th century led to increased focus of governments, universities, and environmental groups on forest health and function. This prominent social and political movement helped expand forest cover and gave birth to the conservation movement. However, forests are again being lost and damaged. It is unlikely that we can maintain our quality of life and restore the Chesapeake Bay unless forests and their conservation become a more prominent part of public discourse. Embarking on conservation over the next 100 years may need a movement no less dramatic than a century ago.

Today, more is known about the role of forests and trees in the regions environment, community, and economy then ever before. Years of research, management, and lessons learned have provided the tools and information necessary to sustain healthy forests in the Bay watershed for years to come. At the same time, the issues affecting the "next forest"—future forest cover, health and habitat, and functions—have become increasingly complex. Perhaps for this reason, decision makers and the public in general seem alarmingly unaware of the crucial role forests play in maintaining the quality of our environment and our lives. The question remains—will we learn from the past and use the experience gained or will we repeat the mistakes of the past?

Current trends point to the "next forest" being one that is far more dominated by people and requiring the attention of foresters and other professionals to manage its health and to produce the forest-dependent benefits on which we will depend. It is likely that the total area of forestland will decline in the future and remaining forests will be more heavily fragmented. On the one hand, a large percentage of the "next forest" will be located closer to where people live and for many this will be their most common contact with nature. On the other hand, it will require more management to balance multiple interests. As farmland is developed, new "urban forests" will emerge over time. These "urban forests" will be more valuable to public health because of the benefits they provide in improving air quality and moderating climate.

The restoration of forests and riparian forest buffers on farmland holds promise for reconnecting forest corridors in rural areas. Widespread acceptance of local stream corridor protection ordinances and the growing interest in smart growth and low-impact development points to the potential for local governments to embrace planning that includes both development and "green infrastructure" needs and functions.

The job of protecting and helping manage Chesapeake forests will also present new challenges as a greater number of private landowners will have smaller forest landholdings and many will own forest land for the first time. With more people and competition for resources, the need for important forested areas that protect water quality, habitat, local jobs and income, and drinking water sources will be even greater than it is today. The demand for forest recreation will rise as will the value of protected forest lands.



FUTURE FOREST COVER

An estimated 19 million people will call the Chesapeake Bay watershed home by 2030.[1] If these people move to areas built using conventional sprawl development patterns, forests will suffer further wide-scale loss and fragmentation. Predictions for 2030 indicate that 40% or 9.5 million acres of all privately owned forestland will have experienced increased residential development in the Bay watershed.[2] This area is equivalent to the size of Maryland and West Virginia's portion of the Bay watershed.

FORESTS CONTINUE TO BE LOST AND FRAGMENTED BY DEVELOPMENT

Most forest loss to development will occur in the metropolitan corridor between Harrisburg, Pennsylvania and Richmond, Virginia. Many traditionally rural, forested areas (especially those near water) are becoming increasingly popular for bedroom communities, retirement homes, and vacation destinations. Future growth scenarios developed for the Washington, D.C., metropolitan region showed that the amount of developed land could increase by almost 80% or more than 800,000 acres by 2030 under current development patterns. Almost all of the newly developed land would replace farms and forests.[3]

Source: Google Earth

LESS FARMLAND BECOMES FOREST

After the massive clearing of forests in the 19th century, forest area increased by as much as 200% over the next century, mostly on abandoned farmland. This dramatic increase offset most of the forest loss to development until the late 1970s. As the supply of cheap farmland dwindles due to expanding development however, the net loss of forest will increase in the future, especially in the Ridge and Valley region and the Appalachian Plateau.[1,4]

New growth of "forest" will consist mainly of scattered trees planted in rapidly growing suburban developments. Suburban forests provide numerous benefits, but they do not approach the magnitude and range of benefits that large, contiguous forests provide.

MORE PRIVATE LANDOWNERS HOLD SMALLER FOREST PARCELS

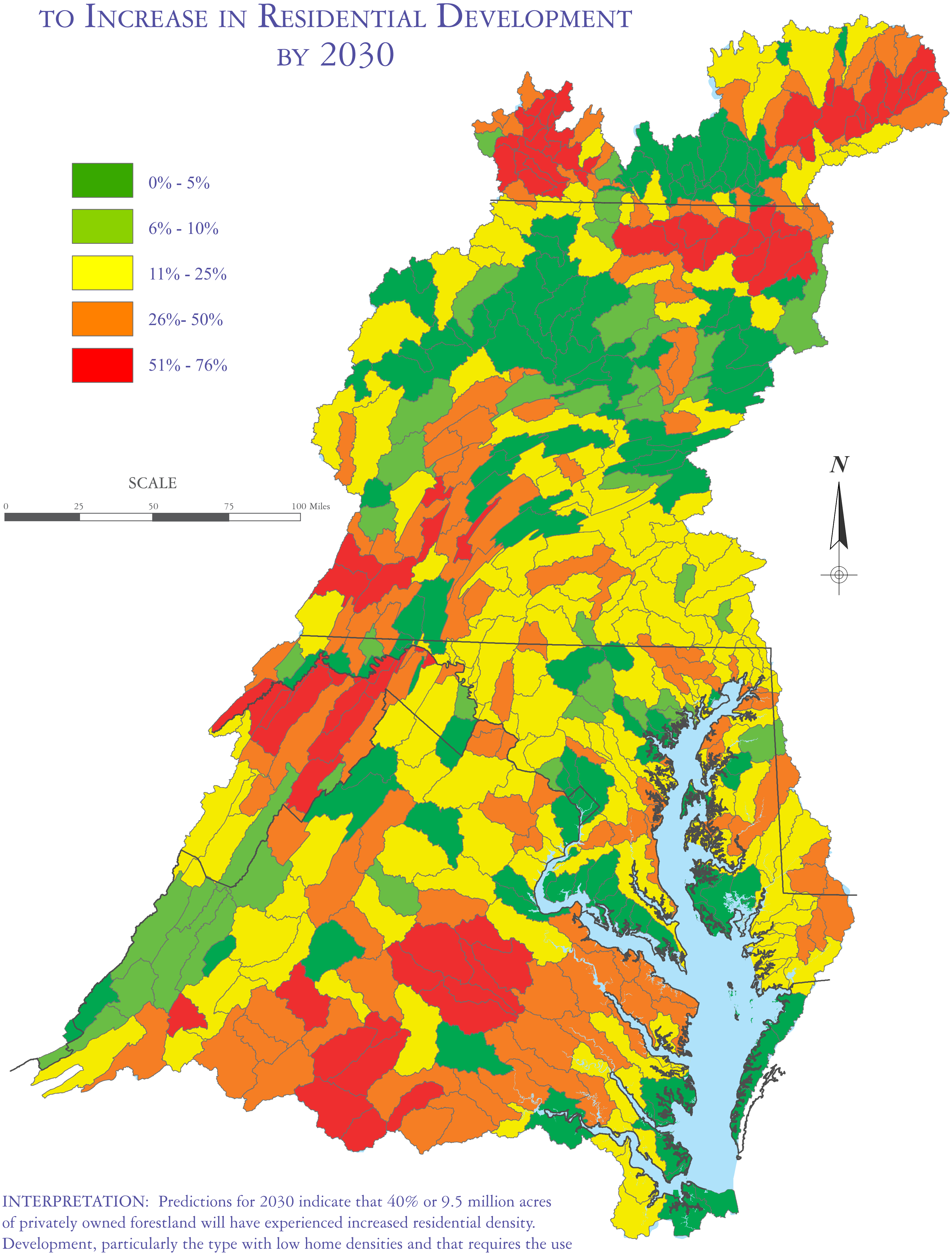
The parcelization of Chesapeake forests will continue through at least the next decade.[1] With increased parcelization of forest holdings, the risk of forest loss increases because of changing landowner objectives, rising barriers to management, and land values that have greatly increased. Over the past ten years, the Bay watershed experienced a 25% increase in the number of family forest owners. The average size of family ownerships decreased by 24% over the same time period so that today almost 70% of family forest owners hold less than 10 acres.

A significant portion of forestland—almost a third of family-owned forest acreage in the Bay watershed—is expected to be sold, converted to another land use, or passed on to heirs in the next five years.[5] Furthermore, the Bay watershed will soon face the largest intergenerational transfer of family-owned forest in the region's history. Aging landowners—more than 70% are older than 55—will transfer a substantial proportion of Chesapeake forests to new owners and heirs.

There is also uncertainty that the next generation of family forest owners will be active managers of their land, increasing the risk that forests will be sold or forest health issues will go unmanaged. The owners of the "next forest" are more likely to:

- Have livelihoods less connected with the land
- Not be raised on, live near, or likely to live on their family forestland in the future
- Lack prior involvement in the management of family forestland and largely do not wish to be involved now
- Lack the knowledge to manage the land, but want to own the land in order to derive income from it.[6]

PERCENT OF PRIVATE FOREST EXPECTED TO INCREASE IN RESIDENTIAL DEVELOPMENT BY 2030



INTERPRETATION: Predictions for 2030 indicate that 40% or 9.5 million acres of privately owned forestland will have experienced increased residential density. Development, particularly the type with low home densities and that requires the use of cars, threaten the economic, environmental, and quality of life benefits provided by forests. Data provide from the USDA Forest Service's Forests on the Edge project.

SOURCE: USDA Forest Service 2006, Forests on the Edge Project

FUTURE FOREST HEALTH AND HABITAT

IMPORTANT FOREST HABITATS ARE LOST TO DEVELOPMENT

The "next forest" will still be significant in size and distribution. However, based on current development trends, 45% of the Bay watershed's network of forests and wetlands is vulnerable to future development.[7] Many of these threatened forests are large, high-quality tracts that are not under public ownership or otherwise protected, especially along the western shore of the Bay and the areas surrounding Richmond and Fredericksburg, Virginia.

Over 50 imperiled plant and animal species are threatened by current development patterns in the metropolitan areas of Baltimore, Maryland; Washington, D.C.; Richmond, Virginia; and Virginia Beach, Virginia alone.[8] An analysis of the Mid-Atlantic region found that 8% of counties that contain sensitive ecological resources are in the path of future land use change.[9]

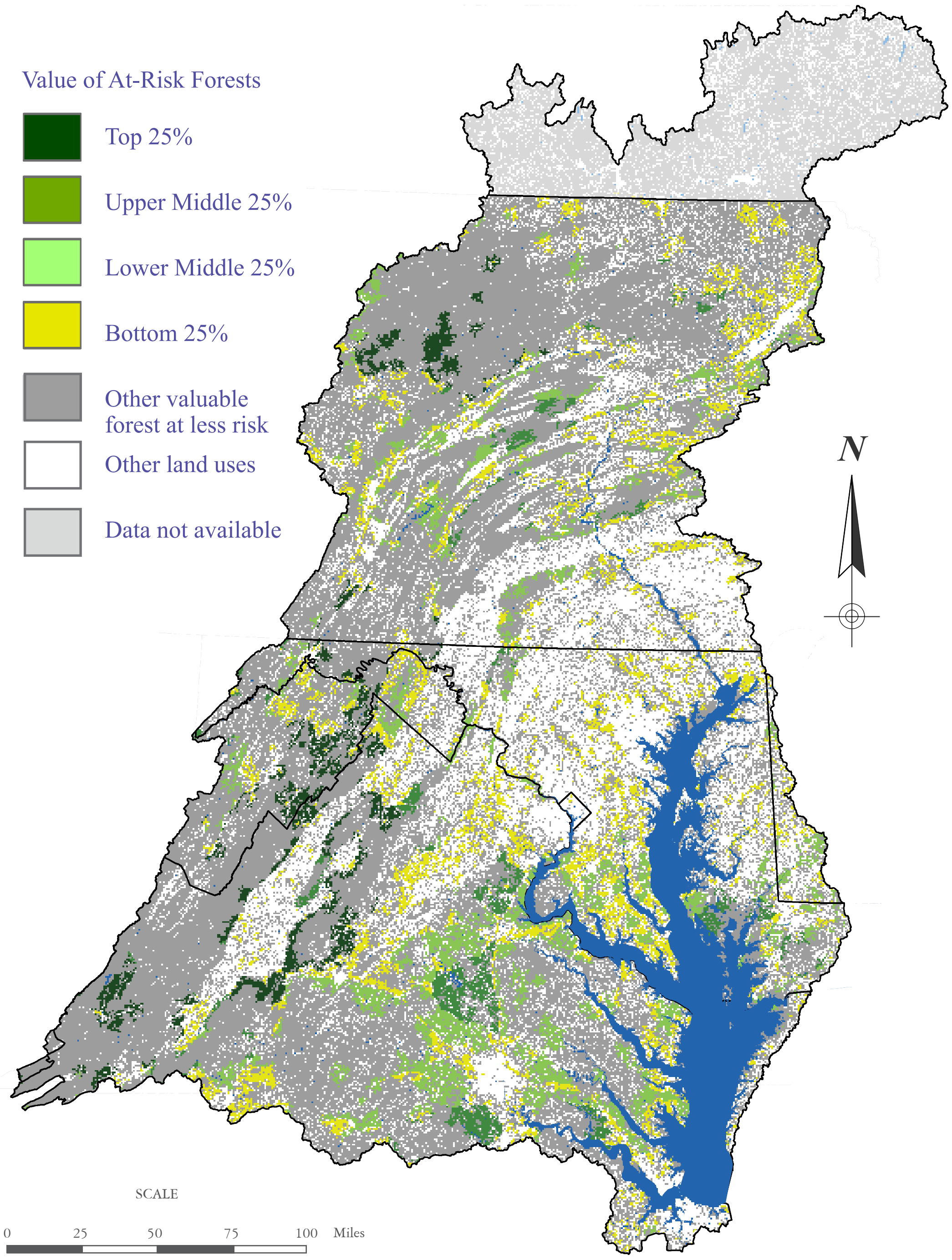
GROWING NUMBERS OF FOREST PESTS CHANGE THE COMPOSITION OF FORESTS

Over the next 15 years, 17% of Chesapeake forests will be at a high risk to mortality from known pests and pathogens like the gypsy moth, beech bark disease, and hemlock wooly adelgid.[10] What is more alarming is the unknown number of new pests that will enter the region. These emerging threats include the:

- Emerald ash borer: Over 470 million ash trees in the Bay watershed are at risk to mortality from the emerald ash borer.
- Sudden oak death: Though not currently known to affect eastern forests, sudden oak death is expected to spread to this area. The fungus-like organism has been found in 18 states since 2000, including Maryland, and affects many plants other than oak trees.[11]
- Asian longhorned beetle: This beetle will threaten many Chesapeake hardwood species including maple, birch, poplar, and sycamore with mortality in the future. Approximately 70% of trees in Pennsylvania and more

ECOLOGICALLY VALUABLE FORESTLAND VULNERABLE TO DEVELOPMENT

RESOURCE LANDS ASSESSMENT



INTERPRETATION: Based on current development trends, 45% of the Bay watershed's network of forests and wetlands is vulnerable to future development. Many of these threatened forests are large, high-quality tracts that are under private ownership and are not protected. Forestland was considered vulnerable if at a "moderate" or "high" risk to development. For the complete methodology, see http://www.chesapeakebay.net/land.htm.

SOURCE: Chesapeake Bay Program 2005

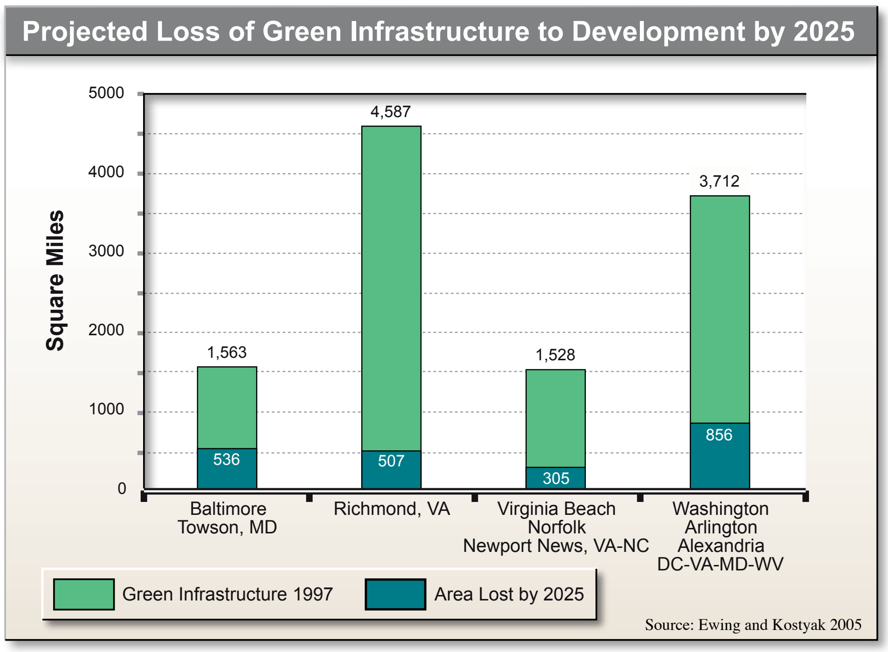
than 50% in West Virginia are at risk to infestation.[12] If the beetle causes a die-off in the 47% of susceptible tree species that are in Baltimore, Maryland, the total compensatory value could reach more than $1 billion.[13]

More than 70% of the forests at high risk to mortality exist on private land.[10] Because families own the majority of private forestland, they are best able to provide early detection and control. However, most family forest owners are not interested in or knowledgeable about forest pests and management. As development spreads across the Bay watershed, roads, suburban gardens, and other avenues will be created that allow invasive pests and plants to increase their presence in Chesapeake forests.

Overabundant Deer Populations Change Biodiversity

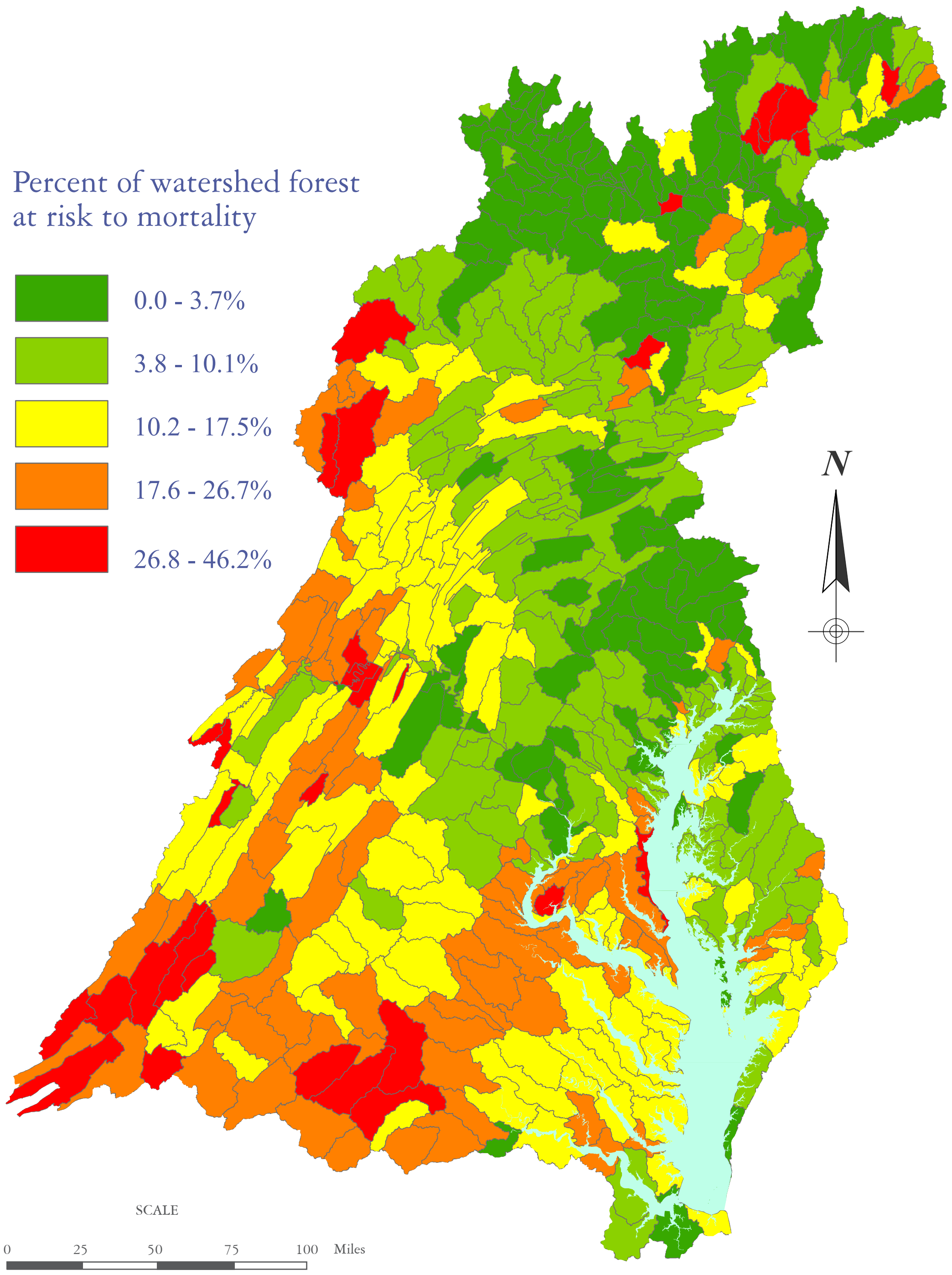
By selectively feeding on certain plants, deer overbrowsing can change forest composition. Shifts in forest plant communities, in turn, affect wildlife species that depend on this vegetation for food and shelter. Continued overbrowsing in the northern Chesapeake forests could produce near monocultures of black cherry with remnants of red maple, American beech, and striped maple. Understories in old and second-growth stands could consist of primarily ferns, mosses, grasses, and seedlings of American beech, striped maple, and black cherry which are resistant to deer browse.

Regeneration of oak trees has been particularly affected by deer. Mixed oak forests with high deer densities and lack of natural fire events are often replaced by ferns, mountain laurel, rosebay rhododendron, flowering dogwood, sassafras, sweet birch, black gum, red maple, or yellow poplar.[14] In Pennsylvania, a more homogenous forest dominated by red maple and sweet birch is slowly replacing the once expansive and diverse oak forests.[15,16]



Source: Ewing and Kostyak 2005

Watersheds at Risk of Mortality from Insects and Disease



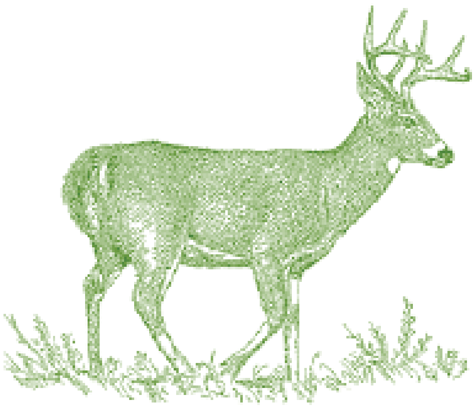
INTERPRETATION: Over the next 15 years, 17% of Chesapeake Forests will be at a high risk of mortality from pests and pathogens like the gypsy moth, beech bark disease and hemlock wooly adelgid. Forestland is considered at risk if 25% or more of trees can be expected to die over the next 15 years.

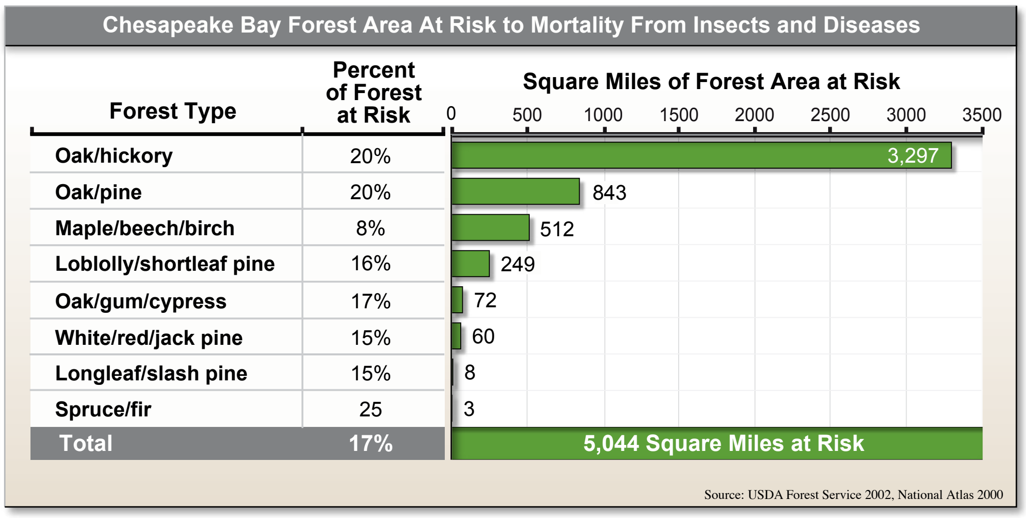
SOURCE: USDA Forest Service 2002

Densities greater than 20 deer per square mile restrict regeneration and diversity of woody vegetation.[17] Densities of even 10 deer per square mile can limit the full regeneration of forest understories.[18,19] Even with strong limitations on deer browsing, many forests may not return to their native conditions because of the introduction of problems like tree diseases, insect infestations, and invasive plants.[15]

Nowhere in the Bay watershed are the effects of deer overbrowsing more evident than in Pennsylvania. More than 50% of all forests lack sufficient numbers of seedlings and saplings to replace the existing forest with a similar tree composition. If deer control is not increased, more than 60% of desirable timber species will not be available to the Pennsylvania timber industry in the future.[20]

While Pennsylvania provides an example of the potential effects of overbrowsing, forests throughout of the Bay watershed have been impacted in similar ways. For example, a recent study of forests in Baltimore County, Maryland, found that they had virtually lost their natural ability to regenerate because of overbrowsing by white-tailed deer.[21] County officials have determined that managing the deer population is critical to protecting the forests that, in turn, protect the region's drinking water supplies.[22]





Chesapeake Bay Forest Area At Risk to Mortality From Insects and Diseases

Forest Type	Percent of Forest at Risk	Square Miles of Forest Area at Risk
Oak/hickory	20%	3,297
Oak/pine	20%	843
Maple/beech/birch	8%	512
Loblolly/shortleaf pine	16%	249
Oak/gum/cypress	17%	72
White/red/jack pine	15%	60
Longleaf/slash pine	15%	8
Spruce/fir	25	3
Total	17%	5,044 Square Miles at Risk

Source: USDA Forest Service 2002, National Atlas 2000

Photo: Will McWilliams

Lack of understory due to overbrowsing by deer.

FUTURE FOREST FUNCTIONS

BAY AND RIVER WATER QUALITY DECLINES BECAUSE OF FOREST LOSS

Based on current development patterns, 31% of the forests that are most valuable for water quality protection are threatened by development.[7] The loss of these forests will compromise or degrade water quality and watershed functions and our ability to protect the Bay. A loss in forest cover of as little as 10% can increase nitrogen loss to water by 40%. Conversely, a gain in forest cover can improve water quality.[23] The majority of vulnerable and highly valuable forestland, including riparian buffers, occurs in the heavily settled Coastal Plain. This is significant because forest loss and fragmentation near the Bay and its tributary rivers can have a proportionately greater impact than similar trends farther away.

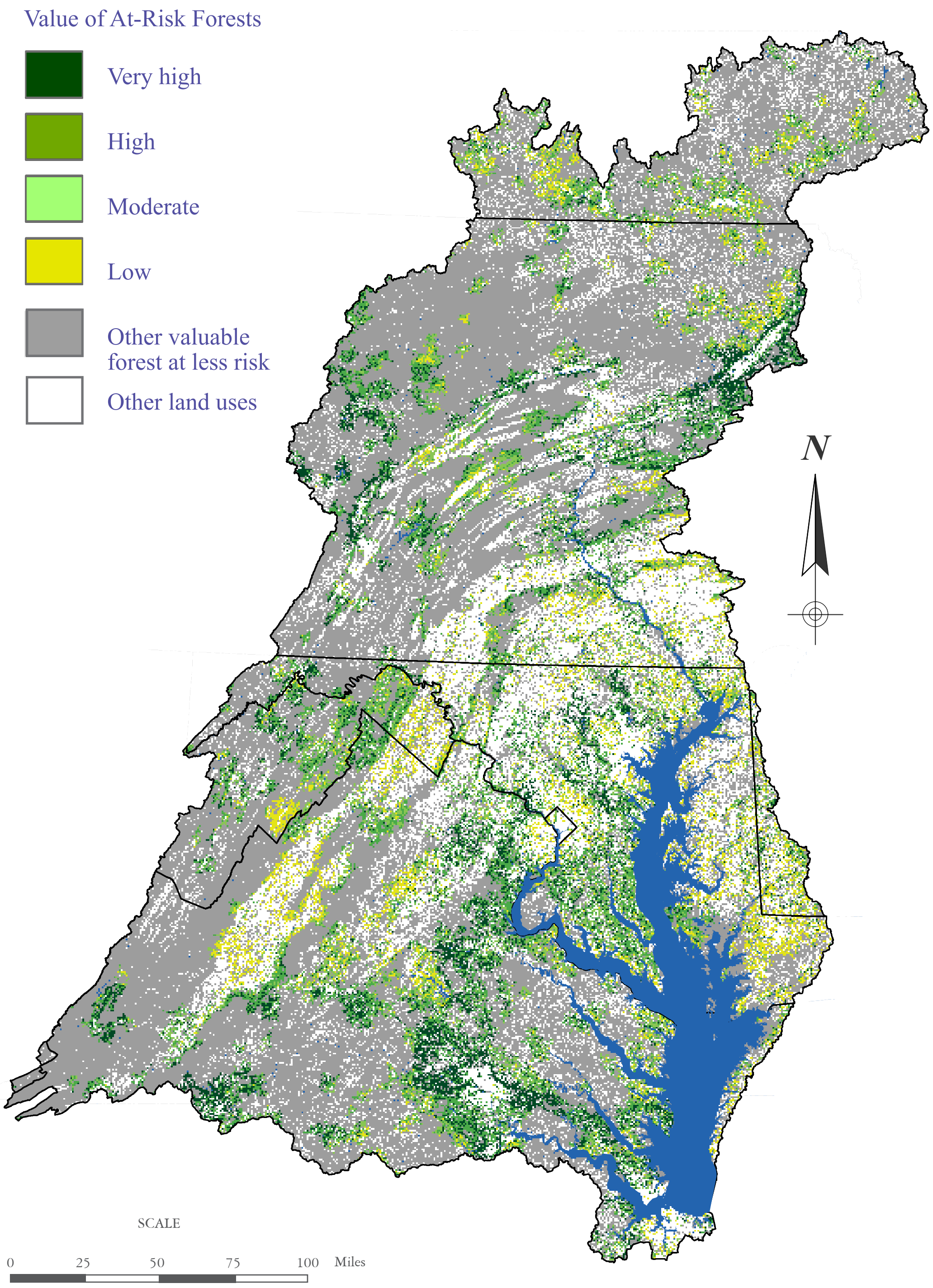
Threats from development are not confined to metropolitan areas, however. Forest loss and fragmentation in headwater regions also will degrade drinking water sources and aquatic habitat.

MORE NITROGEN FROM AIR POLLUTION REACHES THE BAY

If current efforts to control power plant and automobile emissions are unable to decrease the rate of atmospheric deposition of nitrogen in the Bay watershed, nitrogen loss from forests to streams could increase by 200%. If the rate were stabilized at current levels, nitrogen retention rates would still decline over time as some Chesapeake forests become nitrogen saturated. Under current trends the nitrogen loss to streams would increase by more than 30% by 2050 making it harder to reach water quality goals.[24]

VULNERABILITY OF FORESTS IMPORTANT TO WATER QUALITY

RESOURCE LANDS ASSESSMENT



INTERPRETATION: Based on current development patterns, 31% of the forests with the highest value for water quality protection are threatened by development. The loss of these forests will severely degrade water quality and watershed functions. The relative importance of forests to water quality was determined by grouping forest with similar values into four categories from "very high" to "low." The most important forests at risk were in the top two water quality categories and were at a "moderate" or "high" risk to development. For the complete methodology, see http://www.chesapeakebay.net/land.htm.

DECREASED POTENTIAL FOR FOREST HARVESTING IN DEVELOPING AREAS

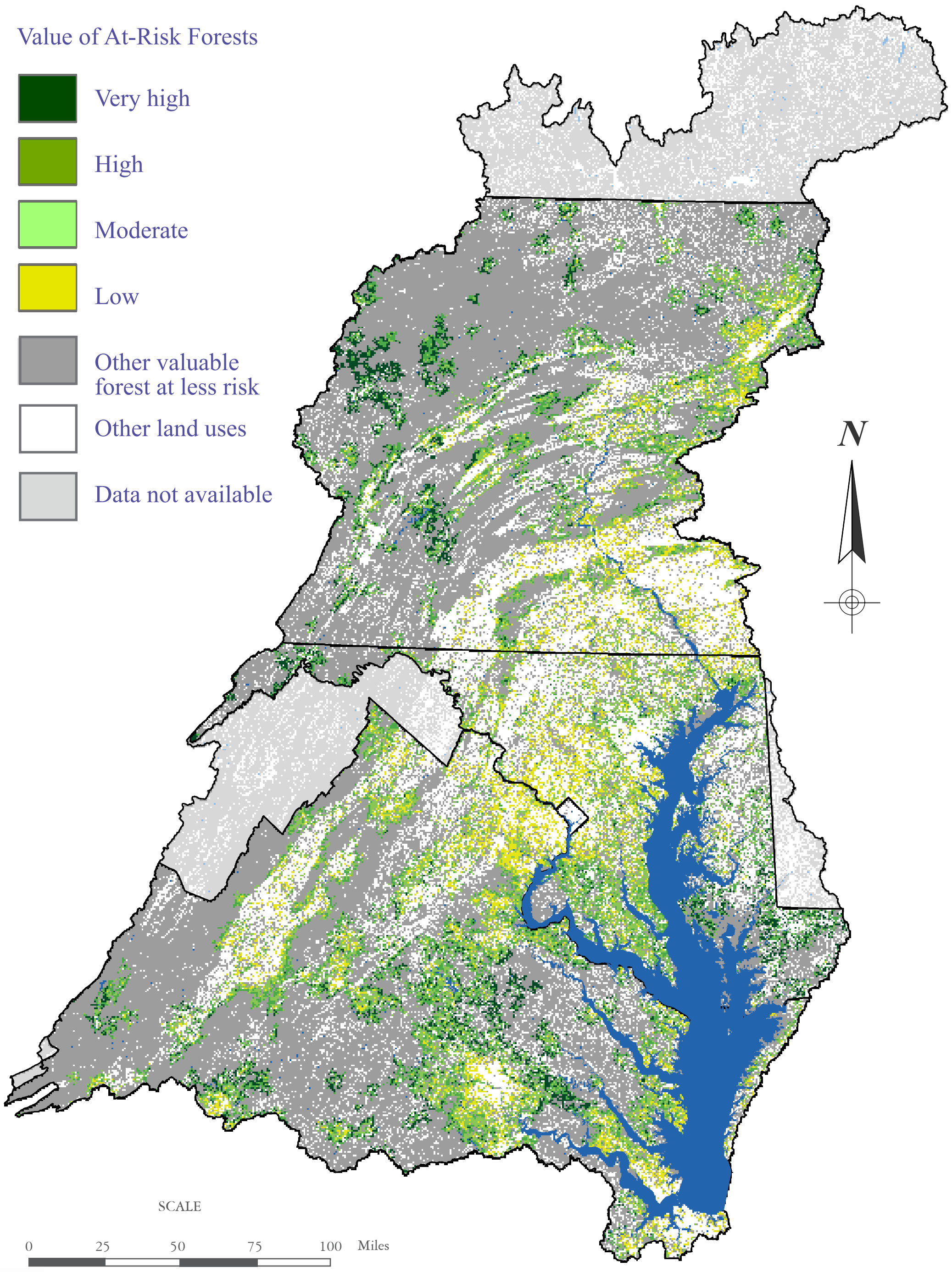
Based on current development patterns, 22% of forestland that currently supports the forest products industry—or has the potential to—is vulnerable to development.[7] These at-risk forests can be found throughout the Bay watershed, but the loss of forests in northwest Pennsylvania, along Maryland's Eastern Shore, and between Washington, D.C., and Richmond, Virginia, would threaten valuable sources of local jobs and income. In Virginia, nearly 20% of all forests are considered incompatible with forest management because of their proximity to population centers. The commonwealth is approaching the point where demand for forest products will outpace the rate at which timber can be grown on available land.[25]

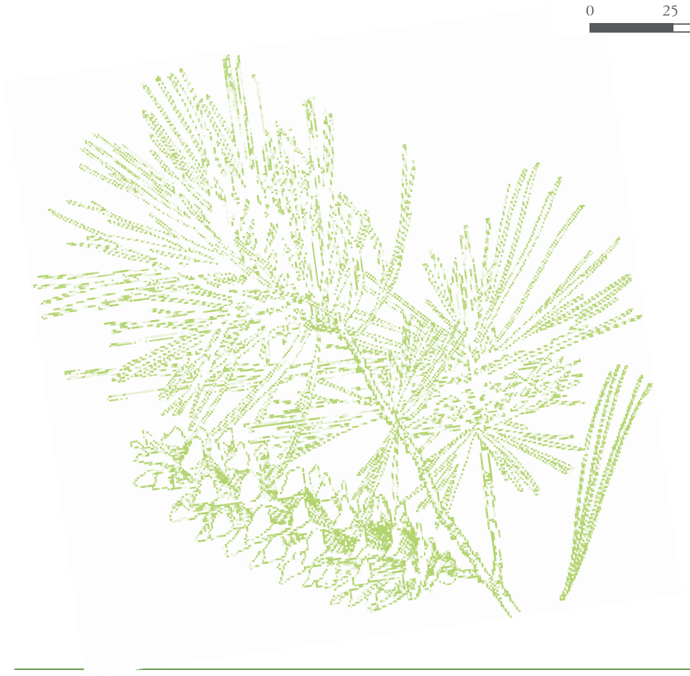
INTERPRETATION: Based on current development patterns, 22% of forestland that currently supports the forest products industry—or has the potential to—is vulnerable to development. The loss of these forests would diminish the constant supply and free source of ecological services like water and air quality protection and threaten valuable sources of jobs and income. The relative importance of forests to state economies was determined by grouping forest with similar values into four categories from "very high" to "low." The most important forests at risk were in the top two economic value categories and were at a "moderate" or "high" risk to development. For the complete methodology, see http://www.chesapeakebay.net/land.htm.

SOURCE: Chesapeake Bay Program 2005

ECONOMICALLY VALUABLE FORESTLAND VULNERABLE TO DEVELOPMENT

RESOURCE LANDS ASSESSMENT





ALTERED FOREST COMMUNITIES DUE TO CLIMATE CHANGE

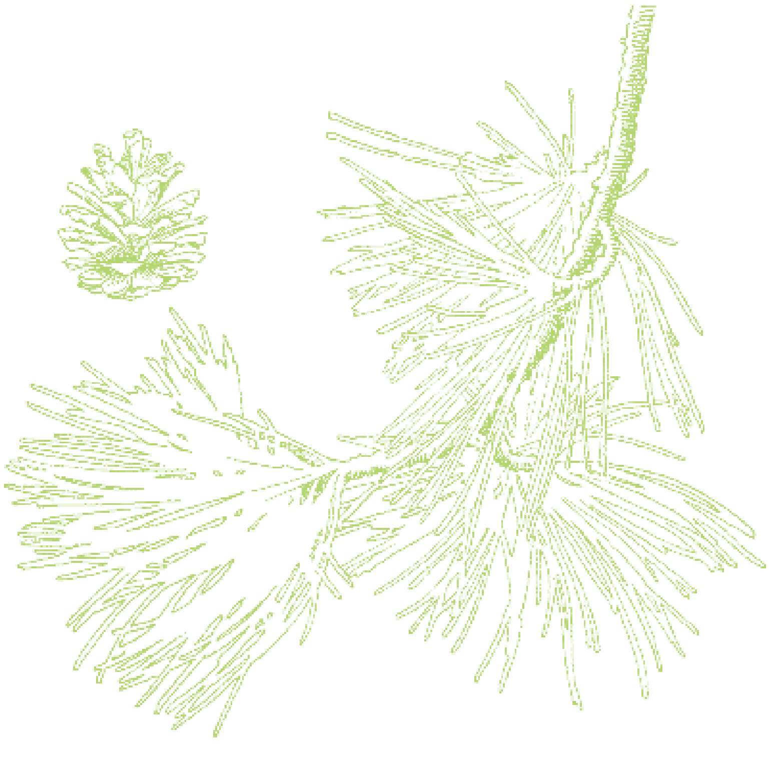
Evidence is mounting that climate change will affect Chesapeake forests.[26] Despite the inability to make specific predictions, it is clear that higher temperatures and altered precipitation regimes will change forest composition and function and the benefits that forests provide to Bay watershed residents. Over the next 30 years, potential impacts include:

- Northward migration of forest types—loss of maple/beech/birch, and the expansion of oak/hickory and loblolly/shortleaf pine
- Enhanced activity of insects and diseases
- Increased incidence of fire and drought
- Extension of growing season, though net growth may not change due to increased respiration[1,27]

It is unlikely that climate change will drastically alter the overall environmental services provided by forests; more likely are gradual changes driven by new environmental conditions. This shift will change the abundance of many plant and animal species, altering the ecological composition of forests.


Photo: Ted Weber

Submerged Pine Forest



Chapter 8:

Strategies for Forestland Protection, Restoration, and Stewardship

The loss of healthy forests directly affects the forest landowners, communities, habitat, and economy of the Chesapeake Bay watershed. At stake is the long-term sustainability of Chesapeake forests as well as the ability to improve and sustain the future health of the Bay. But this and other trends need not continue unabated or unchanged. Choices made in the next decade have the potential to alter these trends and lead to a more sustainable future.

To meet the many "forces of change" altering the health of Chesapeake forests, a collection of potential goals and strategies is presented in this chapter to guide government agencies, regional environmental groups, and other organizations. Many of these protection, restoration, and stewardship strategies are still emerging and may require new funding sources, creative approaches, and diverse partnerships. They do not represent the only means to achieve each goal identified, but are real and innovative ways to sustain healthy forests. Perhaps most critical is realizing that no one strategy alone will ensure forest sustainability. A combination of approaches is needed to best protect forest habitats, drinking water sources, jobs and income, and public health.

Goals and Strategies for Sustainable Chesapeake Forests

GOAL	STRATEGY
Retain and expand the Chesapeake's exceptional forest resource	1. Protect the Chesapeake's exceptional forest resource by identifying, conserving, and restoring forests that have high environmental, economic, and social value at a landscape scale. 2. Direct land use planning efforts to reduce the loss and fragmentation of forest resources in developing areas. 3. Lower the risk of forest loss due to parcelization by encouraging management on family-owned and other private forests. 4. Protect large tracts of forestland by enhancing the viability of the forest products industry.
Improve and sustain the health and high diversity of Chesapeake forests	5. Sustain the naturally high diversity of Chesapeake forests by managing for a variety of habitats and balanced deer populations. 6. Protect Chesapeake forests from widespread damage by preventing new introductions of invasive plants, pests, and pathogens; curbing the sale of highly invasive species; and focusing control efforts on high priority forests.
Manage forests to enhance ecological services and public health benefits	7. Recognize the public benefits of private forestland by compensating landowners with funding and other incentives to sustainably manage their forests to benefit the Bay watershed. 8. Make forest conservation and restoration a primary tool for improving stormwater management by accounting for the superior ability of forestland to remove pollutants, improve stream health, and moderate runoff. 9. Sustain the ability of forestland to improve water quality by restoring and managing forest cover in areas with high nitrogen air deposition rates. 10. Use tree canopies to protect public health by incorporating forest benefits in air quality attainment strategies. 11. Maximize watershed benefits by ensuring that forests buffer greater than 70% of riparian areas in a watershed through a combination of incentives and regulations. 12. Ensure a long-term drinking water supply and reduce treatment costs by protecting and restoring forests in high priority areas. 13. Expand existing urban tree canopy to enhance environmental benefits, public health, and quality of life by assessing tree cover, setting local goals or land use targets, and adopting implementation plans. 14. Bring ecological services into the market place by establishing forest mitigation and trading systems and a registry to facilitate transactions.
Increase public appreciation of forest values and track their condition over time	15. Communicate the public's dependency on forests for daily needs such as high quality drinking water, clean air, jobs, and recreational opportunities, and articulate the need for sustainable management. 16. Measure changes in the state of the Chesapeake's forests through a set of condition indicators.

Goal 1: Retain and expand the Chesapeake's exceptional forest resource.

Strategy 1: Protect the Chesapeake's exceptional forest resource by identifying, conserving, and restoring forests that have high environmental, economic, and social value at a landscape scale.

The Chesapeake Bay watershed contains an expansive stretch of the highest quality hardwood forestland remaining in the temperate climates of the world. A landscape level approach is necessary to prioritize and protect forests for biodiversity, economics, water quality, public health, and quality of life. This is particularly important since funding for conservation is uncertain. A growing number of Chesapeake communities have developed landscape analyses to identify conservation priorities using tools such as green infrastructure and resource land assessments. In 2004, Talbot County, Maryland, developed a green infrastructure assessment in conjunction with a comprehensive plan update in order to help county planners preserve their natural resources, ensure the economic viability of working farms and forests, and orient development in a way that is compatible with the resources and character of the county.

Green infrastructure assessment and mapping efforts provide baseline conditions that can be tracked over time as a barometer of the local forest landscape and the related features they protect, such as streams, air quality, habitats, groundwater, and soils. Goals for future forest cover should be established for watersheds or jurisdictions based on desired ecosystem services and the geographic location of existing green infrastructure. Too often, forest conservation is not considered as an integral part of land use planning. Goal setting should be approached with a strong emphasis on science and quantitative methods that recognize the need to protect the functional role forests play in a specific landscape.

Forest conservation will never again be as cost-effective as it is today. State and local governments, land trusts, and other organizations have a significant opportunity to connect existing forests and restore high priority forests on marginal agricultural land and abandoned mine land in Pennsylvania, along with smaller areas in Maryland, West Virginia, and Virginia.[1]

Photo: Ted Weber

Chesapeake Bay Green Infrastructure Assessments

The Chesapeake Bay Program completed a Resource Lands Assessment to identify the most important remaining forests and wetlands in the Bay watershed. The Resource Lands Assessment identifies conservation focus areas that help guide government, land trusts, and other organizations with forest protection efforts. For customizable data and other information, visit http://www.chesapeakebay.net/land.htm.

Through its Green Infrastructure program, The Conservation Fund works with the public and private sector to promote protection, management, and resource planning activities that are proactive, holistic, multi-functional, and multi-scale. From GIS mapping and land acquisition to education and training, the Fund's Green Infrastructure program is a comprehensive initiative that helps advance strategic land conservation benefiting people, wildlife, and the economy. The Fund has developed plans and scoping assessments for communities and states across the Bay watershed. For more information, visit www.greeninfrastructure.net.

Strategy 2: Direct land use planning efforts to reduce the loss and fragmentation of forest resources in developing areas.

Sprawl or low density, automobile-dependent development is the main cause of forest loss and fragmentation in the Bay watershed. States, local governments, and individual citizens can assess how their land use plans are affecting forest loss and fragmentation. Regional and local land use plans rarely address the future extent of forests, but such plans are needed to direct new development to existing communities and away from high priority forestland. While development pressure may be most acute near metropolitan areas, even rural communities should have a plan that supports their vision, or the future will be decided for them. Compared to sprawl, managed growth can reduce the conversion of forests and wetlands by 26% in Bay watershed states and save nearly 300,000 acres between 2000 and 2025.[2]

The conservation of forestland in the face of development is critical because of the high cost of restoration and difficulty of creating man-made systems to mimic natural processes like water filtration. Too often, open space protection plans are identified after the development of buildings and roads. Using zoning overlays or other techniques that are implemented at the time of land use change (from forest or farmland to development) can be powerful tools protect and restore green infrastructure.


Photo: Jennifer Curkendall

Strategy 3: Lower the risk of forest loss due to parcelization by encouraging management on family-owned and other private forests.

A big unknown for the future of Chesapeake forests is whether the nearly 15,000 families and individuals that own 64% of all forestland in the Bay watershed will sell their land or, alternatively, retain it and become better forest stewards. The owners of small parcels are not likely to manage their forests, and many do not even consider themselves forest landowners. Fewer than 20% of family forest owners have written management plans and only a third have sought professional advice.[4] A well thought-out forest management plan helps landowners identify and recognize the value of their land and better predict the effects of any activities. The State of Maryland has estimated that 75% of privately owned forestland need management plans in order to have a stable, productive land base that sustains both the ecosystems and industries that depend on it.[5] At a minimum most landowners need professional advice.

As the parcelization of Chesapeake forests continues, the risk of forest loss rises due to changing landowner objectives and decreasing economic opportunities for managing forests. Increasing the value landowners derive from their forests—either economic or aesthetic—through management could persuade more owners to hold on to their land instead of selling to developers or investment organizations. A program in the State of Wisconsin works with third parties like non-governmental organizations, local governments, and forest product companies to increase sustainable management on private lands by connecting landowners with markets. Landowners can receive forestry services including plans, harvest assistance, and other plan implementation services such as tree planting at a lower cost than if they acted alone. The forest products industry can profit from easier access to small, private parcels, while environmental concerns can be addressed with less difficulty.

Cooperative management of nearby small forest parcels also can help to pool resources and mitigate some of the economic disincentives to management that small landowners face. Governments and other organizations could establish mechanisms and financial incentives that reduce barriers and encourage cooperative management of forest parcels.

States or university extension programs can also train interested landowners to demonstrate and encourage the development and use of management plans to their neighbors. Pennsylvania has had success with their Forest Stewards program that provides classroom and field training in forest ecology, biodiversity, silviculture, wildlife science, environmental resource management, and other subjects related to stewardship. In exchange, the volunteers agree to invest a like amount of their time relaying what they have learned to motivate forest landowners in their communities. Furthermore, marketing successful local examples of forest management on varying parcel sizes could be a powerful tool to show that management is a viable option.

MARYLAND'S FOREST CONSERVATION ACT

The State of Maryland's Forest Conservation Act provides for the conservation and restoration of trees during development projects. A forest conservation plan is required for any activity needing an application for a subdivision, grading permit, or sediment control on areas 40,000 square feet or greater. Between 1992 and 2002, Maryland forest conservation programs retained 65% of existing tree cover on development sites.[3] This unique model can be modified for local considerations and serve as a valuable tool for protecting forestland in other Bay states as well.

Forest certification is another potential strategy for increasing sustainable forest management on family forests. Certification systems provide a “seal of approval” that serves as a marketing tool among consumers. The American Tree Farm system offers small landowners recognition for good practices and provides professional advice.[6] This certification system also allows small forestland owners to enter into group certifications with surrounding landowners to help offset some of the associated administrative costs.

Tax benefits can also encourage the use of sustainable management. For example, additional property tax breaks could be given to landowners who have a management plan in place and implement its provisions. The benefits could be targeted in priority forest areas to maximize ecological services, promote healthy forest conditions, support timber production, and serve other purposes.

Strategy 4: Protect large tracts of forestland by enhancing the viability of the forest products industry.

The changing economics of the forest products industry has resulted in large transfers of forestland to investment organizations, developers, and other groups. These transfers greatly increase the risk that large areas of forestland will be developed for homes or other uses. A system of "forest economic resource areas" can be established by state and local governments in economic priority areas to protect the working land base and reduce operation costs. Forest economic resource areas can receive targeted incentives to increase use of low-value wood and biomass as well as bolster sawmills and other declining industry infrastructure and to protect working forests threatened by development. In these areas, support through designation of industries as a "growth industry" by state economic development agencies can bring additional investment.

States and local governments can also explore "right to practice forestry" legal protections to ensure that legitimate and sustainable forestry practices are not prohibited by local ordinances or regulations, especially in rural low-income communities vulnerable to development. The State of New York enacted "right to practice forestry" legislation in 2003 to promote sustainable forestry and appropriate forest management practices. Low-income rural counties that contain forests with high economic value include Garrett County, Maryland; Sullivan County, Pennsylvania; Nottoway County, Virginia; Buckingham County, Virginia; Prince Edward County, Virginia; and Somerset County, Maryland.[7,8]

To protect the long-term economic and ecological value of forest economic resource areas, states and other organizations can encourage the certification of sustainable management on public forestland and partnerships with corporations and university extension programs to develop third party certification on private forestland.

Many new structures are being built as "green buildings" using standards set by the United States Green Building Council, called Leadership in Energy and Environmental Design (LEED). The certification system established by the Forest Stewardship Council is currently the only accepted system within the LEED standard and is an important demand driver for certified wood today. The Forest Stewardship Council system has been limited to large forest land holders who can afford the high cost of certification. Acceptance of other certification systems within the LEED system could provide greater demand for sustainable forestry.

Also, past land use and management have created large areas of forestland that are overcrowded with small-diameter trees that are not traditionally valuable to the forest products industry. Establishing commercial markets for these trees can help bolster local economies while improving forest health. Low quality hardwoods and other biomass present an opportunity for a cleaner and renewable fuel source as oil and gas prices rise. Non-timber products such as berries, mushrooms, and ginseng also provide opportunities to provide income to some forest landowners.

FOREST CERTIFICATION IN PENNSYLVANIA

Forest certification is an independent scientific review process that determines whether a forest is being managed in an environmentally responsible manner while considering timber resource sustainability, forest ecosystem maintenance, and financial and socioeconomic factors. The Forest Stewardship Council, American Tree Farm, and Sustainable Forestry Initiative are prominent third-party certification systems in the United States. Pennsylvania's 2.1 million acres of state forestland is the largest tract of forest in North America to be certified by the Forest Stewardship Council.[9] Other Chesapeake states can follow Pennsylvania's example to ensure sustainable management on all state lands. For more information, visit http://www.dcnr.state.pa.us/forestry/certification.aspx

Photo: Broderbund

GOAL 2: IMPROVE AND SUSTAIN THE HEALTH AND HIGH DIVERSITY OF CHESAPEAKE FORESTS.

Strategy 5: Sustain the naturally high diversity of Chesapeake forests by managing for a variety of habitats and balanced deer populations.

To sustain the naturally high diversity of Chesapeake forests, more active forest management is necessary. Building on the conservation priorities identified in landscape assessments, a network of "protection forests" can be established to specifically identify lands for habitat enhancement, protection, or other specific management strategies. This system could consist of existing public lands and other forests that are managed to promote a variety of forest ecosystems, such as late-successional native forests, and to protect unique forest ecosystems and rare species.

Healthy forests include uneven stand ages, layered canopies, downed woody debris, and other characteristics that greatly improve forest habitat. Management options can include allowing or mimicking natural disturbances, establishing and managing landscape corridors, and controlling invasive plants and pests and human activities. Active management of larger "protection forests" would maximize the ability of forestland to withstand extreme storms or other disturbances while also maintaining breeding habitat for species that require protection from the effects of forest edges. Smaller areas would be appropriate in developed or agricultural landscapes and serve as refuges for migrating birds, pollutant filters for streams, and parks for local communities.

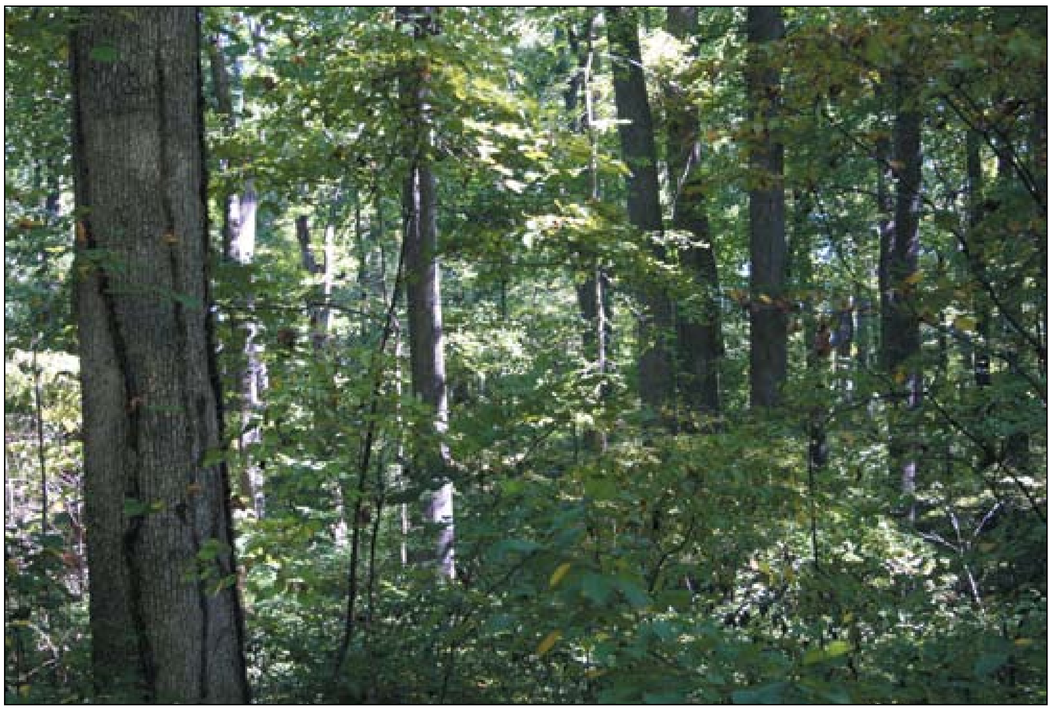


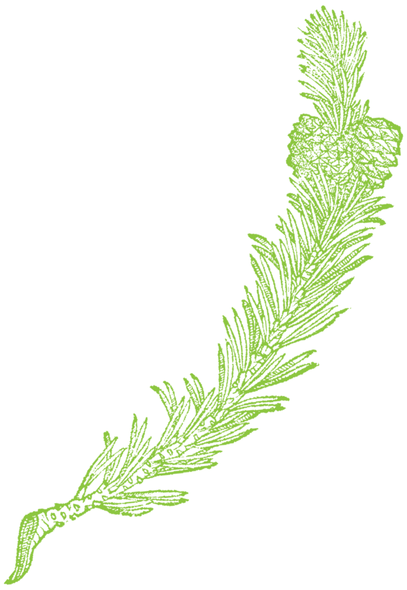
Photo: Eric Sprague

In many areas of the Bay watershed, particularly in Pennsylvania, browsing by overabundant deer populations is destroying tree seedlings, shrubs, and wildflowers. An adaptive management approach should experiment with varying techniques to lowering deer populations. Hunting currently appears to be the only practical solution to managing deer. In addition to increasing harvest limits, geographically targeted hunts such as "Harvest for the Hungry" or those implemented for water supply protection are options. Control via contraception has proven both ineffective and costly. In addition, venison from deer that have been exposed to contraceptives is not approved for human consumption. Trap and transfer methods have been unsuccessful because deer frequently do not survive the traps, and other communities do not necessarily want more deer.[11]

Strategy 6: Protect Chesapeake forests from widespread damage by preventing new introductions of invasive plants, pests, and pathogens; curbing the sale of highly invasive species; and focusing control efforts on high priority forests.

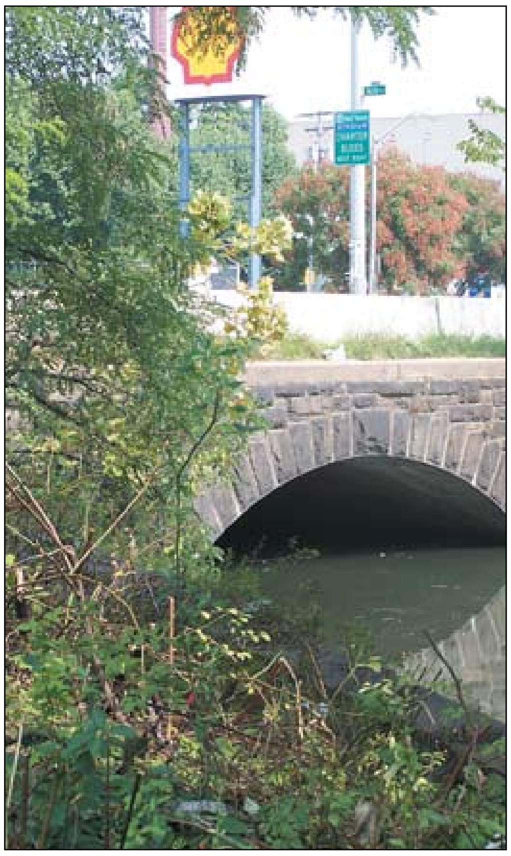
Without more effective restrictions or preventative measures, exotic forest pests and associated diseases will continue to alter forest conditions in the Bay watershed. Preventing entry is paramount: once exotic pests establish populations in the United States, it is nearly impossible to eradicate them because they reproduce rapidly, disperse easily, and lack natural predators. Governments can control particularly egregious pests by prioritizing threats and likely points of entry. To be most effective, organizations can target eradication efforts towards forests with high habitat and water quality value. It is also important to establish emergency response plans to control newly discovered or persistent threats that present significant danger to forest ecosystems.

Tree and plant nurseries have unique opportunities to educate homeowners about the invasive plants threatening forest health and regrowth. Therefore, working with nurseries to slow the use of aggressive invasive plants in gardens and landscaping across the Bay watershed can be an effective strategy. Nurseries should phase out the sale of invasive forest plants.



GOAL 3: MANAGE FORESTS TO ENHANCE ECOLOGICAL SERVICES AND PUBLIC HEALTH BENEFITS.

Strategy 7: Recognize the public benefits of private forestland by compensating landowners with funding and other incentives to sustainably manage their forests to benefit the Bay watershed.



Despite the multiple economic, societal, and ecological benefits that private forestland owners provide the rest of the Bay watershed and its residents, adequate incentives to manage forests for the greatest good do not exist. Governments can provide funding and other incentives to offset the cost of developing, maintaining, and acting on management plans. Incentives could be tied to the type and amount of management as well as forest location to maximize investments and efficiently distribute scarce resources. Incentives to forest landowners could be commiserate to that of agriculture.

Strategy 8: Make forest conservation and restoration a primary tool for improving stormwater management by accounting for the superior ability of forestland to remove pollutants, improve stream health, and moderate runoff.

As required by the Clean Water Act, local governments with populations between 50,000 and 100,000 must submit a stormwater management plan in order to receive state permission to discharge stormwater. These communities (known as MS4s) can incorporate forest conservation and restoration as an attainment strategy for controlling stormwater especially during construction projects. Forests and tree canopies provide an efficient and cost-effective way to control a portion of stormwater runoff, but do not receive any credit in current accounting systems.

VIRGINIA'S CONSERVATION TAX CREDIT POOL

Every Virginia landowner who donates land or an easement for conservation has been entitled to a state income tax credit equal to 50% of the value of the donation. In some cases, donors did not pay enough state income tax to get the full benefit of the tax credit. For land-rich families not in high tax brackets the credit was not very helpful. Virginia has improved the program by allowing easement donors to sell their credits to another taxpayer thus increasing their return on the land donation. The Conservation Credit Pool, LLC helps carry out the transfer of credits from conservation donors to high-income taxpayers who can use the state income tax credits and want to help conserve land.[12]

Strategy 9: Sustain the ability of forestland to improve water quality by restoring and managing forest cover in areas with high nitrogen air deposition rates.

Forest conservation, restoration, and management all have great potential to influence the future health of the Bay. The retention of existing forests, the expansion of forests in critical areas, and the management of forests to improve their growth and nitrogen absorption is an essential part of nutrient reduction strategies for the Bay. Forest restoration would be particularly effective in regions of the Bay watershed that receive high rates of nitrogen deposition from the air, such as Maryland, Pennsylvania, and New York. Integration of forestry practices in nutrient trading schemes is a promising approach.

Strategy 10: Use tree canopies to protect public health by incorporating forest benefits in air quality attainment strategies.

Forty-four percent of Bay watershed residents live in counties that are violating federal air quality standards for ozone and fine particulate matter that is 2.5 micrometers or smaller.[13] The American Lung Association has graded air quality for 64% of Bay watershed residents with a D or F.[14] Increasing urban tree canopy cover in these regions can improve air quality and public health for people in the Bay watershed.

Currently, states can use tree canopy restoration and conservation as a credit under "Emerging and Voluntary Measures" with State Implementation Plans (SIPs) of the Clean Air Act.[15] In the future, urban tree canopies (or urban forests) could be fully accredited in SIPs.

Strategy 11: Maximize watershed benefits by ensuring that forests buffer greater than 70% of riparian areas in a watershed through a combination of incentives and regulations.

Establishing riparian buffers is one of the most cost-effective techniques to reducing pollution to streams. However, more than 7 out of 10 subwatersheds in the Bay watershed have less than 70% stream buffer coverage—the desired threshold to maximize good water quality. The primary program supporting riparian buffer projects, the Conservation Reserve Enhancement Program, will not support even half of the more than 30,000 additional miles as outlined by the Chesapeake Bay Program. To increase the coverage of riparian buffers, private landowners must have access to more technical assistance from states and other organizations.

Incentives and assistance can be targeted to watersheds with the highest potential to remove nutrients. In addition, the cost efficiency of establishing new riparian buffers can be improved through improving site preparation and planting techniques and regional coordination of plant material production, acquisition, and planting. Because of the importance of riparian buffers to water quality, local governments should encourage the use of regulations requiring the planting and conservation of forest buffers during construction projects. To ensure a net gain in buffers, states can develop a tracking system to identify the rate of riparian forest buffer loss in the Bay watershed.

Photo: USDA Forest Service

Strategy 12: Ensure a long-term drinking water supply and reduce treatment costs by protecting and restoring forests in high priority areas.

Forest conservation, restoration, and management in high priority areas can be a valuable tool for protecting drinking water supplies from increasing development pressure. The need to integrate source water protection in local growth management strategies by municipal, county, and regional planning authorities is critical and, in some places, urgent.

Chesapeake communities can reduce the need for costly water treatment infrastructure by conserving and managing watershed forestland for drinking water protection. A recent U.S. Environmental Protection Agency report forecasted a need for capital spending of more than $150 billion over the next 20 years to ensure the continued provision of safe drinking water.[16] The majority of this estimate was derived from the need to build water treatment, storage, and distribution infrastructure.

Water suppliers and treatment facilities can often lower costs by increasing the amount of forest in watersheds that supply drinking water and through improved management of forests for water quality protection. Organizations could educate water suppliers on the benefits of private forest conservation and encourage the use of incentives to enhance management on private forestland.

Developing specific technical information and providing education, training, and technical tools to foresters will help ensure that water resource protection is a primary objective for forestry professions, particularly in watersheds that supply drinking water. Upgrading professional forestry knowledge demands increased communication and partnerships between foresters, water supply providers, public agencies, and private sector firms.

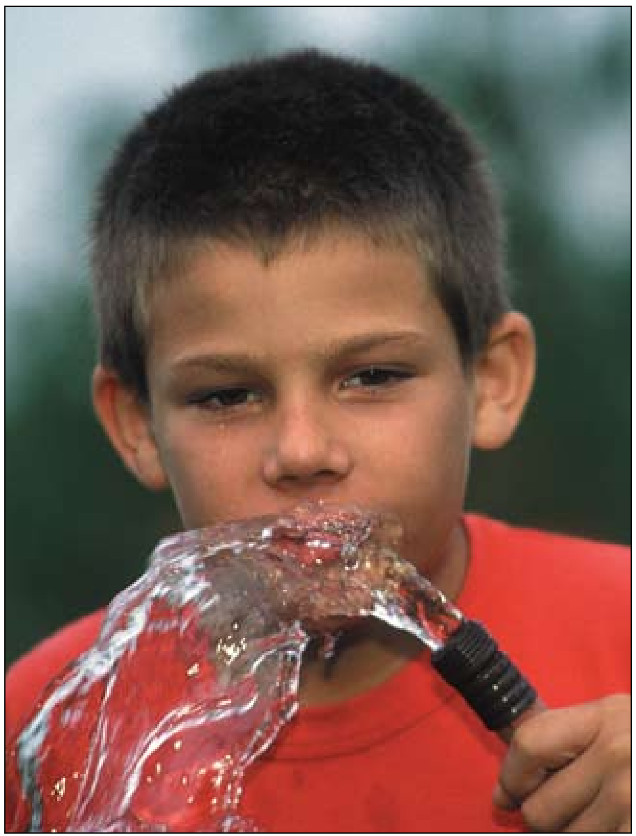


Photo: Charlie Rahm

Strategy 13: Expand existing urban tree canopies to enhance environmental benefits, public health, and quality of life by assessing tree cover, setting local goals, and adopting implementation plans.

Local governments can ensure the continued provision of urban forest benefits by using a combination of regulations and incentives to limit tree removal, protect significant trees, and reforest open land. American Forests recommends a minimum 40% tree cover for most metropolitan areas in the eastern United States. The average urban tree canopy coverage for the Bay watershed is 35%. Goals should take into consideration current forest cover, current and planned development patterns and regulations, and resources available for restoration efforts. Once goals are established, they should be tested against environmental quality to see if the goals are properly set. If not, they should be adjusted to meet or exceed regulations for clean air and water. Urban tree planting can be focused in areas that have the largest potential to improve local conditions. Priority planting sites can be identified using variables such as population density, tree cover per capita, and air quality.

To protect and improve urban tree canopies, communities can consider establishing an urban forest public utility. The utility would allow for assessing fees on businesses and residents based on the value of the public health, safety, and quality of life benefits provided by city trees. Funding could then be used to plan, manage, and enhance the canopy cover of public right-of-ways, parks, urban residential properties, and institutional and city-owned land. User fees, urban tree banks, incorporation of green credits in stormwater fees, and other in-lieu fee payments also offer potential funding sources.

Strategy 14: Bring ecological services into the marketplace by establishing forest mitigation and trading systems and a registry to facilitate transactions.

Forests provide numerous ecological services or ecoservices that watershed residents depend on for daily needs such as water filtration, flood protection, and temperature moderation. When forests are lost to other land uses, so too are the services they provide, forcing communities to spend large sums of money to mimic the original forest functions. A number of these goods, such as food and wood fiber, are bought and sold, but many ecoservices are viewed as free to the public. Lacking a formal market, these natural assets are traditionally absent from society's balance sheet; as a result, their critical contributions are too often ignored by public, corporate, and individual decision makers. For example, Chesapeake forests accounted for 11% of the carbon dioxide storage in the entire United States in the 1990s on just 3% of the land base.[2] However, there is no functioning market to account for this ecoservice and, therefore, the majority of forests in the Bay watershed are not currently being managed to mitigate climate change.

Governments and other organizations can help incorporate ecoservices in land use decisions that impact forests by developing markets that allow forestland owners to seek returns on their land in addition to those associated with traditional forest products. Using a combination of regulations and incentives, a forest mitigation and trading system could be formed to encourage businesses that must disrupt ecological services at one site (such as during land development) by investing in comparable forest services at another location. Businesses that restore more forestland than required could sell or trade these unused "credits" to other corporations to gain revenue. To encourage the restoration of high priority forests, the trading value of credits could be tied to the ecological value of the forest.

Fulfilling requirements to mitigate forest losses through on-site or off-site restoration or management efforts is often problematic due to the difficulties of finding suitable sites. A forest registry can be developed to address this issue. The registry would contain a list of property owners that are interested in managing forests for ecological and other services. Businesses could then invest in management plans, restoration, or other activities that increase the ecological value of the property. A forest registry can also be used to facilitate developing carbon and biodiversity credit trading programs. It also has potential to serve as a marketing tool for private forestland owners that offer fee-based recreational opportunities like hunting or wildlife viewing. If landowners are receiving income from their forest, they may be less inclined to sell to developers or other organizations.

REGIONAL GREENHOUSE GAS INITIATIVE

In 2006, the governor of Maryland signed legislation that requires the state to consider joining New York, Delaware, and northeastern states in the Regional Greenhouse Gas Initiative. The Regional Greenhouse Gas Initiative is a cooperative effort between Northeast and Mid-Atlantic states to develop cap-and-trade and emissions trading systems to lower regional carbon dioxide emissions and their contribution to global climate change at the lowest possible cost. From the start of the initiative in 2009 through the beginning of 2015, emissions will be held at current levels. By 2018, the partner states aim to reduce carbon dioxide emissions by 10%.[17] This offers a significant opportunity to bring ecological services into the marketplace and expand forestland across the Bay watershed. The initiative has a provision for obtaining mitigation credit for carbon sequestration attained by reforestation, and efforts are underway to include urban tree canopies as well.

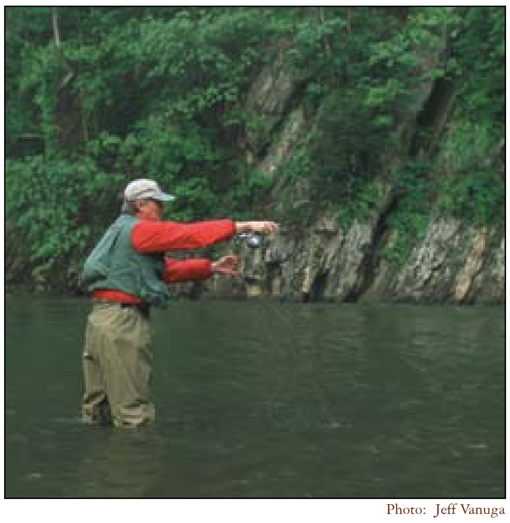


Photo: Jeff Vanuga

GOAL 4: INCREASE PUBLIC APPRECIATION OF FOREST VALUES AND TRACK THEIR CONDITION OVER TIME.

Strategy 15: Communicate the public's dependency on forests for daily needs such as high quality drinking water, clean air, jobs, and recreational opportunities, and articulate the need for sustainable management.

While forest cover dramatically increased over the past century, the capacity of forests to provide the economic, social, and environmental benefits that Bay watershed residents depend on declined. Increases in population and consumption of forest services like water, wood, and recreation outpaced the impressive growth of forests. As a result, the area of forest per person declined by 40%. Additionally, many people have become disconnected from forests and are unaware of the importance forests play in their everyday lives. Fewer than 40% of Americans know what a watershed is, much less the role of the forestland in protecting the water they drink.

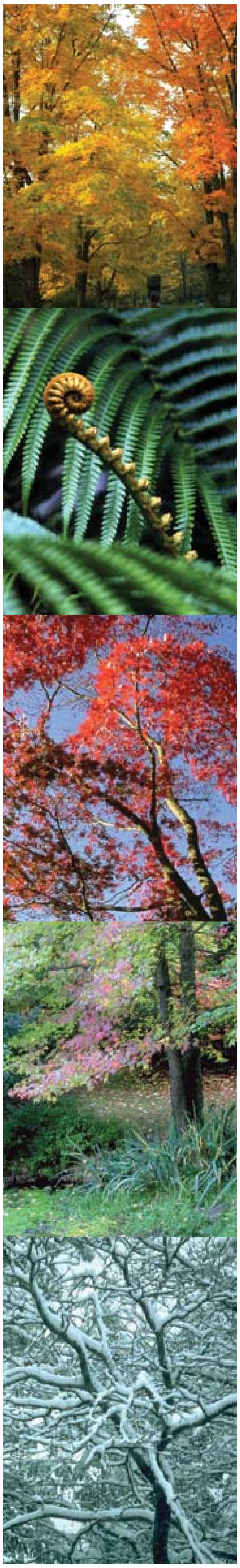
Organizations can develop a marketing campaign using television, radio, public transportation advertisements, and other outlets to increase awareness about public dependency on forest benefits and the importance of sustainable forest management. Furthermore, state departments of education should integrate environmental education with a local focus into primary and secondary curriculums. Without a full understanding of the economic, social, and environmental value of forestland, current and future voters are less likely to support stable sources of funding for forest protection that is on par with other local investments like transportation and telecommunication.

The real estate industry and homeowners associations can be key allies in the communication of tree and forest benefits to those purchasing homes and businesses since trees are important to the value of many properties. Communities with economically important forestland could extend outreach to new homeowners, explaining the types of forest industry activities may take place, how those activities can help improve forest health, and the importance of forestry to the local quality of life. Also, state demonstration forests across the Bay watershed could be used to educate various audiences on the need for sustainable management and techniques that do not affect a local sense of place.

Photo: Keith Weller

Strategy 16: Measure changes in the state of the Chesapeake's forests through a set of condition indicators.

For forest conservation and restoration programs to ultimately succeed, they must be flexible enough to adapt to changing threats, successes, and other future conditions. Establishing a set of environmental indicators that provide an on-going report card of trends in forest conditions and progress in addressing them is a critical component in protecting and restoring Chesapeake forests. The Montreal Process (www.fs.fed.us/research/sustain) provides one set of consistent indicators that the United States and numerous communities have adapted for local use. Potential indicators have been highlighted at the end of each chapter.



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