

Adapting to a Changing Climate: Risks & Opportunities for the Upper Delaware River Region

**Common Waters Partnership
Pinchot Institute for Conservation**



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Model Forest Policy Program | Cumberland River Compact

Foreword

In 2012, the Model Forest Policy Program (MFPP), the Cumberland River Compact, Headwaters Economics, the Common Waters Partnership and the Pinchot Institute for Conservation came together to create a climate adaptation plan for the communities of the Upper Delaware River Region. Development of the plan came about because all parties, led by MFPP, recognized the critical need for local community resilience against the impacts of climate change by protecting forest and water resources. This climate adaptation plan for the Upper Delaware Region of southeastern New York, northeastern Pennsylvania and northwestern New Jersey presents the results of a community team effort, deep and broad information gathering, critical analysis and thoughtful planning. The Common Waters Partnership and Pinchot Institute for Conservation shared the local leadership role to engage with the Climate Solutions University: Forest and Water Strategies program (CSU) and lead their community toward climate resilience with an adaptation plan that addresses their local climate risks and fits their local conditions and culture. This achievement was made possible by the guidance and coaching of the CSU program created by the Model Forest Policy Program in partnership with the Cumberland River Compact and the assistance of Headwaters Economics. The goal of CSU is to empower rural, underserved communities to become leaders in climate resilience using a cost effective distance-learning program. The result of this collaborative effort is a powerful climate adaptation plan that the community can support and implement in coming years. The outcome will be a community that can better withstand impacts of climate upon their natural resources, economy and social structure in the decades to come.

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Executive Summary

This Climate Adaptation Plan for the Upper Delaware River region identifies areas where the region may be vulnerable to the effects of climate change and suggests adaptation strategies to address those impacts that cannot be prevented. The Plan records the results of almost a year of research, outreach and planning performed by the Common Waters Partnership and Pinchot Institute for Conservation, guided by the Model Forest Policy Program's Climate Solutions University. Numerous individuals and stakeholder groups provided important input and feedback during the planning process.

Climate change is already being felt in the Upper Delaware River region. Higher average temperatures, increased magnitude and frequency of heavy precipitation events and flooding, a longer growing season, warmer winters with less precipitation falling as snow and more as rain, and changing hydrologic conditions all put multiple sectors at risk, including forests, water resources, agriculture, human health and regional economies. While we cannot know the exact course of climate change, the region can prepare for the future by taking steps to adapt to changing environmental conditions: to make climate change an integral part of existing planning efforts; to keep people safe by strengthening disaster preparedness; to reduce risks, protect assets and save money; and to safeguard the forest and water resources that support our economy.

The Upper Delaware River Basin is approximately 4,500 square miles in size and rich in natural resources. For this project, the planning area included portions of Monroe, Pike, and Wayne Counties, Pennsylvania; Sussex and Warren Counties, New Jersey; and Delaware and Sullivan Counties, New York. Key regional demographic and economic trends include:

- population growth from in-migration of baby boomers and near-retirees from nearby metropolitan areas
- an aging population with growth in non-labor income (primarily investment income and age-related transfer payments)
- a high percentage of people who commute to work outside of county of residence
- a high second home percentage indicative of recreational and scenic amenities
- an economy driven by the travel, tourism and recreation industries and related services sectors
- entrepreneurship evidenced by steady growth in proprietor employment

These are indicators of the region's "quality of life" - clean water, clean air, abundant public lands and other open spaces, extraordinary recreational opportunities – a significant draw for visitors, residents and businesses alike. The rural economies of the Upper Delaware region as well as community character are intrinsically linked to the natural systems which are vulnerable to climate change.

Forests of the region, largely denuded for agricultural and industrial uses during the 1700s and 1800s, now constitute about 75% of the land cover, supporting generally excellent water quality and providing drinking water for 16 million people in four states, including urban populations of New York City, Trenton New Jersey and Philadelphia, Pennsylvania. However, there are some indicators of long-term forest unsustainability; the region's forests are generally even-aged, maturing, dominated by larger, saw timber-sized trees, lacking in diversity, not fully stocked and predominantly privately owned by an aging

demographic. Additional non-climate forest stressors include parcelization and fragmentation driven by population increases and changes in land ownership and land use. An impressive array of diseases, insects and invasive species are present in forests throughout the Upper Delaware region. Regeneration is negatively impacted by white-tailed deer populations and harvesting practices, such as “high-grading” and diameter limit cuts.

The Upper Delaware region is characterized by excellent water quality, resulting from the predominantly forested landscape. Healthy riparian areas and substantially intact floodplains sustain high quality fish and aquatic insect populations, including native brook trout and rainbow and brown trout, as well as an abundance of freshwater mussels, diverse native aquatic plant communities and spawning habitat for migratory fish, including American shad and American eel. The region is also home to both breeding and wintering populations of bald eagles.

Current non-climate water resource stressors include population growth and associated land use changes, competing demands for water, including the diversion of approximately 50 percent of Upper Delaware water to New York City’s municipal water supply system, and flow management policies that result in flow fluctuations, thermal stress to fish and other ecological impacts. Natural gas drilling is not currently a factor in the Upper Delaware region due to a moratorium on drilling while the Delaware River Basin Commission develops regulations to address potential risks. However, given the shale gas deposits in the region, it is possible that natural gas drilling could become a stressor to both water quality and quantity in the not-too-distant future.

The primary focus of the climate risk analysis for the Upper Delaware region was on forests, water resources and economics. Climate related forest risks described for the Upper Delaware region include:

- Loss of forest ecosystem services with declining forest cover and forest health - impaired flood attenuation and stormwater management functions, reduced pollutant filtration, reduced carbon sequestration
- More insects, invasive plants and diseases harmful to forests
- Reduced winter deer mortality and higher deer populations
- Changes in forest species composition
- Loss of bird and wildlife habitat, migratory corridors and breeding areas
- Longer fire season resulting in increased wildfire risks
- Tree mortality resulting from extreme weather events
- Additional population growth from climate refugees causing more forest loss

Climate-related risks to water resources identified for the region include:

- Increased flooding and stormwater runoff
- Water quality and habitat degradation
- Streambank erosion
- Stream flow fluctuations: earlier peak stream flows/higher winter and lower summer and fall flows
- Thermal stress to fisheries/loss of cold water fisheries
- Enhanced algae growth and lake thermocline changes

- Additional population growth from climate refugees resulting in more development pressure/impervious surfaces increase
- Increasing competition for less available water
- Increased evapotranspiration from reservoirs reducing water storage
- Seasonal impacts to groundwater-dependent water supplies
- Rising sea levels downriver and demands on Upper Basin water to mitigate salt water intrusion

The forest and water risks described above all have economic implications for communities in the Upper Delaware region. In addition, there are a number of risks associated with human health and agricultural enterprises that could have economic consequences. Climate-related economic vulnerabilities identified for the region include:

- Costs associated with extreme weather events
 - Flooding/flood losses/property damages
 - Higher municipal emergency management budgets
 - Infrastructure damages – roads, culverts, bridges, drainage facilities, dams
 - Power disruptions
 - Tourism/recreation and other small businesses losses
- Costs Associated with Forest Risks
 - Expenditures to manage insects/diseases/invasive species
 - Decline in commercially important tree species
 - Increased fire suppression costs and property losses from wildfires
 - Loss of ecosystem services such as flood control and water filtration
 - Shifts in tree species affecting traditional fall tourism peaks
- Costs Associated with Water Resource Risks
 - Water treatment expenses with water quality degradation
 - Outlays to increase water storage capabilities
 - Outdoor recreation interruptions from water quality degradation and nuisance algae
 - Flow fluctuation effects on recreational boating
 - Declining ski, snowboard and snowmobile opportunities and increased operating costs
 - Loss of cold water fisheries and fishing opportunities
- Costs Associated with Human Health Impacts
 - Lyme disease, West Nile Virus, waterborne pathogens
 - Extreme heat-related impacts to vulnerable populations
 - Pollen-related health impacts
- Costs Associated with Agricultural Losses
 - Direct crop damages
 - Delayed planting or harvests
 - Reduced milk production or crop yields
 - Increased crop water demand
 - Increased weed and insect pressure

There is much at risk with climate change, but the Upper Delaware River region also has the natural assets that can help reduce those risks: a high percentage of forest cover; private landowners with a stewardship ethic; clean water and healthy ecosystems; and institutional and organizational frameworks already in place that can facilitate regional climate adaptation strategies. Risks to forests, waters and economies could be reduced significantly by implementing land use policies that focus on maintaining existing forest cover, reducing forest fragmentation, keeping impervious cover at reasonable levels, and taking full advantage of the ecosystem services provided by floodplains and riparian corridors. Local governments in the region have primary responsibility for the land use decisions that can ultimately make communities less vulnerable and more economically resilient to environmental changes. Although it is a challenge to coordinate land use policy in a region that includes three states, seven counties and hundreds of municipalities, this strategy has great potential for far-reaching climate resiliency benefits.

In addition to land use policy tools, the following additional key strategies and solutions for reducing risks have been identified:

- Leverage cooperative conservation efforts already underway in the region and use available funding strategically to conserve priority landscapes
- Work with forest landowners and forestry professionals to implement forest management practices that improve forest health and diversity
- Manage deer populations proactively to promote healthy forest ecosystems and to stay ahead of any population increases associated with changing climate conditions
- Support forest-dependent industries including travel, tourism and recreation as well as the forest products and services sectors
- Improve tax incentives to recognize the many values of forest lands and to help landowners keep forests as forests
- Engage the Basin's water users in investing in source water protection/land and water resources conservation in the Upper Basin
- Improve floodplain and stormwater management standards to reduce risks to people, property and infrastructure

The Climate Adaptation Action Plan maps out an ambitious set of goals, objectives, strategies and actions to be accomplished over the short- and longer term. The adaptation goals below and action plan details were chosen to advance the region toward the climate solutions identified above. This Plan has clear benefits, not just for climate resiliency but for addressing existing non-climate forest and water stressors. Following are the broad climate adaptation goals identified. More specific objectives, strategies and action items are detailed in the Action Plan.

- Build the capacity - both human and financial - necessary to implement the Climate Adaptation Plan for the Upper Delaware River region
- Generate active dialogue and information exchange about climate change by educating and engaging the public, media and local officials on region-specific climate change risks and opportunities.
- Conserve the current 75% forest land cover to protect water quality and quantity and enhance climate resiliency
- Maintain and improve ecological health and sustainability of forests

- Enhance financial investment in Upper Basin forest management and land conservation through engagement with key stakeholder groups
- Reduce the impacts of flooding and stormwater runoff from extreme storm events on people, property and infrastructure
- Support, mitigate impacts to and enhance the region’s agriculture, tourism and recreation industries while identifying and capitalizing on new economic opportunities presented by a changing climate.
- Promote basin-wide flow management policies that will ensure sufficient water quantity for both human and ecological needs.

The Common Waters Partnership and the Pinchot Institute for Conservation will take the lead in Plan implementation. However, developing new partnerships with groups having overlapping interest and/or responsibility for climate change planning and adaption will be critical to its success. Translating this plan to action represents a real opportunity for the people and governing bodies of the region to prepare for a “new normal” set of environmental conditions while supporting those efforts already underway. The outcome will be a solid foundation for lasting prosperity, improving the lives of the people who live here and the experience of visitors, strengthening the economy, and maintaining the health of the natural systems that sustain us - both now and for future generations.

Introduction

A Call to Action

Today we are faced with a challenge that calls for a shift in our thinking so that humanity stops threatening its life support system... In the course of history there comes a time when humanity is called to shift to a new level of consciousness. To reach a higher moral ground.

A time when we have to shed our fear and give hope to each other. That time is now.

– Wangari Maathai accepting the Nobel Peace Prize

It is tempting to assume that the environmental changes associated with a changing climate are happening elsewhere and are problems that future generations, not ours, will need to tackle. The waning debate over whether or not humans are responsible for climate change and the difficulty for our federal government to take meaningful action to reduce greenhouse gas emissions do not alter the fact that the climate is indeed changing, and in ways that are already challenging the Upper Delaware region's forests and water resources, economic vitality and the region's outstanding quality of life.

Consider these responses from October 2013 meetings of the Upper Delaware Roundtable and Upper Delaware Council, where attendees were asked to share their current observations on evidence of climate change in the region:

- Accelerated spring insect hatching on trout streams
- Earlier bird returns and vegetation growth in the spring
- Increased Southern bird species in local bird counts over the last 5 years and Southern species now breeding in the region
- More spotted ticks (a Southern species)
- Upper Delaware *Bioblitz* documented species that have never before been documented in the region, some of which are distributed by flooding and many of which are invasives
- Channel changes and increased bedloads in streams
- More complaints about filamentous algae blooms
- Cut flower and vegetable harvests extended later in the season
- Reduced numbers of Monarch butterflies
- Recent reservoir releases to push back the downstream Delaware River salt line during relatively short-term drought conditions
- Evergreen trees dying off/hardwoods affected by insects and blight

Anecdotal accounts? Yes. Telling signs of change? Most definitely!

This document records the results of almost a year of research, outreach and planning performed by staff of the Pinchot Institute for Conservation and members of the Common Waters Partnership, guided by the Model Forest Policy Program's Climate Solutions University. The planning process included data collection to document current conditions and trends, exhaustive research to identify region-specific risks and vulnerabilities to forests, water resources, and economies associated with climate change, and careful

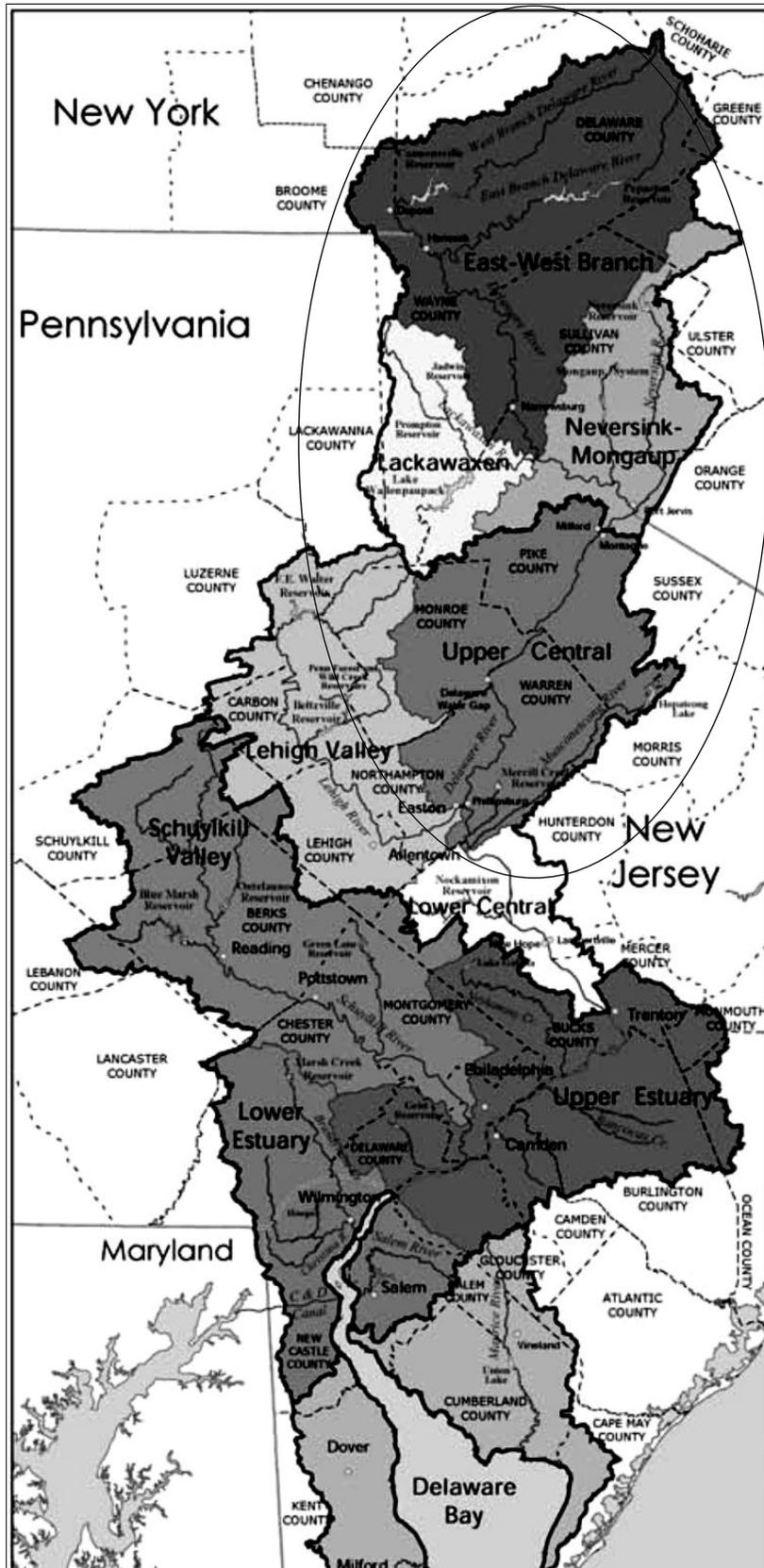


Figure I-1: Upper Delaware region in relation to the Delaware River Basin.
Source: DRBC, 2013.

analysis of potential practical solutions to protect the forest, water and economic assets of the Upper Delaware region in the face of local climate impacts.

The time is right to begin a dialogue and to collectively act to ensure that our communities are well positioned to meet the challenges associated with the environmental changes we are already experiencing and those to come. The Common Waters Partnership and the Pinchot Institute for Conservation, along with many others in the Upper Delaware region, understand and respect the interconnectedness among the region's natural resources, its people and communities, its economic well-being and the broader global environment. The long-standing working relationships that these organizations have with landowners, governmental and non-governmental agencies, researchers, policy-makers and the public positions them well to engage diverse stakeholders in seeking innovative, practical, and broadly-supported solutions to conservation challenges such as climate change. Climate change, although seemingly overwhelming, is a solvable problem. There are things we can do to prepare for it and to limit its overall impacts on the people and resources of the Upper Delaware region. The most costly thing we can do is nothing.

The Upper Delaware River Region at a Glance

The mainstem Delaware is the longest undammed river east of the Mississippi, flowing freely for 330 miles from southern New York State, through eastern Pennsylvania, New Jersey, and Delaware to the Atlantic Ocean. The Delaware's 13,539 square mile watershed drains about four percent of the continental United States land area and provides drinking water for some 16 million people in four states.

Located between the Catskill Mountains to the north, and Pocono Mountains to the south, the headwaters, or the *Upper Delaware region*, serve as a state border between New York and Pennsylvania and Pennsylvania and New Jersey. The headwaters of the West Branch originate in Schoharie County, NY at 1886 feet above sea level and flow until they emerge from the Catskills. The East Branch begins in Roxbury, NY and flows southward towards New York City to create the Pepacton Reservoir, the largest reservoir in the NYC water supply system. The confluence of both branches is just south of Hancock, NY. For the purposes of this project, the planning area was limited to include portions of Monroe, Pike, and Wayne Counties, Pennsylvania; Sussex and Warren Counties, New Jersey; and Delaware and Sullivan Counties, New York.

The Upper Delaware region lies between the Appalachian Plateau Physiographic Province and Catskill Physiographic Province. Elevations vary from 800 to 2,000 feet, and as a result, many unique land forms exist. The Delaware River Gorge, identified as an outstanding scenic geologic feature, begins above Matamoras, PA and runs north along parts of the river. Below Port Jervis, NY, the Walpack Ridge deflects the Delaware River into the buried, glacial till of the Minisink Valley, where it follows the southwest edge of the eroded Marcellus beds along the Pennsylvania–New Jersey state line to the Delaware Water Gap National Recreation Area. It then travels along the Kittatinny Ridge which it crosses at the Delaware Water Gap between nearly vertical walls of limestone before passing through farms and forests of the Appalachian Plain.

The Upper Basin is approximately 4,500 square miles in size and is rich in natural resources, the same resources that created a unique history for the region in the 19th and early 20th centuries. Before railroads, the Upper Delaware River was a main form of transportation and was used to ship lumber and stone from the region to cities such as New York and Philadelphia. Overexploitation during this period left large

tracts of land devoid of forests. The forest has long since regenerated and logging and quarrying are still viable industries in the area today. Agriculture is not as big of an industry as it once was, however the dairy industry still persists and a new dynamic toward specialty farm markets has been forming in recent years.

Today's forest species have climaxed; the northernmost areas of the region are dominated by maple/beech deciduous forests with a mixture of coniferous eastern hemlock. To the south and along the river valley, oaks are the dominant deciduous species with a mixture of coniferous species. Areas that were once pasture and farm land have been trending towards pioneer species of birch, ash, and cherry or in some cases, housing sub-divisions. Forests in the region have been increasingly impacted in recent years by insect pests such as gypsy moth, forest tent caterpillar, emerald ash borer and hemlock woolly adelgid.



Figure I-2: The Upper Delaware region offers an outstanding array of outdoor recreation opportunities for residents and visitors. *Source: DRBC Collection.*

Stretches of the Upper Delaware and its tributaries are world renowned for the wild trout fishery they sustain. The Delaware River is an important waterway for American shad, and their presence is indicative of the water quality improvements that have occurred over time. The fact that there are no dams on the mainstem Delaware contributes to the American shad's success at traveling upriver to spawn. The region is also home to two distinct populations of bald eagles. Breeding eagles remain in the area year-round, while wintering eagles migrate to the region from points north in search of open water, food sources, and suitable habitat. The 120-mile stretch of the

Delaware River from Hancock, N.Y. to the Delaware Water Gap is one of the largest and most important inland bald eagle wintering habitats in the Northeastern United States (NY DEC 2010). Outdoor recreation in the river valley in the form of hunting, fishing, canoeing and kayaking and, of course eagle watching, are important economic generators in the area.

The Upper Delaware watershed provides drinking water to millions of people in urban populations of New York City, Easton and Trenton, New Jersey and Philadelphia, Pennsylvania. Overall, 8 billion gallons of water are withdrawn daily from the Delaware River, including significant amounts for thermoelectric cooling, manufacturing, and other public and commercial uses. The Upper Basin's forests are critical for maintaining water quality for all of these uses, and especially for the people of New York, New Jersey, and Pennsylvania that rely on the Delaware River for their drinking water.

Many local communities are struggling with increased tax burdens and high unemployment rates. On the other hand the area also has a high ratio of second home owners from metropolitan areas. Major flooding has taken its toll on residences and infrastructure, and has even claimed lives over the last decade.

The controversial debate over natural gas extraction has polarized many communities in the northern part of the region. Proponents cite economic opportunities and job creation; however concerns persist about potential environmental, social and human health impacts and detrimental effects on economic drivers, such as tourism and agriculture, which have been the foundation of the local economy for generations. Current regional plans are in development to revitalize local waterfront towns and river accesses with the hope of generating more ecotourism and cross-border collaboration in the region.

About the Lead Organizations

Both the Common Waters Partnership (<http://www.commonwatersfund.org/partners>) and the Pinchot Institute for Conservation (<http://www.pinchot.org/>) took leadership roles in collaboration with the Model Forest Policy Program's Climate Solutions University to assess climate risks and develop an adaptation plan to protect forest, water and economic assets of the Upper Delaware region in the face of local climate impacts. Common Waters is a regional partnership of public and non-profit organizations and agencies focused on supporting of sustainable communities and working landscapes in the Upper Delaware River watershed. The mission of Common Waters is to conserve clean water, natural places, and working lands through cooperation, scientific research, education, and technical assistance by and for the stakeholders of the region. Its primary focus is providing good scientific information at a regional level and encouraging cross-boundary communication. The Common Waters Partnership is facilitated by the Pinchot Institute for Conservation, whose mission is to advance conservation and sustainable natural resource management by developing innovative, practical, and broadly-supported solutions to conservation challenges and opportunities.

In the summer of 2012, the Common Waters Partnership had some real accomplishments under its belt. It had just hosted a successful conference, *Natural Economies: Making the Most of the Delaware River Region's Natural Assets*. Over the years prior, the Partnership launched the *Common Waters Fund* (www.commonwatersfund.org), a program that mapped priority forest areas in the Upper Delaware region, identified best management practices for forest stewardship, and created a funding mechanism for private forest landowners administered with the assistance of a cadre of local partners. Three *Land Use Leadership Alliance* (LULA) training programs were conducted for municipal officials and other community leaders in cooperation with the Pace University School of Law (www.law.pace.edu/landuse). The Partnership facilitated community dialogue and information sharing on the *Common Waters Marcellus Shale Project* (http://www.pinchot.org/gp/Marcellus_Shale), created an *Atlas of the Upper Delaware Region* that highlights the region's unique natural and cultural characteristics as well as the forces of change, and held regular Common Waters Partnership meetings, bringing stakeholders from the tri-state region of Pennsylvania, New Jersey, and New York to the table for regular dialogue.

No one in the Common Waters Partnership was really searching for more to do when we learned of a unique opportunity to work with the Model Forest Policy Program (MFPP), a national nonprofit organization dedicated to forest stewardship and sustainable forestry practices as a means to provide long term, cost-effective climate solutions. This focus, which was not previously prominent in the Partnership's work, seemed a perfect enhancement for other Common Waters initiatives, and the opportunity to collaborate with the experts at MFPP and communities across the country on issues so relevant to the Upper Delaware region was one the Common Waters Partnership's steering committee felt we could not pass up.

The Planning Group and Planning Process

A core planning group included representatives of the Pinchot Institute for Conservation and Common Waters Partnership members representing several county planning agencies, the Upper Delaware Council based in Narrowsburg, NY, Lacawac Sanctuary in Wayne County, PA and the National Park Service Delaware Water Gap National Recreation Area. With the leadership of Susan Beecher, this group brought to the effort both their expertise in different resource management and community planning disciplines and their capabilities for outreach to the greater regional community. They participated in weekly Climate Solutions University webinars and met periodically throughout the nearly year-long effort. Products were developed collaboratively through email, telephone and in-person meetings. In addition to the core planning group, many other individuals and organizations served in an advisory capacity over the course of the project to inform particular sections of the plan.

The Core Planning Group

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Foresters
Sullivan Co. Legislature Agriculture & Sustainability Policy
Committee
Sullivan County Community College Sustainability Group
Upper Delaware Council
Upper Delaware Roundtable
Wayne Tomorrow

Climate Overview

Everybody talks about the weather but nobody does anything about it.

– attributed to Mark Twain

Life on earth is supported by relatively warm temperatures – a result of gasses such as water vapor, carbon dioxide and methane in the atmosphere that trap some of the heat radiating outward from earth, limiting its escape into space. Certain levels of these “greenhouse gasses” are essential to moderating global temperatures. Since the start of the Industrial Age, however, human activities such as burning fossil fuels (oil, coal, natural gas), clearing forests and certain agricultural activities have released ever-increasing amounts of greenhouse gasses into the atmosphere in a relatively short time, enhancing the greenhouse effect and intensifying the warming of the earth.

The Global Picture

Regardless of the causes, the evidence is strong that the earth’s climate is changing. Consider these trends:

- The 2001-2010 decade is the warmest since 1880- the year when enough temperature records became available worldwide to calculate a global average.
- Over the last 50 years, the number of cold days and record low temperatures in various locations has declined, while the number of hot days and heat waves has risen most places worldwide.
- Each of the last three decades has been hotter than the one before.
- The best projections show that average global temperatures are likely to increase 3.1-7.2° F (1.8-4.0° C) by the end of the century depending on the amount of carbon emissions (NOAA. 2013).

Trends in the Northeastern United States

Warmer average global temperatures set off all sorts of other changes - on land, in the oceans, and in the atmosphere - that can affect our region’s people, plants and animals in various ways. Over the last several decades, the Northeastern United States has experienced noticeable changes in its climate. Since 1970, the average annual temperature rose by 2°F and the average winter temperature increased by 4°F. This warming has been correlated with many other climate-related changes across the region (Frumhoff, et al. 2007), including:

- More frequent days with temperatures above 90°F
- Increased magnitude and frequency of heavy precipitation events
- A longer growing season (frost-free season)
- Less winter precipitation falling as snow and more as rain
- Reduced snowpack and increased snow density
- Earlier breakup of winter ice on lakes and rivers
- Earlier spring snowmelt resulting in earlier peak river flows

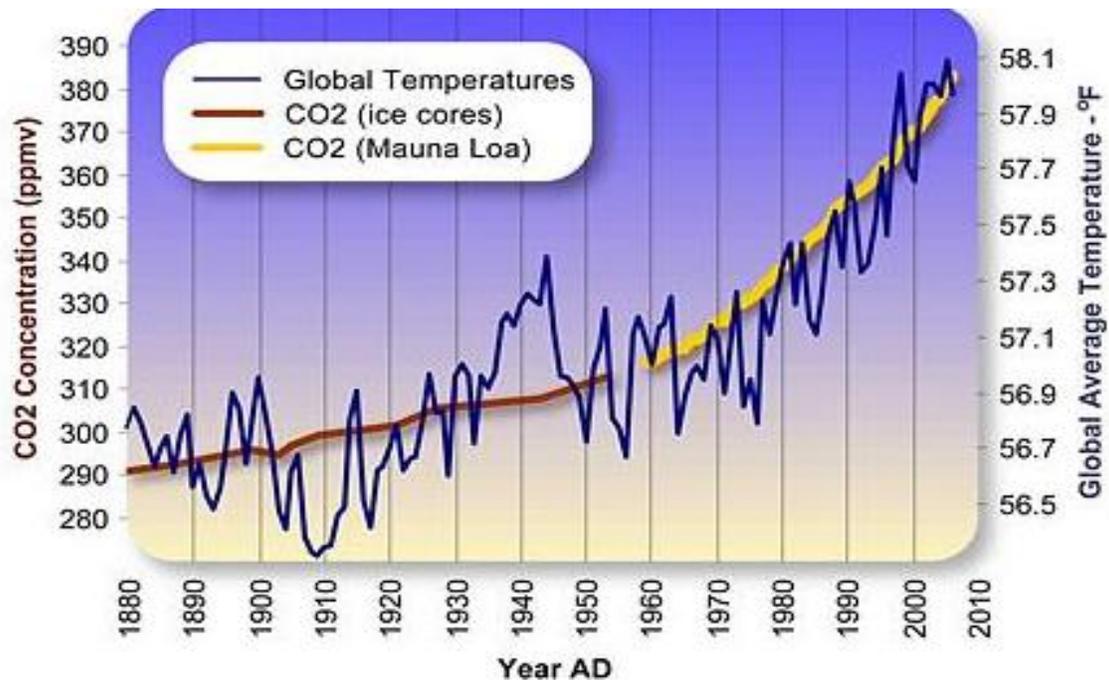


Figure I-3: Global average temperature & CO₂ concentrations since 1880.
 Source: "Climate Change Primer" Woods Hole Research Center.

Trends in the Delaware River Basin

A 2012 *Technical Report for the Delaware Estuary and Basin* summarized climatic trends in the Delaware River Basin, including trends at a number of sites in the Upper Delaware region (Najjar, et al. 2012). Both annual mean temperature and annual mean precipitation in the Upper Basin have increased significantly over the past 100 years. The trend over the past 30 years for temperature and precipitation is more than 3 and 5 times the 100 year trend, respectively. Scientists project that these trends will continue. Future projections show the basin getting progressively warmer and wetter throughout the 21st century. The median projections of 14 climate models for the end of this century are as follows:

- Temperatures will rise between 1.9 and 3.7 degrees Celsius, with substantially more warming in summer than in winter, resulting in more extreme heat days.
- Precipitation will increase by 7-9%, with substantially more increase in winter months, and 5-8 more days of heavy precipitation annually.
- The growing season will increase substantially (by 15-30 days annually).
- The number of frost days will decrease substantially (by 20-40 days annually).
- Sea-level will rise by between .5 meters and 1.5 meters (or more), resulting in larger tidal volumes that bring more salt water up the estuary. Some of that salinity increase could be offset by increases in precipitation, at least during cooler months.

What Climate Change Means to the Upper Delaware River Region

Although moderate warming might have positive effects for some, such as allowing some recreational activities to occur earlier in the spring and later in the autumn, increased production of some crops or reduced expenditures on heating, the negative impacts appear to far outweigh the positives. The climate-related changes occurring now and projected for the future could alter the region's economy, landscape character, and quality of life. More extreme precipitation events are likely, increasing the frequency of flooding and flood-related damages. The frequency, intensity and duration of heat waves are expected to increase along with seasonal drought risk. Shifts in local and regional water cycles can be expected. Earlier spring melt, seasonal declines in stream flows, longer periods of low flows and increased surface water temperatures are patterns that are expected to continue. Warmer temperatures will likely reduce cold-water fishery habitats, impacting the region's recreational and sport fisheries. Fluctuations in stream flow levels can also impact fisheries as well as recreational boating. The region can expect more competition for less available water. The Upper Delaware region already includes three of the fastest growing counties in Pennsylvania, New York and New Jersey. Population increases may be hastened by people migrating from more vulnerable urban and coastal areas. These are all issues that, regardless of their association with climate change, are already of importance to communities in the Upper Delaware region.

In forests of the Upper Delaware region, shifts in the types and distribution of forest species are likely. Some of the trees that are currently common across the region, such as maple, birch, and beech, could experience a significant northward shift in their growing region. Warmer temperatures could also allow

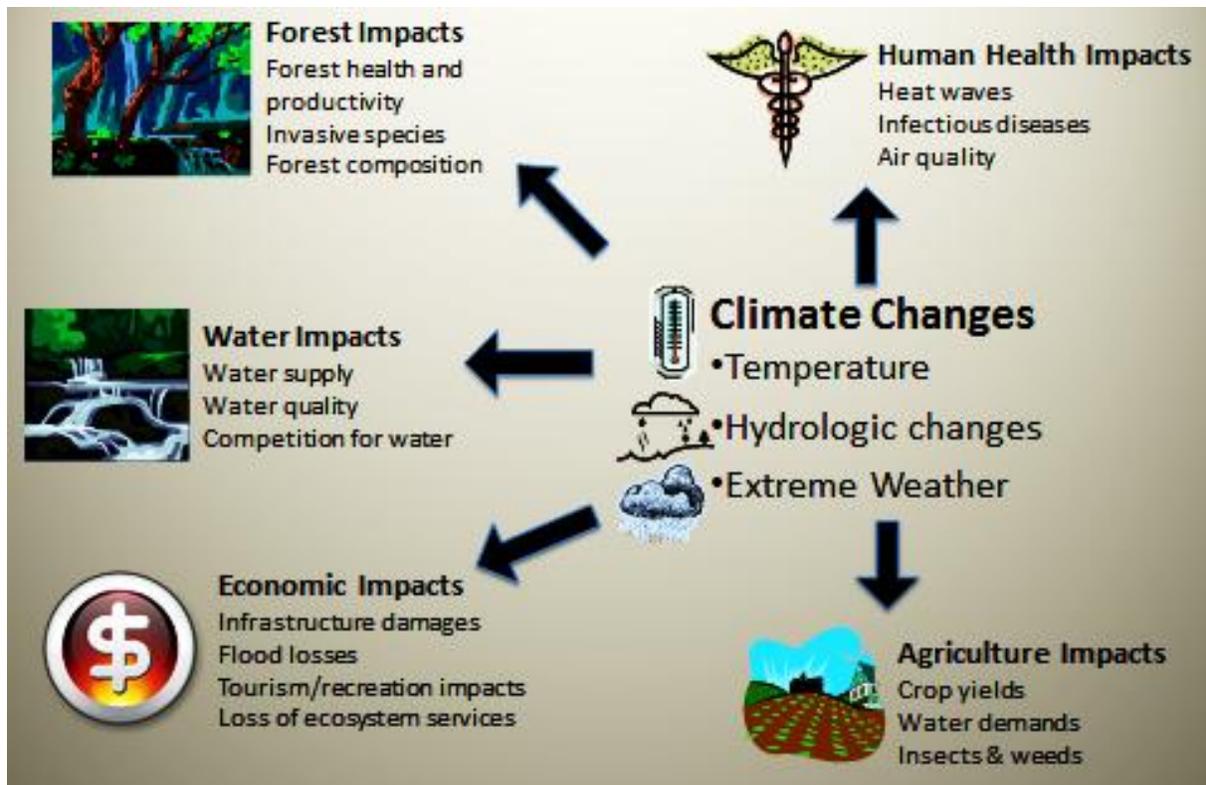


Figure I-4: Initial scoping of climate risks for the region. Source: UPDE Core Planning Group.

certain destructive insects, diseases and invasive species to thrive. The hemlock woolly adelgid, the gypsy moth caterpillar and the Asian longhorn beetle are pests, already impacting forests in the Northeast, whose populations could increase with warming winter temperatures. In addition, extreme weather (including droughts, strong winds, and heavy rains) increases the exposure of forests to disturbances and makes them more susceptible to pests and diseases. Vectors for human health concerns such as Lyme disease and West Nile Virus are also favored by increasing temperatures and precipitation.

Many sectors of the local economy could be affected by the changing environment. Agricultural impacts include direct crop damage from extreme precipitation events, delayed planting from wet springs, delayed harvest dates, and increased weed and pest pressures. Local governments, businesses and residents are well aware of the infrastructure and property damage costs associated with extreme weather events such as Super Storm Sandy in 2012 and back-to-back Hurricane Irene and Tropical Storm Lee in 2011 (DRBC 2011). Three major floods in September 2004, April 2005 and June 2006, caused devastation along the main stem Delaware River, repeatedly damaging property and infrastructure and disrupting tens of thousands of lives. These were the worst floods to occur on the main stem since the flood of record in 1955. Nine deaths are attributed to these three events; one on the main stem and the remaining eight due to tributary flooding. (DRBC 2007)

Why Adaptation Planning Is Important

Observations and measurements from all over the world provide strong evidence that climate change is already happening and that human activities have and will continue to influence those changes. The main questions now are over how fast it is occurring and to what degree and in what ways different regions will be affected. While we cannot know the exact course of climate change, we can prepare for the future by taking actions in our communities that make sense whether or not the most dire climate threats actually materialize: to keep people safe, strengthen disaster preparedness, reduce risks, protect assets, save money and safeguard the forest and water resources that support our economy regardless of what the future brings.

Approaches to responding to climate change fall into two general categories: mitigation and adaptation. Mitigation strategies focus on ways to diminish climate change by reducing emissions of greenhouse gases into the atmosphere. This approach, a very important determinant of the severity of future climate change impacts, is being undertaken by many communities across the country and throughout the world. There are also numerous ways that individuals can change personal behaviors and consumer choices to reduce greenhouse gas emissions. However, as we have come to understand that some degree of climate change is inevitable, it is also important to develop strategies to help human and natural systems adapt and adjust to the changes. This report identifies areas where the Upper Delaware region may be vulnerable to the effects of climate change and suggests adaptation

Sullivan County is a Climate Smart Community

Sullivan County is addressing climate and energy issues by participating in the NYS Department of Conservation's Climate Smart Communities Program. By signing the Climate Smart Communities Pledge in 2010, Sullivan County initiated a range of efforts that include making municipal buildings and vehicles more energy efficient, developing a Climate Action Plan for the county, and encouraging similar efforts at the town and village level.

strategies to address those impacts that cannot be prevented. The issues raised are intended to spur dialogue and are not envisioned to be all-inclusive. We have an opportunity to take steps now to help our region adapt to a world of warmer temperatures and more unpredictable weather patterns, to factor in climate changes as an integral part of existing planning efforts, to manage risks, and to reduce the social, economic and environmental costs associated with those risks.

Goals for the Adaptation Planning Process

The ultimate goal beyond the planning is to bring climate resilience to local communities through effective adaptation strategies that sustain forest and water resources and promote economic stability. The focus is on reducing vulnerability and building resilience - the capacity for systems to withstand change and still retain their vital characteristics. Some additional goals include development of a Plan that:

- articulates no-regrets actions that can be undertaken by communities in the short and long-term;
- identifies cost-effective actions that deliver results;
- aims to build a flexible and coordinated local capacity to cope with climate change as it affects our resources and communities now and for decades to come;
- informs other planning initiatives, and;
- leverages partnerships and collaborations.

Local governments are on the front lines of managing the aftereffects associated with natural hazards. As impacts such as increased flooding, extreme heat, drought, and other extreme weather events become more frequent, local budgets and infrastructure will be strained, putting people and property at risk. It is our fervent hope that local government officials will find in this Plan resources and tools to incorporate into their own climate mitigation and adaptation initiatives and to help prepare their communities and build local resilience to climate variability and climate-related disasters.

Economics and the Environment

Demographic and Economic Trends in the Upper Delaware Region

Because the rural economies of the Upper Delaware region, as well as community character and quality of life, are intrinsically linked to the natural systems which are vulnerable to climate change, it is useful to understand important characteristics of the region’s population and economy. Following is a summary of basic demographic and economic information for a seven county region that comprises the majority of the area that, for the purposes of this plan, is described as the Upper Delaware region.

Trends in Population, Employment, and Personal Income

In 2011, 662,819 people lived in the seven counties of the Upper Delaware region. Monroe County, PA was the most populous and Delaware County, NY the least populated of the counties. In the decade between 2000 and 2011, the region as a whole saw a 10.2% increase in population, with Pike and Monroe Counties’ populations growing over 20% during that period.

Summary of Key Regional Demographic & Economic Trends

- Population is growing and aging
- Population growth has been predominantly from in-migration from nearby metro areas
- High percentage of population commutes out of county of residence
- Travel, tourism, recreation sectors important
- Non-labor income (mostly investment income and age-related transfer payments) grew significantly in the last decade
- Second home percentage is high indicating recreational and scenic amenities such as public lands
- Rising entrepreneurship

Compiled by UPDE Core Planning Group

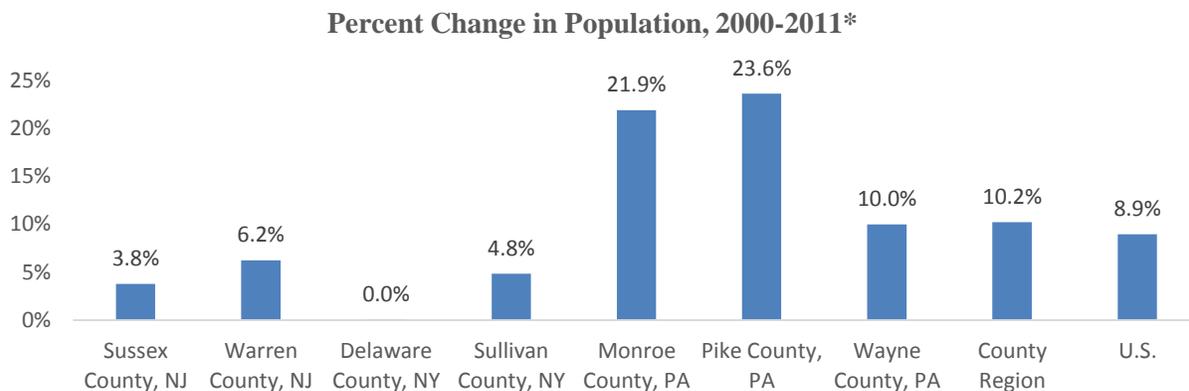


Figure E-1: Changes in population numbers and percentages by county and for the region: 2000-2011.
Sources: U.S. Department of Commerce, US Census Bureau, 2013.

About 81% of the region’s population growth has resulted from in-migration, a trend expected to continue due to the proximity of the region to major metropolitan areas.

In addition to population increases, other indicators of overall regional growth in the last several decades include steady increases in employment, personal income and per capita income. All of these growth indicators, however, have leveled off or declined somewhat during the current recession, starting at about the end of 2007.

Population, 2000-2011*								
	Sussex County NJ	Warren County NJ	Delaware County NY	Sullivan County NY	Monroe County PA	Pike County PA	Wayne County PA	County Region
Population (2011*)	149,589	108,829	48,079	77,553	169,050	57,242	52,477	662,819
Population (2000)	144,166	102,437	48,055	73,966	138,687	46,302	47,722	601,335
Population Change (2000-2011*)	5,423	6,392	24	3,587	30,363	10,940	4,755	61,484
Population Percent Change (2000-2011*)	3.8%	6.2%	0.0%	4.8%	21.9%	23.6%	10.0%	10.2%

* The data in this table are calculated by ACS using annual surveys conducted during 2007-2011 and are representative of average characteristics during this period.

Sources: U.S. Department of Commerce, US Census Bureau, 2013

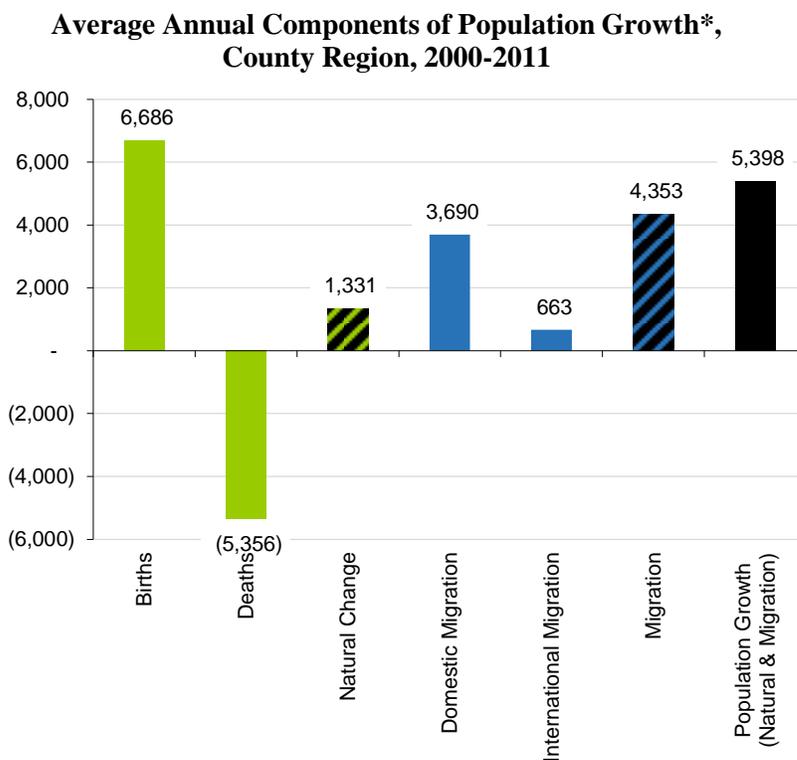


Figure E-2: Components of regional population growth showing the influence of in-migration from nearby metropolitan areas. Data Sources: U.S. Department of Commerce, 2012. Census Bureau, Population Division, Washington, D.C. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.

Unemployment

Annual unemployment in the region has risen from a low of 3.6% in 2000 to a high of 9.3% in 2010. The unemployment rate of 9.2% for 2012 was above the U.S. annual average rate of 8.1%. Unemployment rates in the region typically show some seasonal increases during the winter months.

The Self-Employed

The self-employed (referred to as *proprietor employment*) represented 27.6% of total employment in 2011. This is an increase in the number of proprietors of almost 30% over the 2000 estimate. In contrast, wage and salary jobs, which comprise a higher percentage of total employment (72.4% in 2011), grew by only 5.3% during the same 10 year period. Proprietor employment is often an indicator of entrepreneurship, and is commonly seen in communities with a high quality of life where entrepreneurs locate to live and do business. Conversely, during periods of recession, proprietor employment may rise because there are few jobs available. Generally, if proprietor employment and personal income are both trending upward, which is the case for the Upper Delaware region; this is a healthy indicator of entrepreneurial activity.

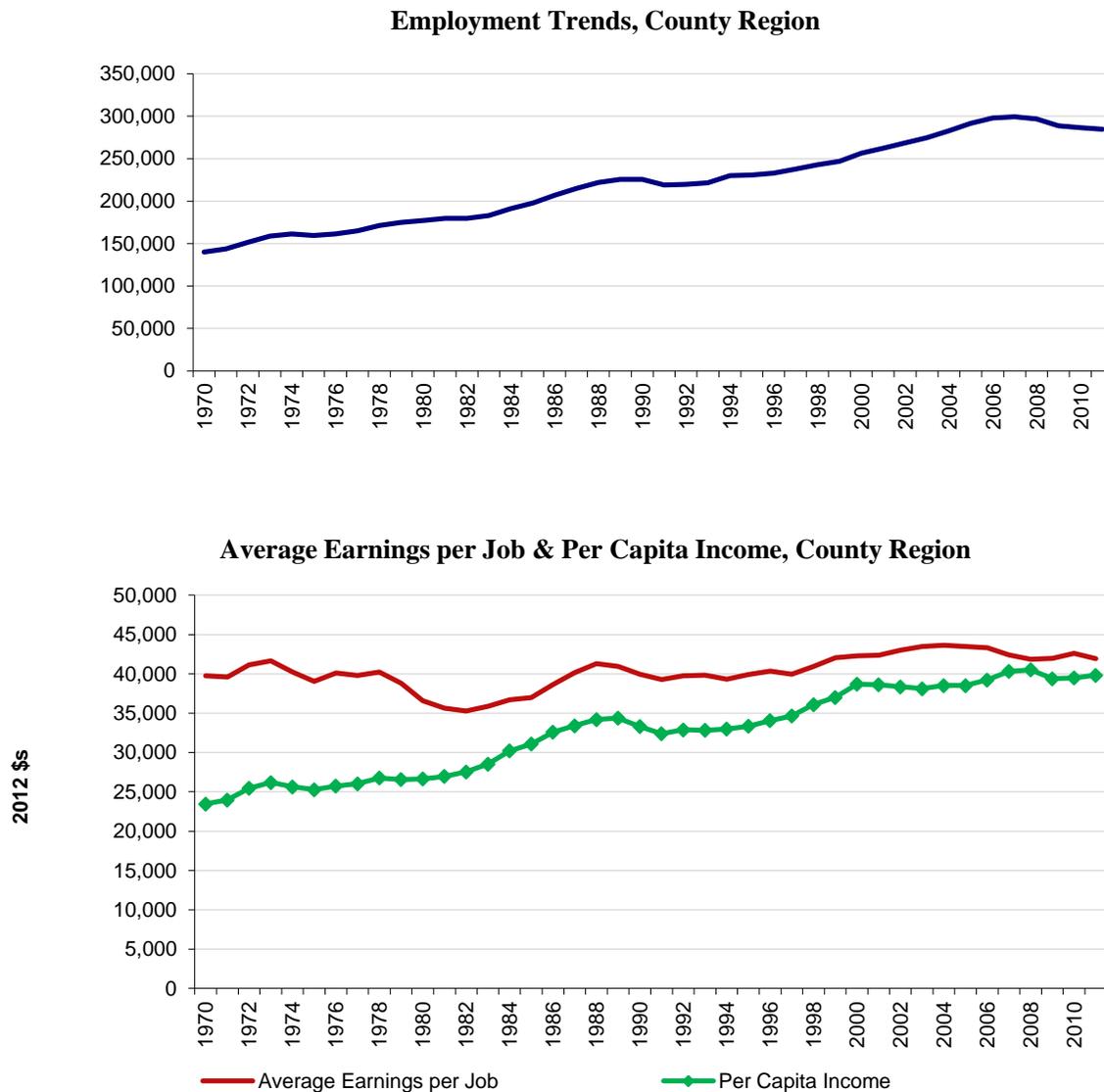


Figure E-3: Trends indicative of overall regional growth over the last several decades.
 Data Sources: U.S. Department of Commerce. 2012. Bureau of Economic Analysis, Regional Economic Information System, Washington, D.C. Table CA30. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.

Average Annual Unemployment Rate, County Region

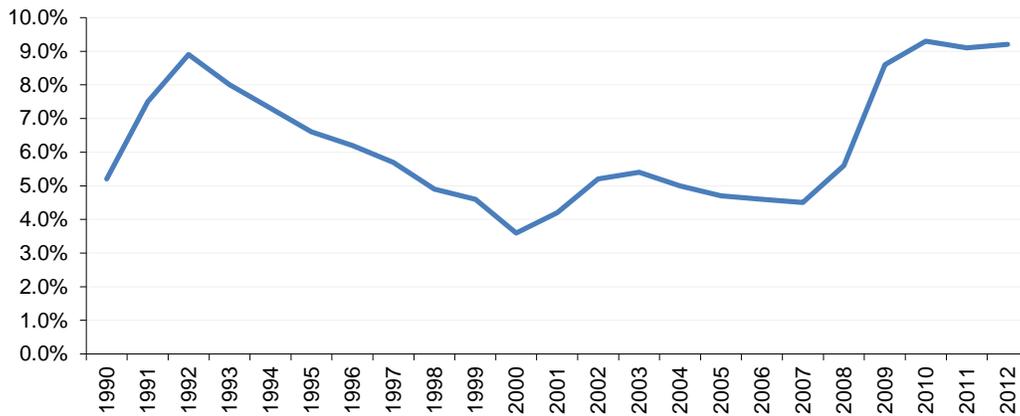


Figure E-4: Trends in annual average unemployment rates for the region.
Data Sources: U.S. Department of Labor. 2012. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.

Components of Employment, County Region

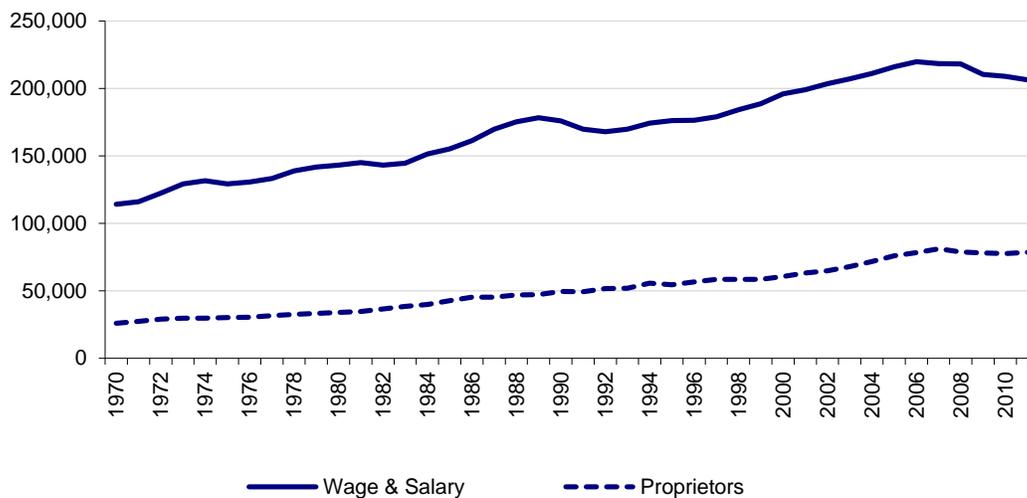


Figure E-5: Changes over time in regional wage & salary jobs and proprietor (self) employment.
Data Sources: U.S. Department of Commerce. 2012. Bureau of Economic Analysis, Regional Economic Information System, Washing, D.C. Table CA30. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.

Employment and Wages by Industry

The largest component of the regional economy is in services related occupations; the largest of these is retail trade, transportation and utilities (20.3%), followed by education and health (16.4%), and leisure and hospitality (13.3%). Government employment comprises an estimated 17.9% of total employment for the region, with local government jobs representing the largest share. In non-services related components of the economy, manufacturing, which includes forest products and construction constitute 9.1% and 3.8%, respectively, of total jobs.

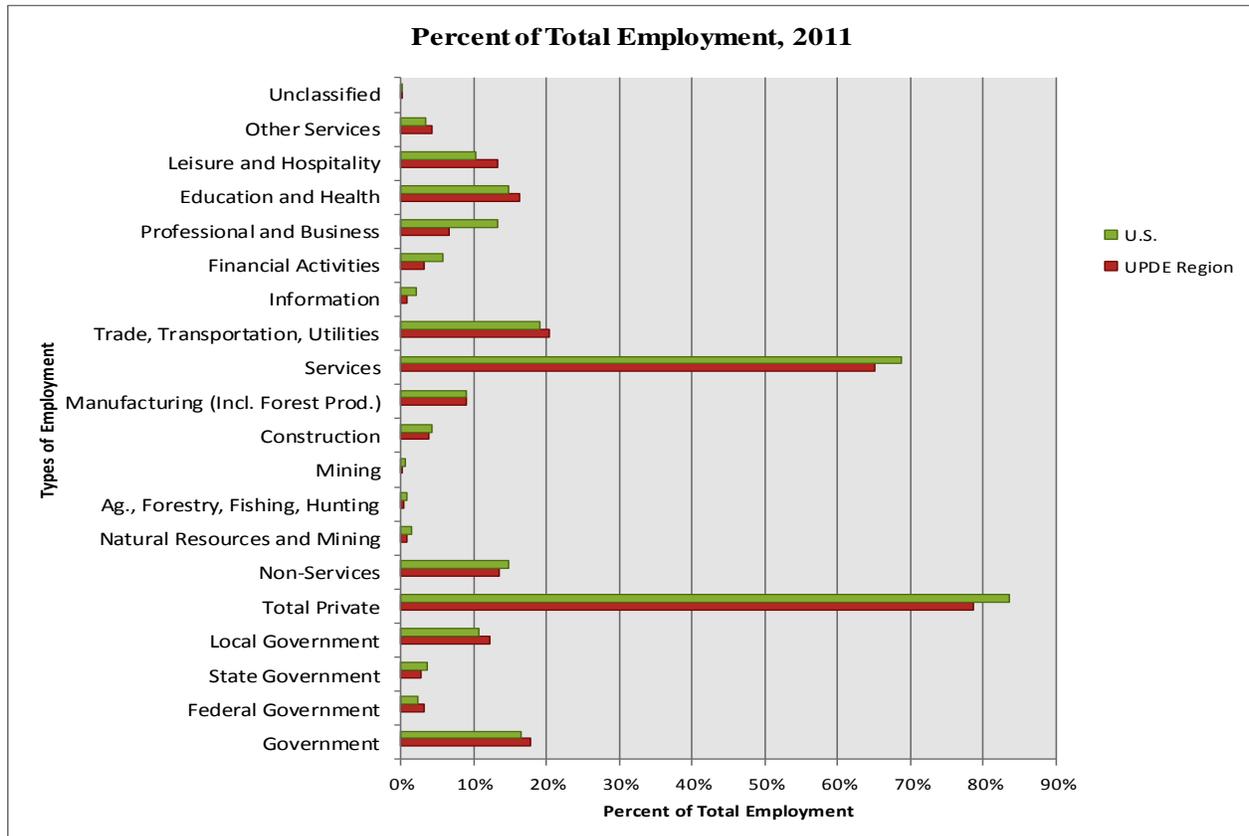


Figure E-6: Components of the regional economy compared to U.S. services related occupations.
Sources: U.S. Department of Labor, 2012. Bureau of Labor Statistics, 2013.

Average earnings per job for the region were below the average for the U.S., with service-related job rich Pike County showing the lowest figure. Average annual wages in 2011 for non-services related and government jobs were typically significantly higher than wages for services-related jobs.

In 2011, 47% of those who do not work at home worked out of their county of residence, a figure that is significantly higher than the national average. 20% of non-home based workers had commuting times over 60 minutes. Pike County PA had the highest estimated number of people who worked outside of the county at 60.9%. This sector of the population could be disproportionately impacted by transportation disruptions associated with extreme weather events.

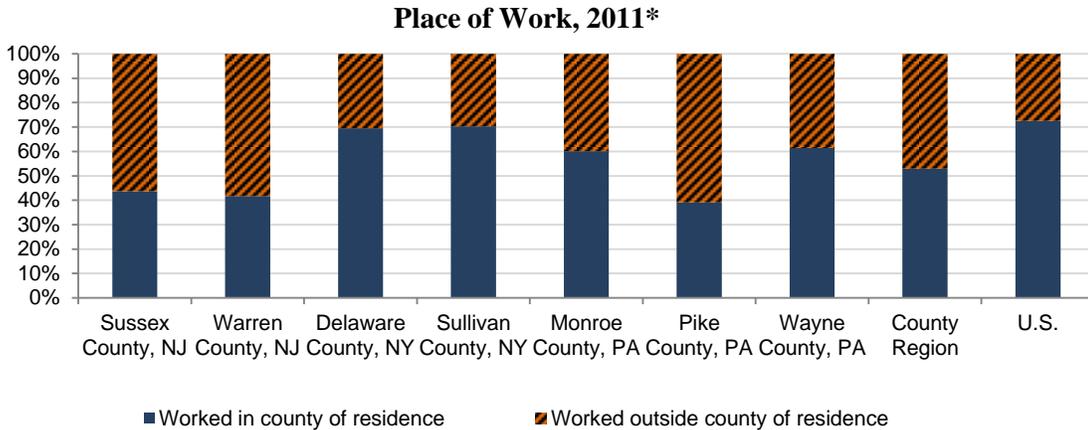


Figure E-7: Estimated percent of people that worked outside the county of residence in 2011. This sector of the population could be disproportionately impacted by transportation disruptions associated with extreme weather events. *Data Sources: U.S. Department of Commerce, 2012. Census Bureau, 2013.*

Travel and Tourism

The Upper Delaware Region’s economy includes a number of sectors related to travel and tourism that provide goods and services to visitors as well as to the local population. These include accommodations and food service, retail trade, arts, entertainment and recreation, and passenger transportation. In 2010, these sectors combined represent an estimated 21% of the region’s and about 30% of Pike and Monroe Counties’ total private sector jobs. Of the four sectors that contribute to Travel and Tourism, regional jobs in arts, entertainment and recreation showed the most growth over the last decade.

While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when visitors move families and businesses to communities they first visited as tourists.

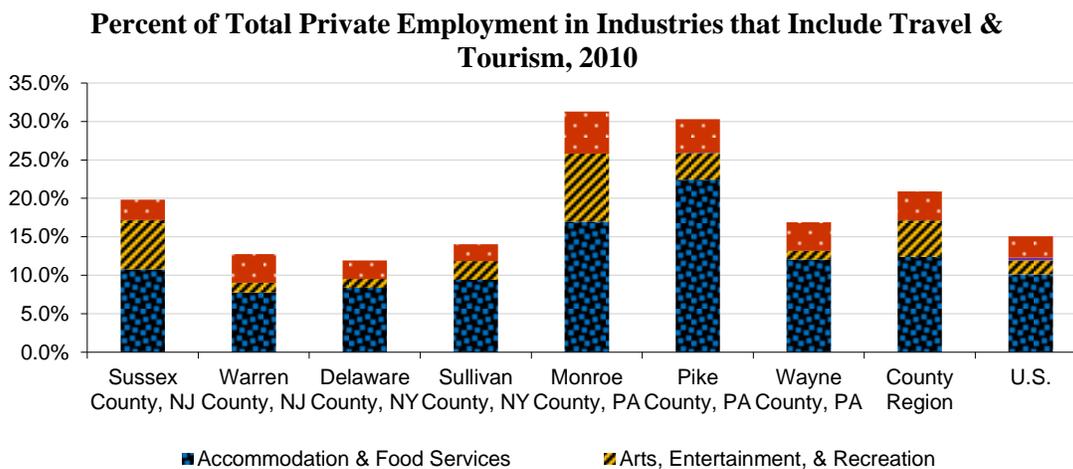


Figure E-8: Profile of travel and tourism employment and jobs by county and region. *Data Sources: U.S. Department of Commerce, 2012. Census Bureau, County Business Partners, Washington, D.C. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.*

Jobs in Industries that Include Travel & Tourism, County Region

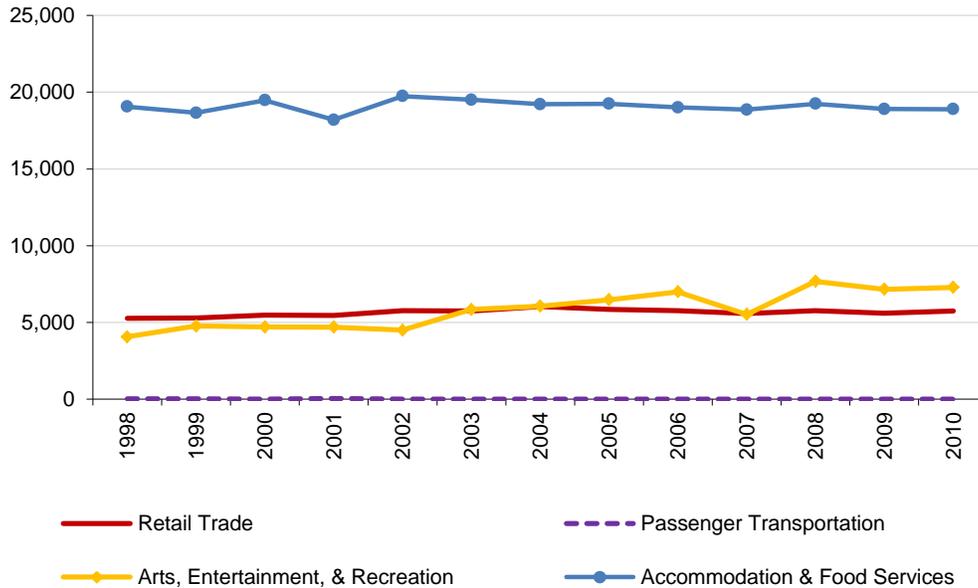


Figure E-9: Regional travel and tourism jobs in the arts, entertainment and recreation showed the most growth over the last decade. Data Sources: U.S. Department of Commerce, 2012. Census Bureau, County Business Partners, Washington, D.C. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.

Agriculture

Although agriculture is a relatively small component of the overall regional economy, in some Upper Delaware region counties it represents a significant portion of the land base, contributes to local economic diversity and is part of the mix that attracts and retains people and businesses to the region. Farm land in the Upper Delaware region typically has a considerable percentage of the total land area in woodland, contributing forest-related benefits as well.

Farm jobs as a percent of total employment

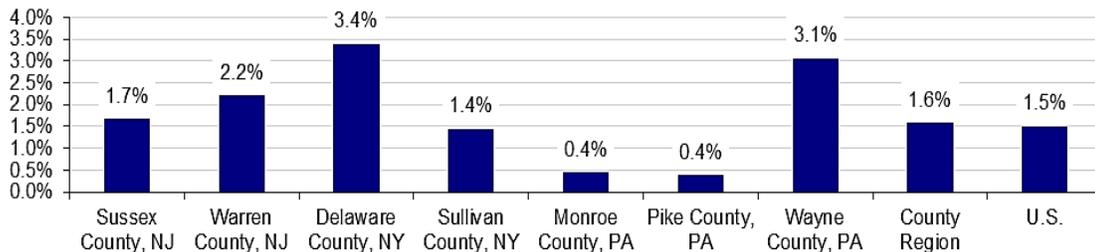


Figure E-10: Farm jobs as a percent of total employment. Delaware County, NY had the largest percent of total farm employment. Data Sources: U.S. Department of Commerce, 2012. Bureau of Economic Analysis, 2013.

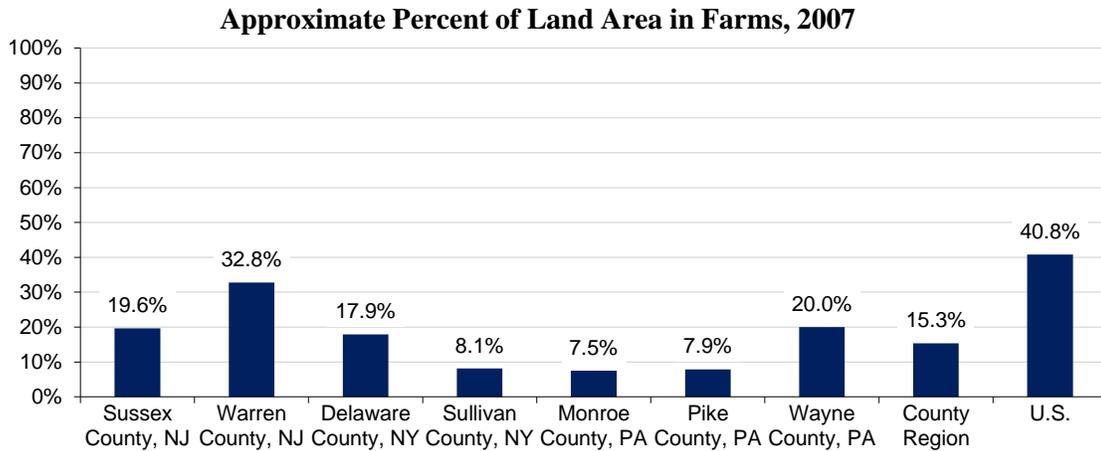


Figure E-11: Percent of land area in farms by county and region. Data Sources: U.S. Department of Agriculture. 2009. National Agricultural Statistics Service, Census of Agriculture, 2013.

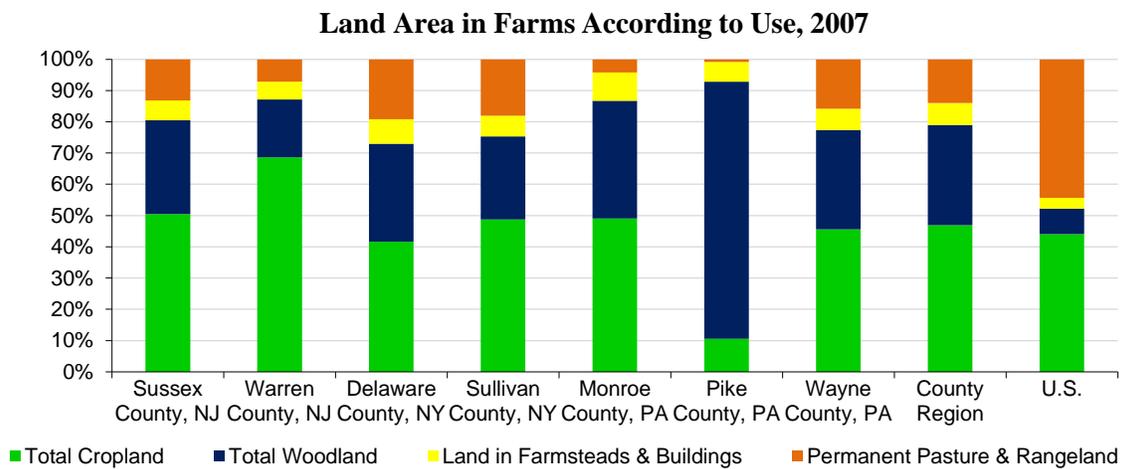


Figure E-12: Breakdown of farm land use showing the percentage of woodland associated with farms. Data Sources: U.S. Department of Agriculture. 2009. National Agricultural Statistics Service, Census of Agriculture, 2013.

With an upturn in the demand for locally grown and produced food and the proximity of the region to major metropolitan areas, agriculture also represents an opportunity for new economic growth in the region. In Sullivan County, NY, for example, farming is considered big business, with \$80 million in direct annual spending and a total impact of \$240 million per year on the local economy (Economic Development Corporation (EDC) of Sullivan County). Although the County has seen a decrease in traditional dairy and livestock farms, smaller niche and diversified vegetable and livestock farms are growing in numbers. The EDC and its partners are currently focused on several initiatives to encourage growth in this area.

In Sussex County, NJ, agri-tourism is promoted in “New Jersey’s Greenest County” where a variety of agricultural enterprises offer products or services to the public: farmers’ markets offering seasonal farm fresh produce, “pick-your-own” vegetables, fruit or berries, “cut your own” Christmas trees, horseback riding, locally grown flowers and honey, meat and dairy products.

Timber

Another relatively small economic driver overall in the Upper Delaware Region, the forest industry is nonetheless a source of local jobs and manufactured products in some counties that, based on estimates of underutilized forest productivity in the region, could, see future growth.

Retirement, Investments, and Non-Labor Sources of Income

Non-labor income consists of dividends, interest and rent (money earned from investments), and transfer payments (retirement, disability and Medicare benefits, and unemployment, Welfare and Medicaid benefits). From 2000 to 2011, labor income increased by 6.3%, while non-labor income grew by 27.3 %. Investment income (dividends, interest and rent) and age-related transfer payments (retirement, disability, Medicare) make up a large share of the non-labor income for the region.

Percent of total private employment in Timber, 2010

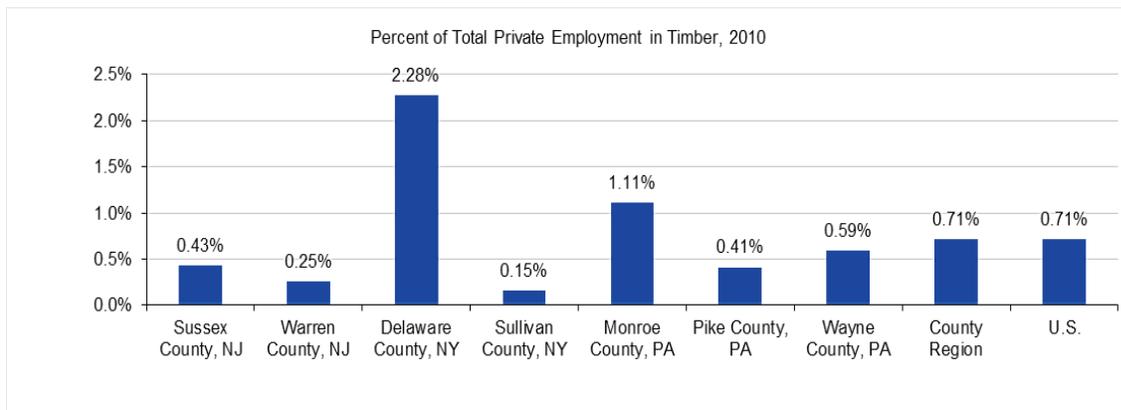


Figure E-13: Percent of total private employment in timber-related industries. Data Sources: U.S. Department of Commerce. 2012. Census Bureau, County Business Patterns, Washington, D.C. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.

Non-Labor Income Share of Total Personal Income, County Region

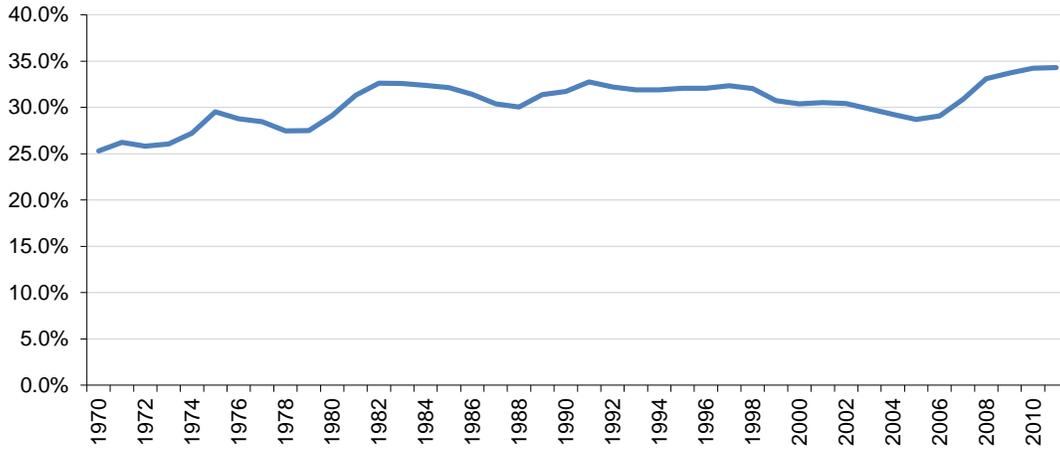


Figure E-14: Non-labor income grew significantly during the last decade.
 Data Sources: U.S. Department of Commerce, 2012. Bureau of Economic Analysis, 2013.

Components of Non-labor Income, County Region

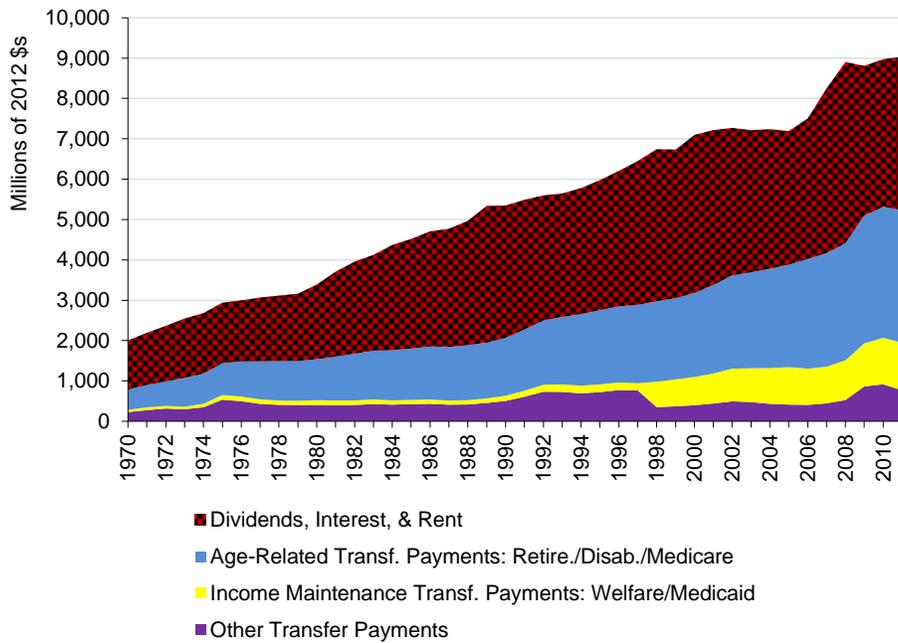


Figure E-15: Investment income and age-related transfer payments make up a large share of the non-labor income for the region.
 Data Sources: U.S. Department of Commerce, 2012. Bureau of Economic Analysis, 2013.

Age Distribution of the Population

In 2011, 30.5% of the region’s population was in the 45-64 years group. This age group also had the largest estimated increase for the period of 2000 to 2011 (23.5%).

Age Distribution and Change, 2000-2011*

	2000	2011*
Percent of Total		
Under 18	26.2%	23.3%
18-34	18.5%	18.0%
35-44	17.7%	14.1%
45-64	24.7%	30.5%
65 and over	13.0%	14.0%

* The data in this table are calculated by ACS using annual surveys conducted during 2007-2011 and are representative of average characteristics during this period.

Figure E-16: Changes in age distribution 2000-2011. The 45-64 years group had the largest estimated increase for the period. Data Sources: U.S. Department of Commerce, 2012; Bureau of Economic Analysis, 2013.

Similarly, the median age of people in the region showed an upward trend in all counties between 2000 and 2011. All of these indicators point to population that is aging.

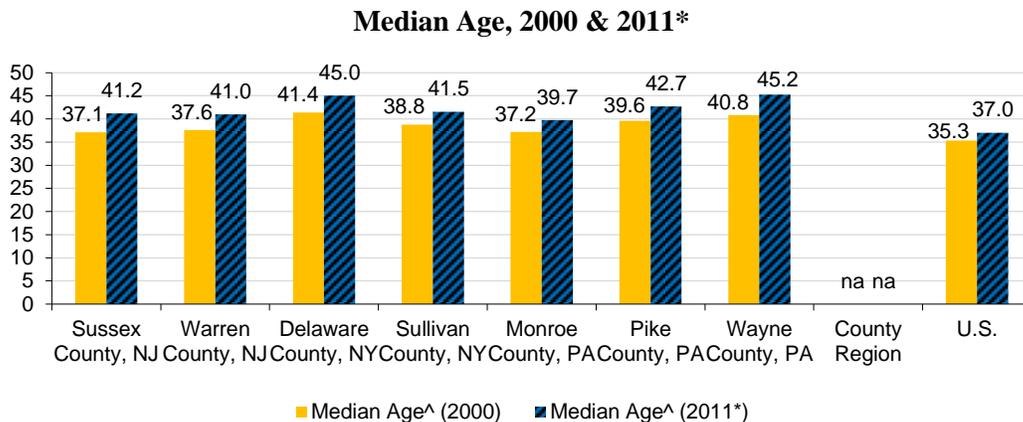


Figure E-17: An upward trend in median age from 2000-2011. Data Sources: U.S. Department of Commerce, 2012; US Census Bureau, 2013.

Education

Overall, about 25% of the region’s people over the age of 25 held a bachelor’s degree or higher. This is just below the US average of 28.2%. Sussex County had the region’s highest percentage of people with a bachelor’s degree or higher while Wayne County had the lowest. An estimated 10.5 % of the region’s people over the age of 25 had no high school degree.

Educational Attainment, 2011*

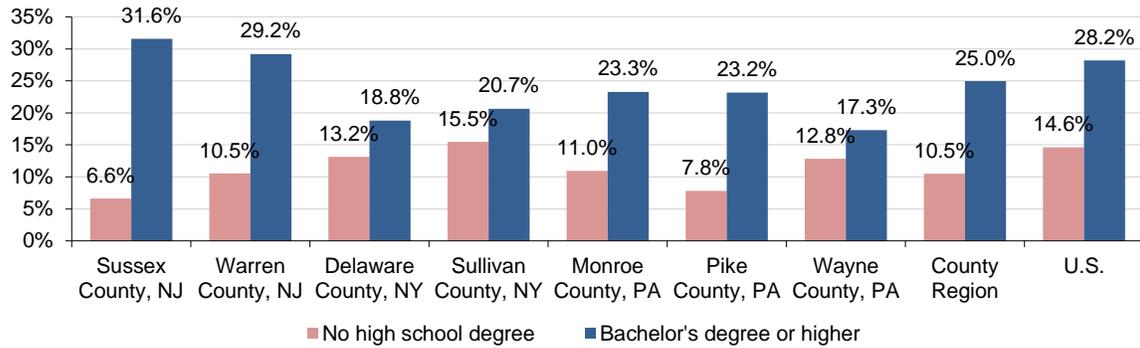


Figure E-18: Educational attainment by county and for the region.
 Data Sources: U.S. Department of Commerce. 2012. US Census Bureau, 2013.

Income Distribution and Poverty

Per capita income and median household income, which often follow trends in educational attainment, were highest in 2011 for Sussex County, NJ and lowest for Delaware County, NY. About 20% of the households in the region had income between \$50,000 and \$74,999. An estimated 9.8% of people and 6.9% of families in the region live below poverty levels. These figures are below the nationwide averages.

Household Income Distribution, 2011*

	Sussex County, NJ	Warren County, NJ	Delaware County, NY	Sullivan County, NY	Monroe County, PA	Pike County, PA	Wayne County, PA
Per Capita Income (2011 \$s)	\$36,986	\$33,616	\$23,120	\$24,023	\$25,096	\$27,989	\$23,500
Median Household Income (2011 \$s)	\$84,860	\$72,615	\$43,554	\$48,303	\$57,700	\$58,672	\$49,020

Household Income Distribution, County Region, 2011*

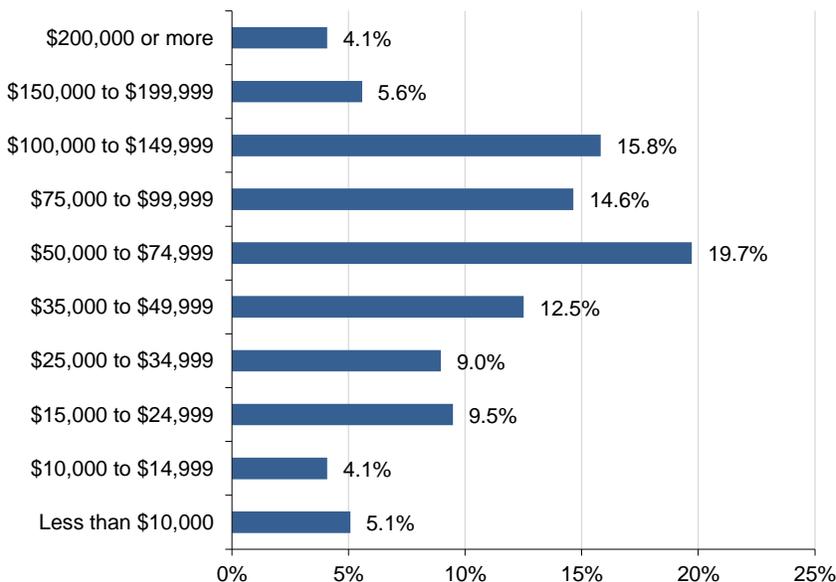


Figure E-19: Household income distribution by county (top) and for the region (bottom). Data Sources: U.S. Department of Commerce. 2012. US Census Bureau, 2013.

Individuals and Families Below Poverty, 2011*

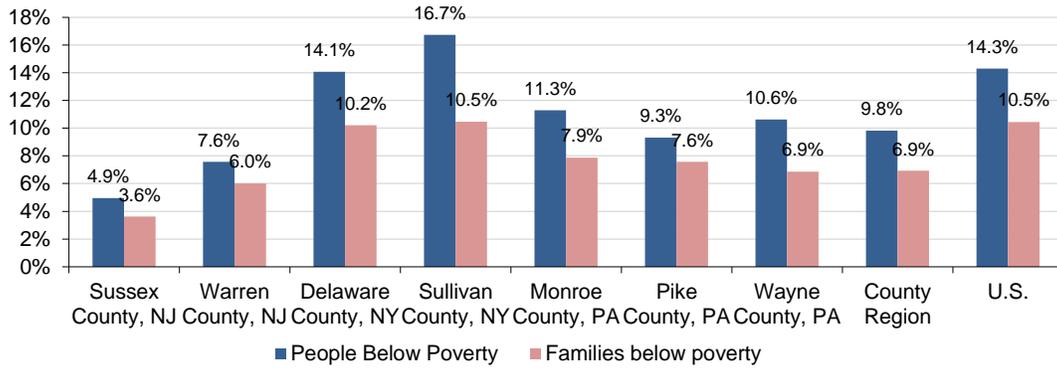


Figure E-20: People and families below poverty by county and for the region compared to the U.S.
Data Sources: U.S. Department of Commerce. 2012. US Census Bureau, 2013.

Housing Trends and Affordability

In 2011, mortgage costs exceeded 30% of household income for 45% of owner-occupied households in the region. Similarly, 47.8% of renter-occupied homes in the region spent greater than 30% of household income on rent. Many government agencies consider housing costs that exceed 30% of monthly household income to be *excessive* or *unaffordable*. When compared to the U.S. averages, unaffordable home ownership rates in the Upper Delaware region are about 8 percent higher.

Housing costs as a percentage of household income, 2011

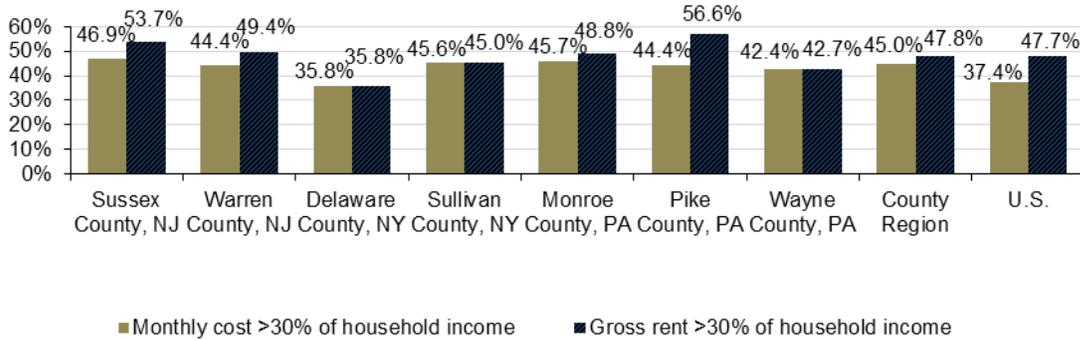


Figure E-21: Housing costs as a percentage of household income, 2011. *Data Sources: U.S. Department of Commerce. 2012. Census Bureau, American Community Survey Office, Washington, D.C. Graphics produced by Economic Profile System-Human Dimensions Toolkit, 2013.*

As a whole, the region had a relatively high percentage of housing in second homes in 2011 (20.1%), down somewhat from the 2000 census figure of 23.7%. Pike County, PA (38.9%), Wayne County, PA (35.1%) and Sullivan County, NY (30.5%) had the highest percentage of second homes and Warren County, NJ had the lowest (0.9%). The percentage of second homes is considered an indicator of the desirability of a place for recreation and tourism and/or an indicator of recreational and scenic amenities, such as public lands.

Relationship of the Economy to the Environment

The Upper Delaware region’s economy has evolved appreciably in the last several decades, showing growth in population, employment, personal income and per capita income. The population appears to be aging; much of the growth in population has resulted from in-migration of baby boomers and near-retirees. In the last decade, the 45-64 age group showed the greatest increase region-wide, followed by the 65 and over age group. Non-labor income, primarily investment income and age-related transfer income, represents over one third of total personal income in the region.



Figure E-22: Shops in downtown Milford, Pike County, PA.

Source: Pike Co. Office of Community Planning.

The economy is driven in part by the travel and tourism industries and the related services sectors that are associated with these industries. Retail trade, education and health, and hospitality and leisure are major components of service-related jobs. Even through the recent recession, the region saw increases in jobs related to the arts, entertainment and recreation. Entrepreneurism in the region is indicated by steady growth in proprietor employment. Second home percentage region-wide is just over 20 percent with some counties in the 30+ percent range.

As previously discussed, climate change often exacerbates existing natural resources stressors, one of which is a growing population. The population growth experienced by the Upper Delaware region in the last few decades, characterized by significant in-migration, is likely to be further enhanced by additional in-migration of “climate refugees” from nearby urban areas and coastal communities impacted by sea level rise and increasing vulnerability to hurricanes and other coastal storms.

Many of the economic indicators summarized here point to the region’s “quality of life” - clean water, clean air, abundant public lands and other open spaces, recreational opportunities – as a significant draw for visitors, residents and businesses alike. In rural areas such as the Upper Delaware region, amenity-based economic activities – travel and tourism, recreation and leisure, entrepreneurship, second home and retirement development – can put pressure on infrastructure and the natural environment and changes in climate are likely to increase these stresses.



Figure E-23: Rafting on the Upper Delaware River.

Source: Kittatinny Canoes.

Economic Vulnerabilities Associated with a Changing Climate

Climate change presents a unique challenge for economics: it is the greatest example of market failure we have ever seen. – The Stern Report

Rural communities have particular geographic and demographic challenges in responding to climate change risks. Physical isolation of some populations, limited economic diversity, reduced access to health systems, aging or remote transportation and communications systems and infrastructure and an aging population all contribute to the vulnerability of rural communities in general and the Upper Delaware region in particular (see *Demographic and Economic Trends in the Upper Delaware Region*). In addition, governments in rural communities may have limited financial resources and emergency response systems available for responding to climate risks (NCADAC 2013).

Extreme Weather Damages

Increases in extreme weather events – heavy downpours accompanied by strong winds, flooding, nor'easters, hurricanes, drought, and heat waves – are perhaps the most tangible evidence of a changing climate for people of the Upper Delaware region and may also have some of the greatest associated costs. Extreme precipitation events are happening more frequently, the biggest storms are getting bigger, extreme storms are responsible for a larger percentage of annual precipitation and projected future temperature increases for the region will drive even more frequent and more intense precipitation events (Frumhoff, et al. 2007). Extreme heat can result in buckling of

Summary of Climate Economic Vulnerabilities

- **Costs associated with extreme weather events**
 - Flooding/flood losses/property damages
 - Higher municipal emergency management budgets
 - Infrastructure damages – roads, culverts, bridges, drainage facilities, dams
 - Power disruptions
 - Tourism/recreation and other small businesses losses
- **Costs Associated with Forest Risks**
 - \$\$ to manage insects/diseases/invasive species
 - Decline in commercially important tree species
 - Increased fire suppression costs and property losses from wildfires
 - Loss of ecosystem services such as flood control and water filtration
 - Shifts in tree species affecting traditional fall tourism peaks
- **Costs Associated with Water Resources Risks**
 - \$\$ for water treatment with water quality degradation
 - \$\$ to increase water storage capabilities
 - Outdoor recreation impacts from water quality degradation and nuisance algae
 - Flow fluctuation effects on recreational boating
 - Declining ski, snowboard and snowmobile opportunities and increased operating costs
 - Loss of cold water fisheries and fishing opportunities
- **Costs Associated with Human Health Impacts**
 - Lyme disease, West Nile Virus, waterborne pathogens
 - Extreme heat-related impacts to vulnerable populations
 - Pollen-related health impacts
- **Costs Associated with Agricultural Losses**
 - Direct crop damages
 - Delayed planting or harvests
 - Reduced milk production or crop yields
 - Increased crop water demand
 - Increased weed and insect pressure

Compiled by UPDE Core Planning Group

roadways and/or bridges due to expansion of concrete and softening of bituminous pavements. Some of the direct risks, and those with the potential to be most costly to Upper Delaware communities from extreme weather events, include flood losses, infrastructure damages, and utility system vulnerabilities. (See *Climate-Related Water Risks* section for a more in-depth examination of the economic costs of extreme storm events.)

Dam Vulnerabilities

A major financial and public safety challenge for the lake and reservoir-rich Upper Delaware region is whether dam design and spillway capacity are sufficient to withstand possible added pressure from extreme precipitation events and higher flows in the winter and spring with increased rain-on snow events. In its 2010 *Report Card for Pennsylvania’s Infrastructure*, the Pennsylvania Department of Environmental Protection (PA DEP) reported that about 39% of the state’s “high hazard” dams - dams

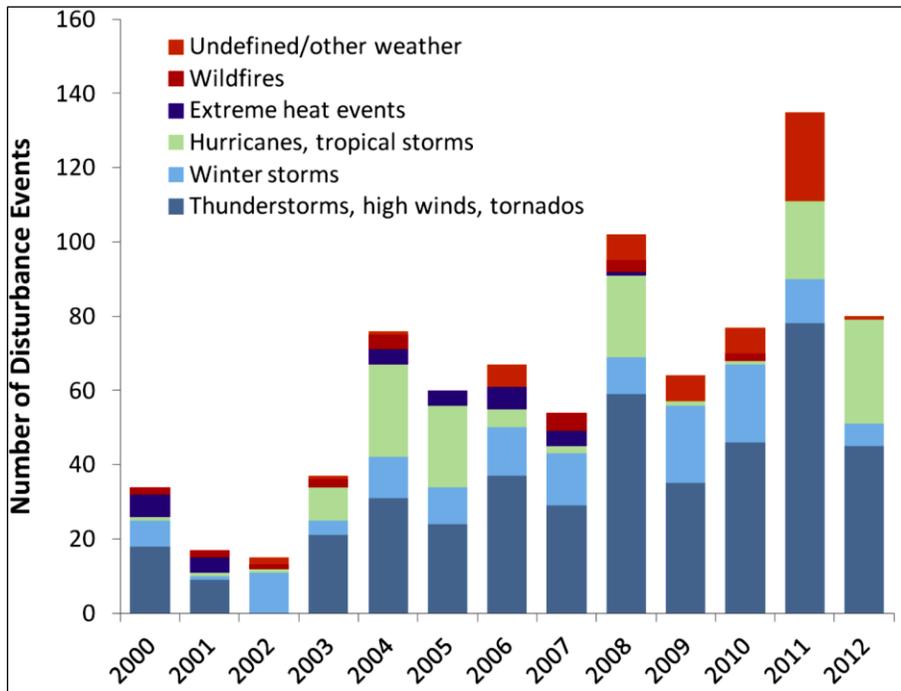


Figure E-24: Weather-related power grid disruptions in the US, 2000–2012.
Source: U.S. Department of Energy 2013.

whose failure would cause probable loss of human life and substantial property damage - are considered deficient. There are 40 high hazard dams located in Pike County and over 50 in Monroe County. Sullivan County, NY lists 14 and Delaware County, NY lists 8. In New Jersey, Sussex County has 36 high hazard dams. These numbers do not include the next most hazardous category of dams – considered “significant” hazards. With many of the high hazard dams in the region under private ownership and with estimated average repair costs ranging from \$1.5 million to \$4 million per dam, the estimated cost for upgrading deficient high hazard dams, absent the additional design considerations introduced by climate change, could be an extreme burden. In addition, many of the dams that were upgraded in the early to mid-1980s may soon reach a point where additional upgrades and/or repairs are necessary. PADEP projects that the

number of deficient and high hazard dams will increase significantly by 2015 if needed upgrades are not completed (PADEP 2010).

Energy Vulnerabilities

Changes in climate have the potential to significantly impact U.S. energy security by forcing the present aging energy system to operate outside of the ranges for which it was designed. Nationwide, weather related power disruptions are on the rise, with thunderstorms, high winds and tornados causing the most disruptions. In six of the last twelve years, hurricanes and tropical storms were responsible for a high number of power disruptions.

In the tri-state region, during Super Storm Sandy, for example, power outages in New York, New Jersey and Pennsylvania shattered records with nearly six million without power for prolonged periods. In twenty nine Pennsylvania counties it serves, PPL Electric Utilities estimated the storm recovery costs at between \$70 million and \$80 million. An estimated 800,000 plus PPL and Met-Ed customers were without power, some for up to two weeks, in the 42 Pennsylvania counties served by the companies. About 90,000 of those were in the Poconos region of northeastern Pennsylvania.

Small Business Sector

In a 2013 report, *Climate Change Preparedness and the Small Business Sector*, the Small Business Majority and the American Sustainable Business Council highlighted the unique vulnerabilities of small businesses to the impacts of climate change as well as the vital role that small businesses can play in improving communities' resilience to climate change. This information is very applicable to the economies of the Upper Delaware region, which is characterized by a relatively large and growing percentage of proprietor/entrepreneur employment (see *Demographic and Economic Trends in the Upper Delaware Region*). In addition to the direct risks of destructive events such as hurricanes, extreme downpours and flooding, extreme heat and wildfires, small businesses are also vulnerable to indirect effects of extreme weather such as power outages, road closures, telecommunications failures, loss of water supply, increased demand for air conditioning, rising insurance costs, supply chain disruptions, interrupted access to natural resources, employee absences and loss of work hours. The median cost for small businesses of downtime from an extreme weather event is estimated at \$3000 per day. An estimated 40% of small businesses experiencing long-term power outages from extreme weather events close permanently due to physical losses in perishable inventory and lost revenue. Small businesses often lack the physical assets and back-up systems, financial capital and human resources that make larger companies more resilient during extreme weather events (Reynolds 2013).

The Harford insurance company devotes pages on its website to the trend of increased extreme weather events and the vulnerabilities of small businesses to these events. Some recommendations for improving small business resiliency include:

- Recognizing the threats that nature poses in a particular geographical area and taking measures to reduce or eliminate exposure;
- Having protective systems in place, for example, an emergency generator, surge protectors, storm shutters, etc.;
- Backing up computer data regularly and storing copies of files at an offsite location;

- Developing a business continuity plan that identifies specific steps needed to return to operations after a disaster (The Hartford 2013).

Tourism and Recreation

Tourism and related businesses are particularly vulnerable to economic losses resulting from weather disruptions. Interrupted travel plans, cancelled reservations or events and losses associated with power outages, even over relatively short time periods, can have profound negative financial impacts. If these events happen more frequently and with greater intensity as projected, businesses associated with the tourism industry will be hard-hit.

Tourism is often climate-dependent as well as seasonally-dependent. The figures below illustrate projected changes in climatic attractiveness (based on maximum daily temperature and minimum daily relative humidity, mean daily temperature and mean daily relative humidity, precipitation, sunshine, and wind speed) in July for much of North America. While a longer outdoor recreation season may benefit some tourism-related activities, unfavorable summertime conditions are projected to push northward in the northeastern U.S. under current climate change scenarios.

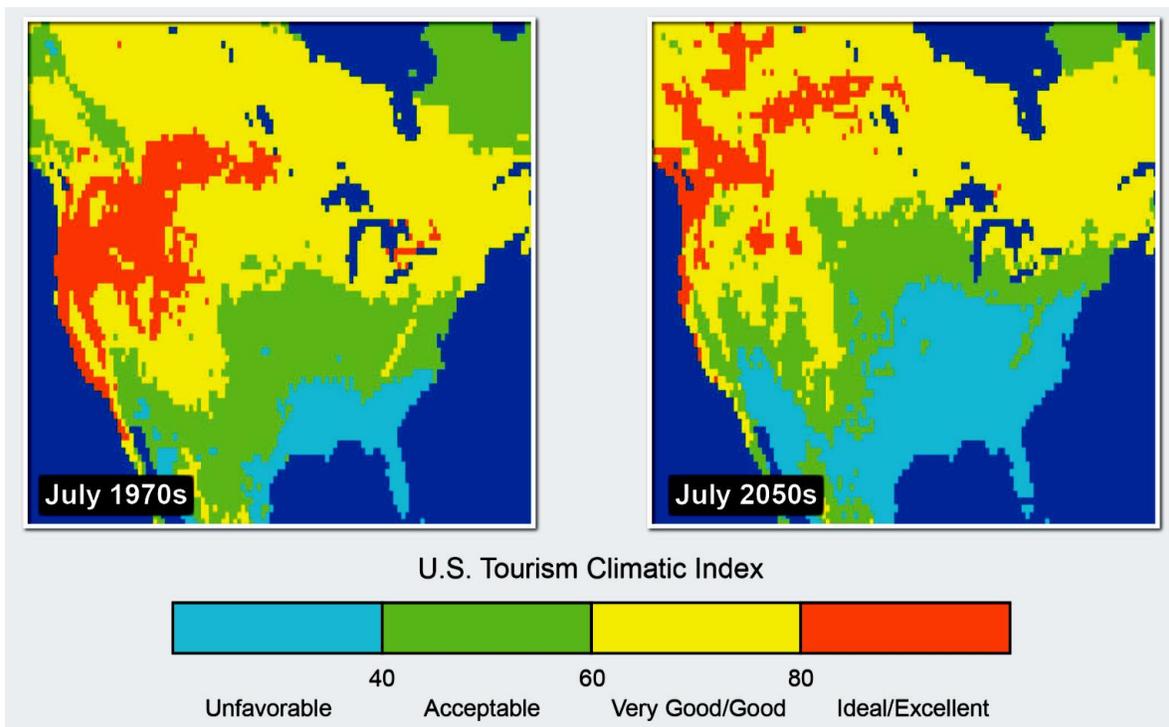


Figure E-25: Climate change impacts on summertime tourism. *Source: NCADAC 2013.*

Lakes and reservoirs are part of the Upper Delaware region’s economy. There are state-managed lakes, which attract anglers and vacationers and provide water and hydroelectric power to inhabitants in the region. Privately-owned lakes attract first and second-home buyers, vacationers, boaters and anglers. Climate-related changes in lake health affect water quality, recreational uses, angling and boating activities and the general aesthetic benefits that lakes provide. Warming is projected to increase the growth of algae and invasive species, particularly in areas already facing water quality impairments

(Hansson et al. 2012). During algal blooms, recreational activities tend to decrease as the water is uninviting and potentially toxic to swimmers, boaters, and anglers, which impacts tourism and related activities in the area.

Warmer winter temperatures and the projected reduction in snow cover will adversely affect winter recreation and the industries that rely upon it. Skiing and other snow sports (not including snowmobiling) account for a \$4.6 billion annual contribution to the regional economy in the northeast and snowmobiling accounts for another \$3 billion (Karl, et al. 2009).

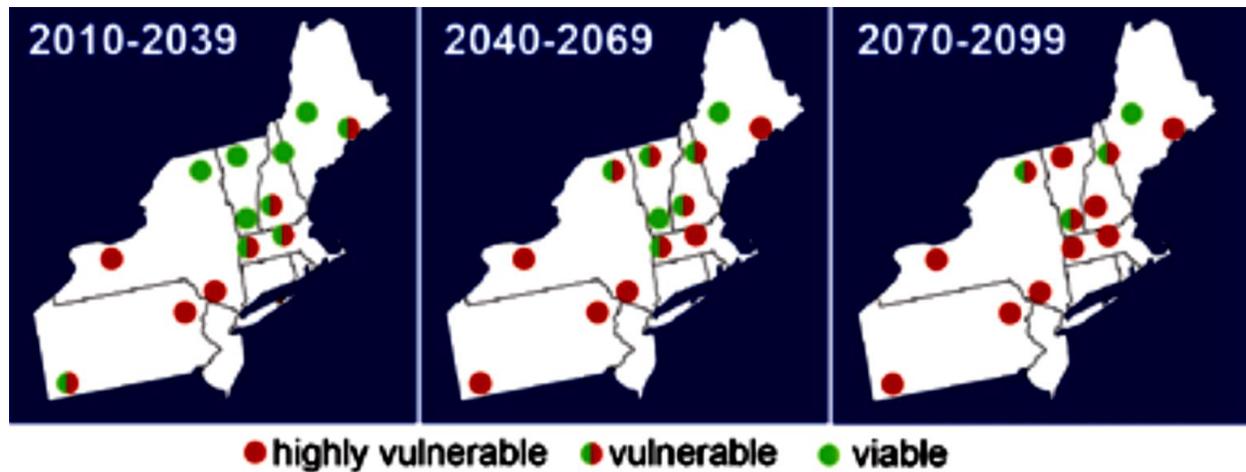


Figure E-26: Ski Areas at risk under higher emissions scenario. *Source: Karl, et al. 2009.*



Figure E-27: Warmer winters and earlier ice melt will affect ice fishing, a popular winter activity. *Source: PA Fish & Boat Commission.*

In the Pocono Mountains of Pennsylvania, 9 ski areas withdraw 1 million gallons of water per day from the Delaware Basin for snowmaking on 1,005 skiable acres. Using figures from the Pennsylvania Ski Areas Association, Kaufmann, et. al. (2013) estimated the economic value of these 9 ski areas in the Delaware Basin at \$325 million, including aggregate annual revenues of \$88 million from 1.9 million ski visits based on a mid-week lift ticket rate of \$45 per day.

Warming winters will shorten the average ski and snowboard seasons and increase artificial snowmaking requirements thus driving up operating costs and potentially stressing water resources used for snowmaking. Prospects for the snowmobiling industry are worse, with much of the northeast region projected to have a marginal or non-existent snowmobile season by mid-century (Karl, et al. 2009). Warmer winters and early ice melt on lakes will also impact ice fishing enthusiasts who flock to the region’s larger lakes during the winter season.

Agriculture

Because of its effects on the water cycle and on the frequency and severity of extreme weather events, climate change has the potential to wreak havoc with the emerging variety of agricultural enterprises in the Upper Delaware region. Climate risks to agricultural enterprises include: direct crop damages, delayed planting or harvests, reduced milk production or crop yields, increased crop water demand and increased weed and insect pressure.

Agricultural producers already have experience adapting to climate change through changing crop rotations, planting times, genetic selection, water management, and shifts in crop production. These practices and other conservation measures that prevent soil erosion and reduce water use will become increasingly important with increasing temperatures and changing hydrologic conditions.

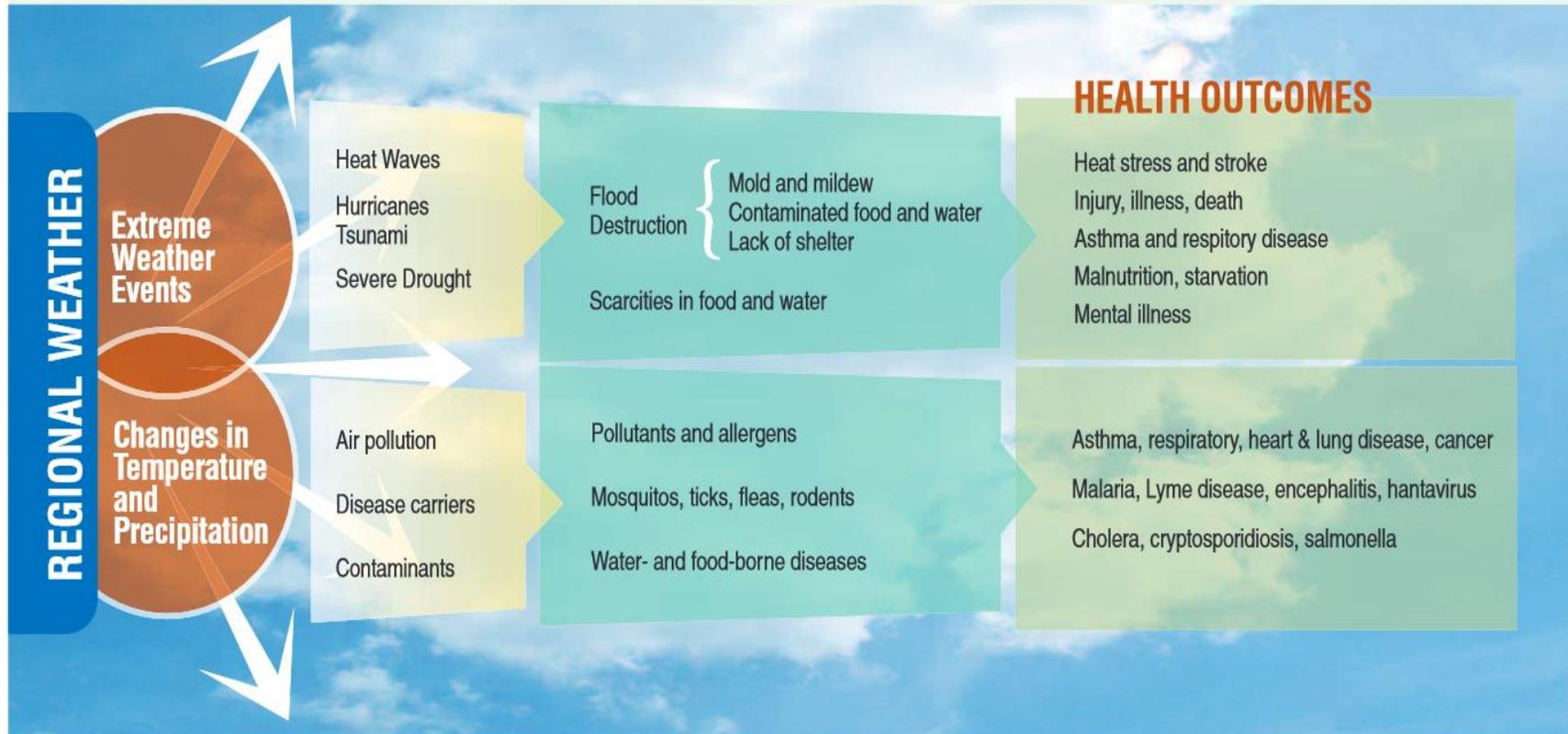


Figure E-28: Leased agricultural lands along the Delaware River within Delaware Water Gap National Recreation Area. Source: NPS, DWGNRA.

Vulnerable Populations and Health

The impacts of climate change go beyond physical damages, threatening human health in a variety of ways. The American Public Health Association (APHA), in a 2007 press release, declared climate change to be “one of the most serious public health threats facing our nation”. Yet, according to APHA, “few Americans are aware of the very real consequences of climate change on the health of our communities, our families and our children.”

How Can Climate Change Harm the Public's Health?



Source: United States Global Change Research Program. Climate Change Impacts. 2009

Figure E-29: Range of potential climate-related health impacts. Source: *Climate Change is a Public Health Issue*, APHA n.d..

The range of potential climate-related health impacts, which generally hit poor, elderly and already health-compromised populations especially hard, is summarized in Figure E-30.

One type of extreme weather event, heat waves, in addition to impacting forests and hydrologic processes, contributing to drought, and straining energy infrastructure, can also inflict substantial harm on sensitive human populations including the elderly and those with pre-existing health conditions. The northeastern U.S. can expect significant increases in heat wave intensity, frequency and duration as depicted in Figure E-31 below. Heat stress, heatstroke, disease and mortality are some of the health concerns associated with these trends in extreme heat.

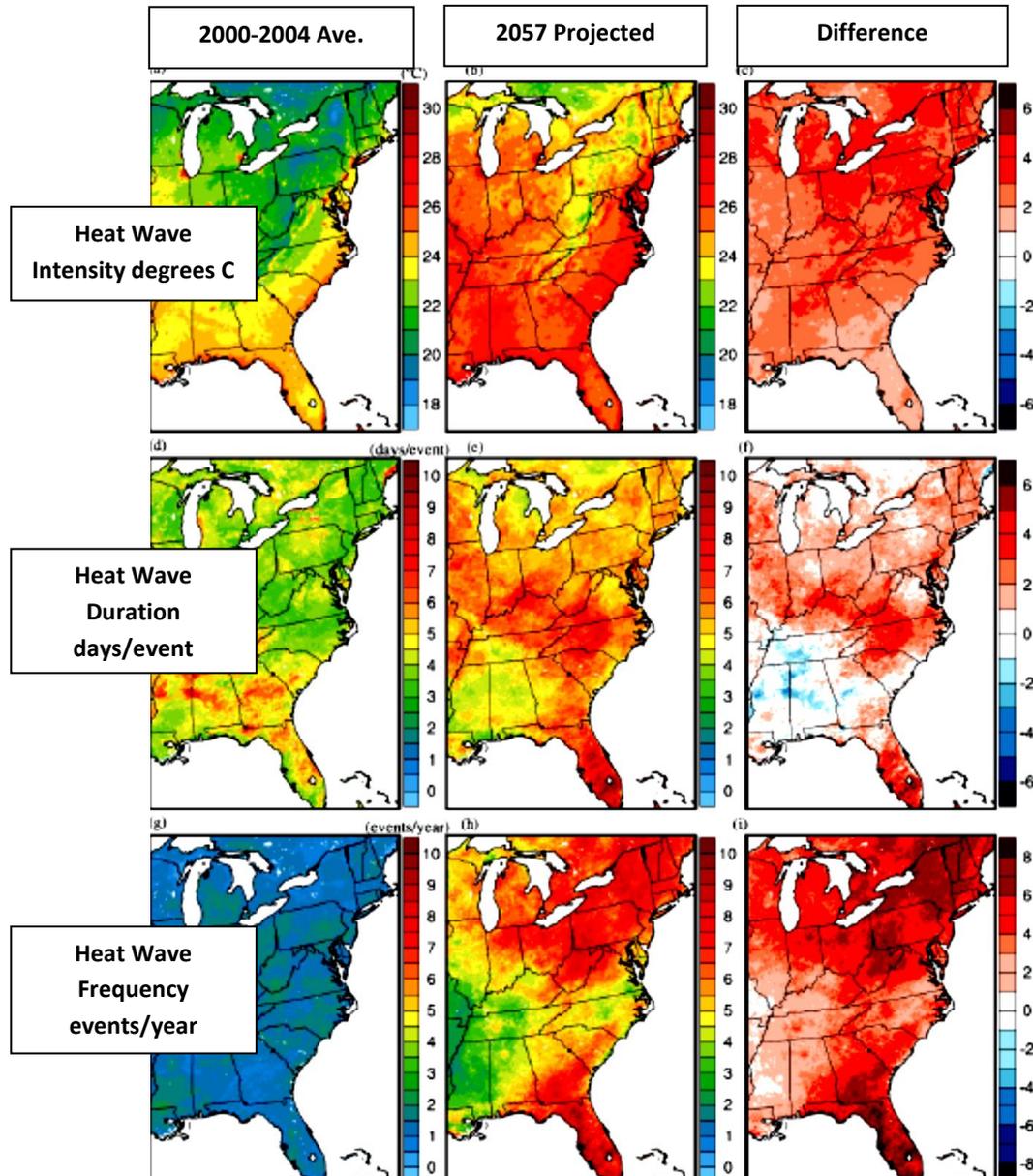


Figure E-30: The spatial distributions of heat wave intensity (top row), duration (middle row) and frequency (bottom row) at present climate (left column) and 2057 projected (center column). Differences in heat wave intensity, frequency and duration are depicted in the right column.

Source: Y Gao, et al. 2012.

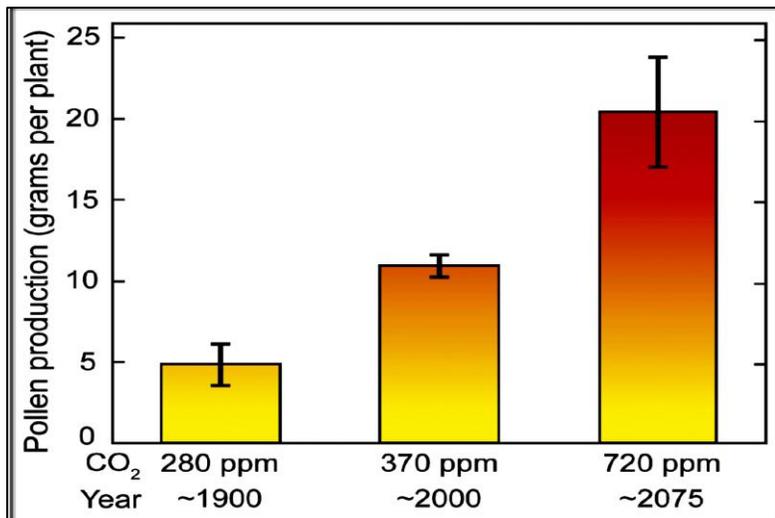


Figure E-31: Pollen counts rise with carbon dioxide.
 Source: NCADAC 2013.

In the Northeast region, rising temperatures, warmer winters and extended growing seasons have lengthened pollen seasons and increased growth of toxic plants such as poison ivy, creating risks for people with allergies and respiratory disease (Cooney 2011).

Warmer winter temperatures are also facilitating expansion of the geographic range of disease-carrying insects, such as ticks that spread Lyme disease and mosquitoes that spread diseases including West Nile virus and malaria. The incidence of Lyme disease increased about 80% in the United States from 1993 to 2007, especially in northern states previously thought too cold to support the ticks that spread the disease. The differences in statewide trends are consistent with expectations under climate change projections and suggest that warming temperatures have already affected the ecology of this disease (Tuite, et al. 2013). In addition to shifting disease vectors' geographic ranges, warmer temperatures and longer growing seasons increase reproductive and biting rates and shorten pathogen incubation periods (Patz, et al. 1996). A 2009 Yale University study showed that a changing climate also affects the *severity* of Lyme disease infections by influencing the feeding patterns of deer ticks that carry and transmit it (Gatewood and Liebman 2009).

Warmer temperatures affect the spread of West Nile virus by extending the length of the mosquito season and by reducing the time it takes for mosquitoes to reach biting age and speeding multiplication of the virus within insects. Higher humidity, heavier rainstorms and increased overall precipitation have also been associated with higher rates of West Nile virus infection (Patz, et al. 1996). One vector of West Nile virus, the Asian tiger mosquito (*Ae. Albopictus*), is a highly invasive species with severe human biting activity. This mosquito is poised to significantly expand its range in the northeastern United States in the next few decades primarily due to warming winter temperatures. The expansion represents an important public health threat since there are currently no cost effective options for control of this mosquito species (Rochlin, et al. 2013).

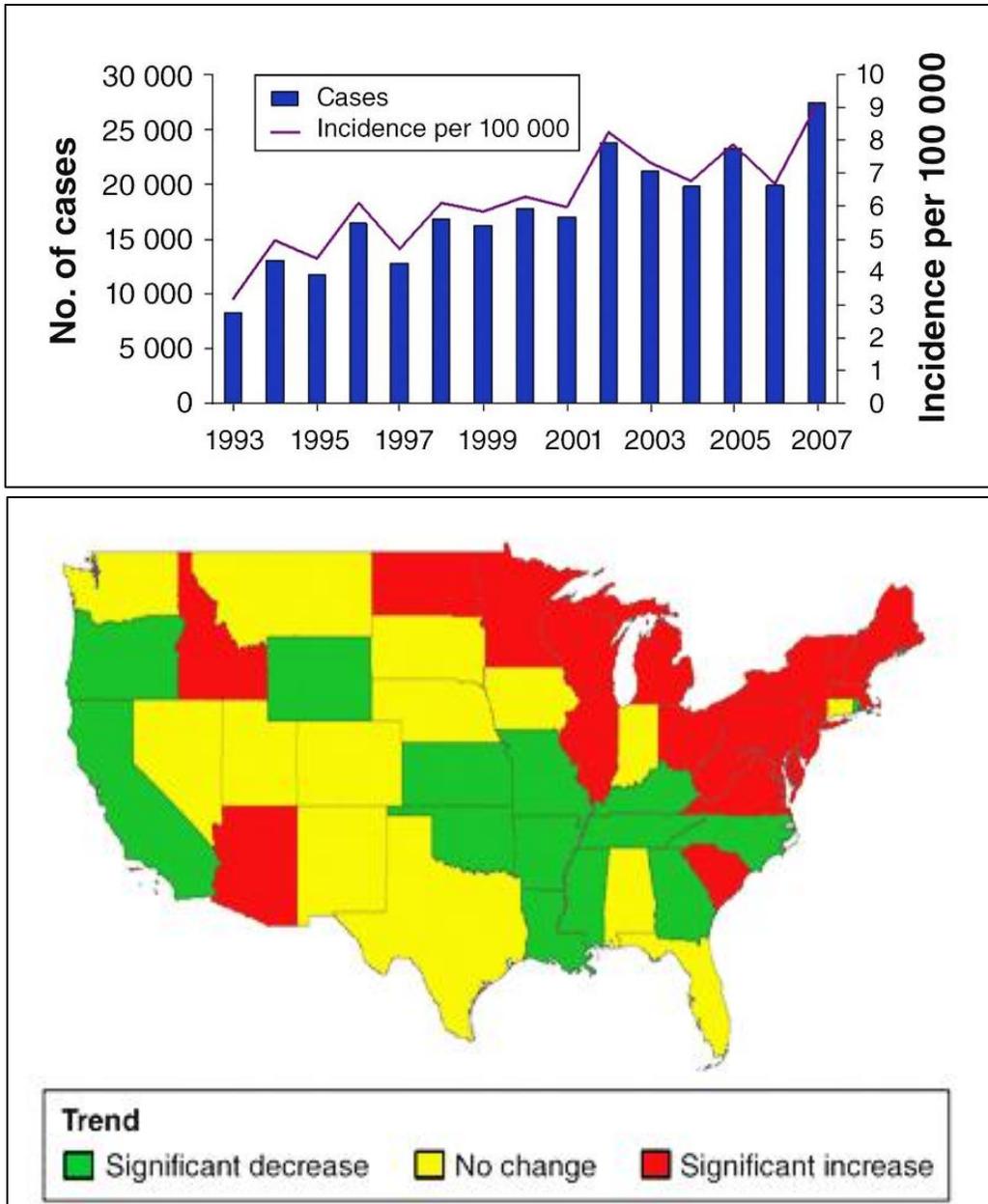


Figure E-32: Trends in Lyme disease incidence from 1993 to 2007. Source: Tuite, et al. 2013.

Suffering from any illnesses, loss of property or loss of loved ones can take a toll on a person’s mental health. The effects of personal trauma after an extreme weather event vary in severity and length. Dr. George Luber, an epidemiologist and the Associate Director for Climate Change at the Centers for Disease Control and Prevention, stated in a February 26, 2013 webinar *Climate Change & Public Health*, hosted by Ohio State University, that “there are much longer and significant impacts for individuals and public health systems as a result of the increase of frequencies of disasters. This certainly came to light in looking at Hurricane Katrina and Super Storm Sandy that the most persistent effect of these storms on individuals and communities are the mental health problems. Our capacity to deal with post disaster mental health issues needs to be enhanced” (Luber 2013).

Loss of Ecosystem Services

The natural systems of the Upper Delaware region provide an array of goods and services that are essential to the economic viability of the region. In the past, these goods and services were considered “free” and were therefore historically undervalued. However, there is a growing understanding of the important benefits to people from natural systems, the real cost in dollar value of losing those benefits through environmental degradation and the long-term investment value of conserving key natural systems. Some of the most prominent ecosystem services provided by forests and water resources of the Upper Delaware, both within and beyond the watershed boundaries, include the following:

- Drinking water purification and supply
- Stormwater management and flood protection
- Fish and wildlife habitat for recreationally or commercially important species
- Recreation opportunities and aesthetics
- Local weather and climate stability

Ecosystem Service	Median \$/acre of temperate forest (2013\$)	Value of ecosystem services from forests in Upper Delaware watershed (2013\$)
Gas & climate regulation	\$31.60	\$65,016,747
Water supply	\$14.22	\$29,257,536
Pollination	\$255.96	\$526,635,652
Refugium and wildlife conservation	\$440.82	\$906,983,623
Aesthetic and recreation	\$17.38	\$35,759,211
Total	\$759.98	\$1,563,652,770

Figure E-33: Estimated value of ecosystem services associated with forests of the Upper Delaware region (not including flood control). Source: *Headwaters Economics (personal communication), Costanza et al, 2006.*

Figure E-34, compiled by Headwaters Economics, estimates the value of some ecosystem services that can be applied to the forests of the Upper Delaware, using a commonly-cited study by Costanza et al (2006). Because it does not include values for flood control, it is likely an underestimate of the total value of services from the watershed. All of the values listed have the potential to be impacted by the temperature and hydrologic impacts projected for the Upper Delaware region, decreasing the value of ecosystem services provided by the region’s forests and increasing the real dollar costs of replacing them.

In another approach to ecosystem services valuation, Kousky, et al. (2013) conducted an economic analysis of the costs versus benefits of preserving floodplain lands to avoid future flood damages. The analysis was used to target investments in land conservation that would achieve net benefits. Given the extent of flooding and flood related damages in the Upper Delaware region and the projected climate-related increases in these impacts, conducting this type of cost/benefit analysis could be very beneficial for targeting investments in land conservation for the Upper Delaware region to mitigate future flood damages.

Forest and Water Resources Assessment Findings

The Region's Forests and Waters – A Brief History

The most recent ice sheet (Wisconsin) covered the Upper Delaware region completely, creating much of the geological landscape that we are familiar with today. The transition to the flora and fauna currently typical of the region began after the last glacier started to retreat some 15,000 years ago. Most of the Upper Delaware region was scraped over by the glaciers, and then covered with a layer of glacial debris. As the cold climate of the glacial period gradually warmed, plants began to migrate north to colonize the post-glacial landscape. Pollen grain studies indicate that the early forests were dominated by large expanses of open coniferous pine-spruce forests interspersed with grasslands and deciduous forests colonizing riparian zones and wet areas. As the climate moderated and moved towards seasonality during the early Holocene period, the coniferous forests moved northward with the retreating glaciers, and species such as oak, beech and later chestnut migrated to the region. The warming climate also promoted the establishment of forest understory and edge vegetation typical of today's forests. A continued warming trend resulted in the expansion of oak and hemlock mixes and the development of glacial remnants such as wetlands, bogs and swamps (Oplinger and Halma 1988).

The Upper Delaware region is believed to have been inhabited by people for at least 10,000 years. Long before European settlers arrived in the heavily forested, rocky and rugged wilderness frontier, Native American Lenape tribes and their ancestors lived off the region's abundant plant and animal life, first as hunter-gatherers and later as farmers. Along the Delaware, Native Americans relied on fish and shellfish as important food sources. Wild plants, acorns and other nuts were abundant, as were animals such as deer, elk, bear, turkey, waterfowl and small game. The river and its tributaries were important as transportation routes, with dug-out canoes a principal means of travel.

Early settlers to the region included Dutch, Swedish, German and eventually British immigrants who cleared forest land for farming. The arrival of European settlers resulted in many changes in Native American culture. Exposure to diseases such as measles and smallpox, for which they had no immunity, proved devastating to the Native Americans and conflicts arose with the colonists' preference for private ownership of land. The wars for independence and subsequent growth of the United States further stressed Native American populations, and by the mid-1700s, most Lenape had left the Delaware River Valley and moved west.

As settlement increased, the Upper Delaware region was soon transformed by industrial activities, which were characterized by exploitation and took their toll on the forest and water resources. The Delaware River was a key transportation route during the industrial revolution and its forest lands were heavily utilized in the construction of eastern cities and railroads and in the ship building industry. The Upper Delaware timber industry was born in 1794 when Daniel Skinner, of Damascus, PA, came up with the idea of floating rafts of pine timbers cut along the banks of the River downstream to the shipyards of Philadelphia. At its height in the late 1800's, as many as 3000 timber rafts were employed in flotillas on the river. Inns and boarding houses proliferated throughout the valley to provide support services for the raftsmen. However, within the next century and a half, the forests of the Upper Delaware were all but denuded by this industry (Henn 1975).

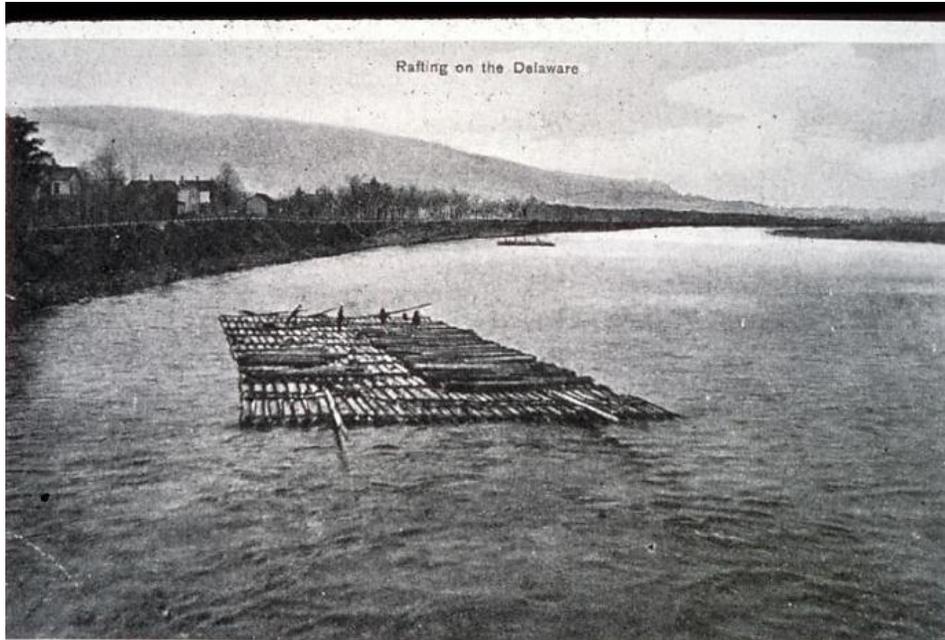


Figure H-1: Log rafting on the Delaware River

Source: U.S. Department of the Interior, National Park Service 2013.



Figure H-2: Timber Transport on the D&H Canal

Source: U.S. Department of the Interior, National Park Service 2013.

The Delaware & Hudson Canal (D&H Canal), which opened for business in 1828 to carry coal from Pennsylvania to the Hudson River for shipment to New York City, fueled further population increases in the Upper Delaware region. Numerous other goods and materials, including lumber and bluestone, were transported on the canal. Built in 1847 for the D&H Canal, the Delaware Aqueduct (also known as Roebling Bridge) was designed by and constructed under the supervision of John A. Roebling, future

engineer of the Brooklyn Bridge. Today the Delaware Aqueduct remains as the oldest existing wire cable suspension bridge in the nation (National Park Service 2013).

The D&H Canal also played an instrumental role in another of the region's major industries - tanning. Abundant hemlock forests produced high quality tannins that spawned a thriving tanning industry, which in turn supplied an abundance of leather to outfit the Union Army during the Civil War. However, by the end of the 1880s, the hemlock stands were rapidly being depleted and the tanneries and the wealthy industry associated with them had all but disappeared (Conway 2009). American chestnut was also a species common in the Upper Delaware colonial forests, but it declined dramatically by the mid-1900s as a result of a lethal fungus infestation, known as the chestnut blight.

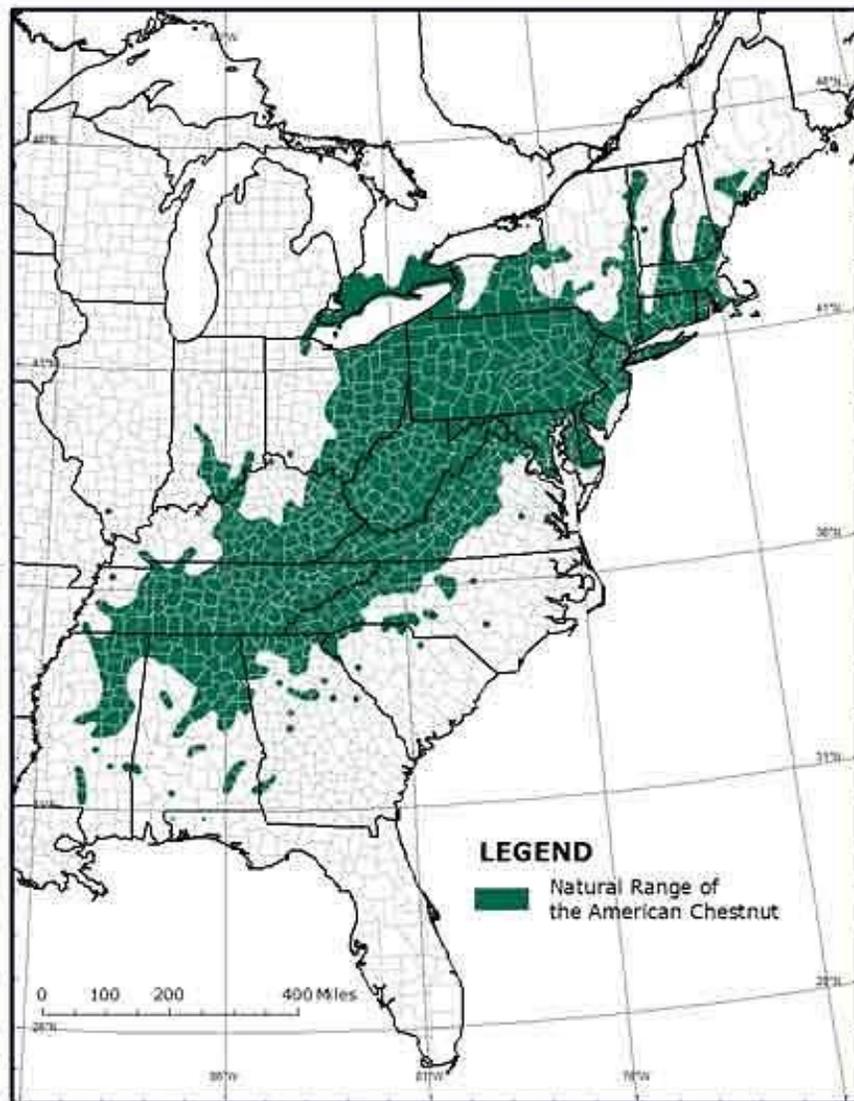


Figure H-3: The American chestnut was once up to 1/4 of the hardwood tree population in its historical range. Source: *The American Chestnut Foundation*, http://www.acf.org/range_close.php.

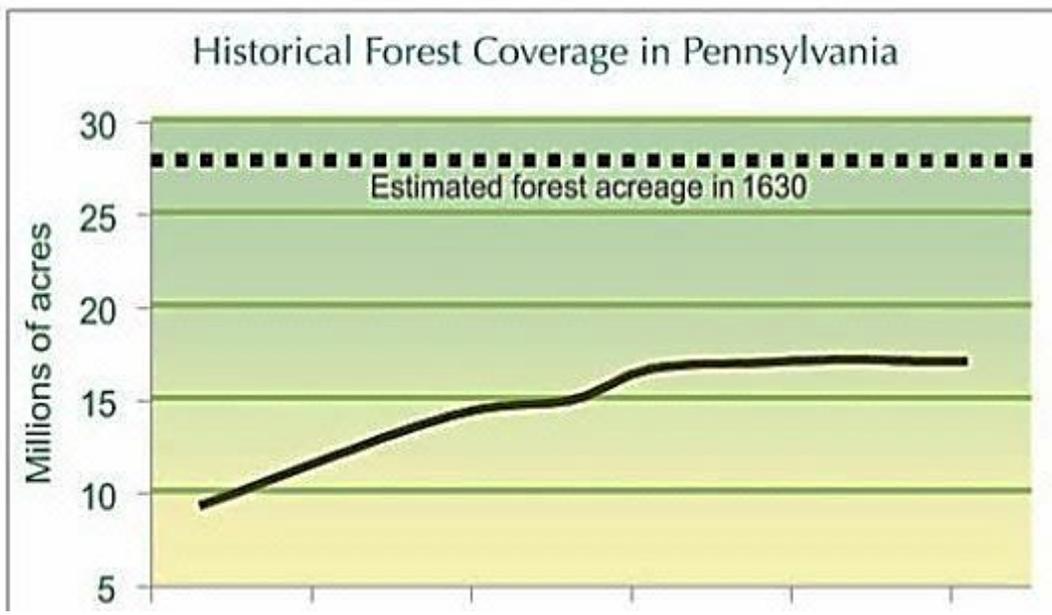


Figure H-4: Upper Delaware forest recovery followed statewide trends starting around the late 1800s. *Source: Price and Sprague 2012.*

Forests were viewed as an inexhaustible resource until the late 1800s when the states began to enact legislation and establish state agencies and state forest lands to protect and sustainably manage forests. In some areas, agricultural lands abandoned as settlers moved west or relocated to cities and towns were purchased by states for reforestation purposes. These acreages were the beginnings of a considerable state forest, state parks and state game lands system important in the region today.

Ironically, with its wealth of forest resources all but gone, the Upper Delaware region, also rich in scenic geologic attractions and game fisheries, began attracting artists, writers, sportsmen and vacationers from nearby metropolitan areas and a new industry – tourism - took shape. Famed western novelist Zane Grey was one such visitor to the Upper Delaware in his youth - fishing, canoeing and enjoying the outdoors. He eventually settled with his wife, Dolly, at the junction of the Lackawaxen and Delaware rivers. As a struggling young writer, his first published article was "A Day on the Delaware," in *Recreation* magazine, May 1902. Many fishing and outdoor adventure articles, serialized stories and books followed, including the western novels that made Grey famous. The ashes of both Zane and Dolly are interred in a cemetery near their home in Lackawaxen, where they wished to remain together beside the Delaware River (National Park Service 2013).

The tourism industry was closely linked with a growing railroad system in the valley, which enthusiastically promoted the Upper Delaware region as a vacationers' and sportsmen's paradise. Boarding houses, inns and grand hotels and eventually summer resorts, complete with lawn tennis and golf courses, were constructed. The railroads also supported a growing agricultural industry and, over the years were joined by an expanding network of constructed roads - main arteries of commerce which further linked communities up and down the valley.



Figure H-5: Zane Grey fishing on the Upper Delaware River.
Source: Photo Gallery: National Park Service 2013.

While tourists flocked to resorts in the Upper Basin, pollution in the Delaware River, particularly in the tidal reaches of its urban centers, began to be a recognized problem by the early eighteenth century and continued to be a serious issue over the next 200 years, mostly due to rapid population growth and increased industrial activities. Severe pollution was most evident by the prevalence of waterborne illnesses and in the sharp decline of migratory fish populations, such as the American shad.

By the height of World War II, in the mid 1940's, the lower reaches of the Delaware River were largely considered an open sewer for public and industrial waste, and pollution was rampant. The river's water was so foul that it would turn the paint of ships brown as they traveled through or were docked for any period of time. People were sickened by the smell of the river. Parts of the estuary were considered dead zones, almost or completely devoid of oxygen needed for the survival of fish and other aquatic life.

Motivated to address these water pollution issues, President John F. Kennedy created the Delaware River Basin Commission (DRBC) in 1961. This represented a landmark step toward improved management of the basin's water resources. The Delaware River Basin Compact's foremost principle (then and now) is that the waters and related resources of the basin are regional assets vested with local, state, and national interests that all share joint responsibility to maintain and protect those assets.

In 1966, the federal government began a major and very controversial land acquisition program in the region, initially for the construction of the Tocks Island Dam, reservoir and associated national recreation area. Although the dam was never built (the project was ultimately deauthorized by Congress in 1992),

the land acquired became the Delaware Water Gap National Recreation Area and both the upper and middle sections of the Delaware River were added to the National Wild and Scenic Rivers System.

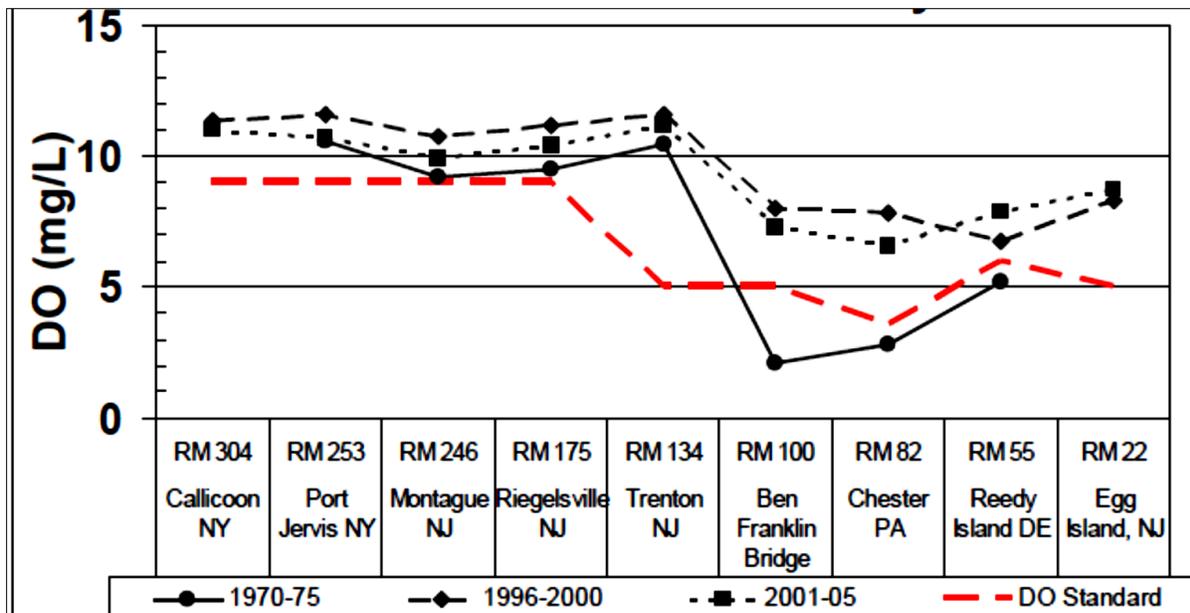


Figure H-6: Dissolved Oxygen (DO) Trends (one indicator of water quality) along the Delaware River 1970 - 2005. Upper reaches (left) maintained higher DO than lower reaches in each period.

Source: Kauffman et.al. 2008.

In 1967, the DRBC adopted comprehensive water quality standards which were tied to a then- innovative waste load allocation program - a predecessor to today's "Total Maximum Daily Loads (TMDLs)". A year later, the DRBC adopted regulations for implementing and enforcing the standards. The Federal Water Pollution Control Act Amendments of 1972, commonly referred to as the Clean Water Act, further assisted the implementation of water pollution control efforts in the basin, as did state-led efforts. By the late 1980s, over one billion dollars had been spent on improving wastewater treatment facilities in the Delaware River Basin, which reduced pollution and aided fish populations. While these efforts were underway to clean up the lower reaches of the river, monitoring showed that the water quality in the less-developed upper and middle reaches was, for the most part, already better than standards. With this information in hand, the DRBC began to examine strategies for "keeping the clean water clean" (Delaware River Water Quality, DRBC).

Today, the clean-up of the Delaware, although still ongoing, is acknowledged as a true water quality success story. The river now supports year-round fish populations, as well as those returning to spawn. Bald eagles, which depend on fish as their primary food source, nest and overwinter in the basin with high concentrations found in the Upper Delaware. River-based and other outdoor recreation of all types is among the region's top economic drivers, although the emphasis on grand hotels and resorts evolved to the development of vacation or second home communities, which often included amenities such as lakes, golf courses, ski facilities and horseback riding. Many of these developments became primary "bedroom communities" to major metropolitan areas as interstate highways and other transportation facilities expanded.

Forests - Current Conditions and Trends

Regional Trends

The counties of the Upper Delaware region exhibit many of the trends noted in the statewide forest assessments for New York, New Jersey and Pennsylvania. Common themes include:

- Upper Delaware forests, largely denuded for agricultural and industrial uses during the 1700s and 1800's, have recovered to a great extent over the last 200 years.
- Current forest cover in the region, at about 75%, is above the averages reported for the three states of New York, New Jersey and Pennsylvania.
- The region's forests are relatively even aged and maturing, with a majority of trees in the saw-timber size class.
- Species composition is changing, with red maple, black birch, and white pine becoming more common while sugar maple, hemlock and oaks appear to be declining.
- Regeneration is negatively impacted by white-tailed deer browse and some harvesting practices, such as "high-grading", where forest harvesting removes only the highest value, healthiest trees. This practice can cause long-term damage to forests by changing the structure and shifting the tree species present from historically valued hardwoods to species such as red maple and black birch. High-grading results in forests that are poorly stocked and appears to be an underlying reason that private lands grow significantly less high quality timber than public lands (Price and Sprague 2012).
- Although there are substantial acreages of publicly owned forestland in some Upper Delaware counties, forest ownership follows state trends in that forest lands are predominantly privately owned.
- Parcelization is a concern as land ownership changes and size of forest parcels decreases. Information compiled by Penn State University and the Pinchot Institute for Conservation for Pennsylvania indicates an aging demographic of forest landowners and the potential for an increased rate of parcelization in the near future. It is estimated that half of Pennsylvania's private forests will change hands in the next two decades and the next generation of landowners will have varying viewpoints of forest ownership, thus raising additional uncertainty of future management and stewardship. (Price and Sprague 2012)
- Forest fragmentation is an existing stressor in the region, which includes several counties exhibiting high population growth percentage rates, although population growth has slowed somewhat in recent years. Expansion of natural gas exploration into northeastern PA and southern New York as well as pipeline and overhead transmission line expansion for energy conveyance are also contributing to forest fragmentation now and will likely continue in years to come.

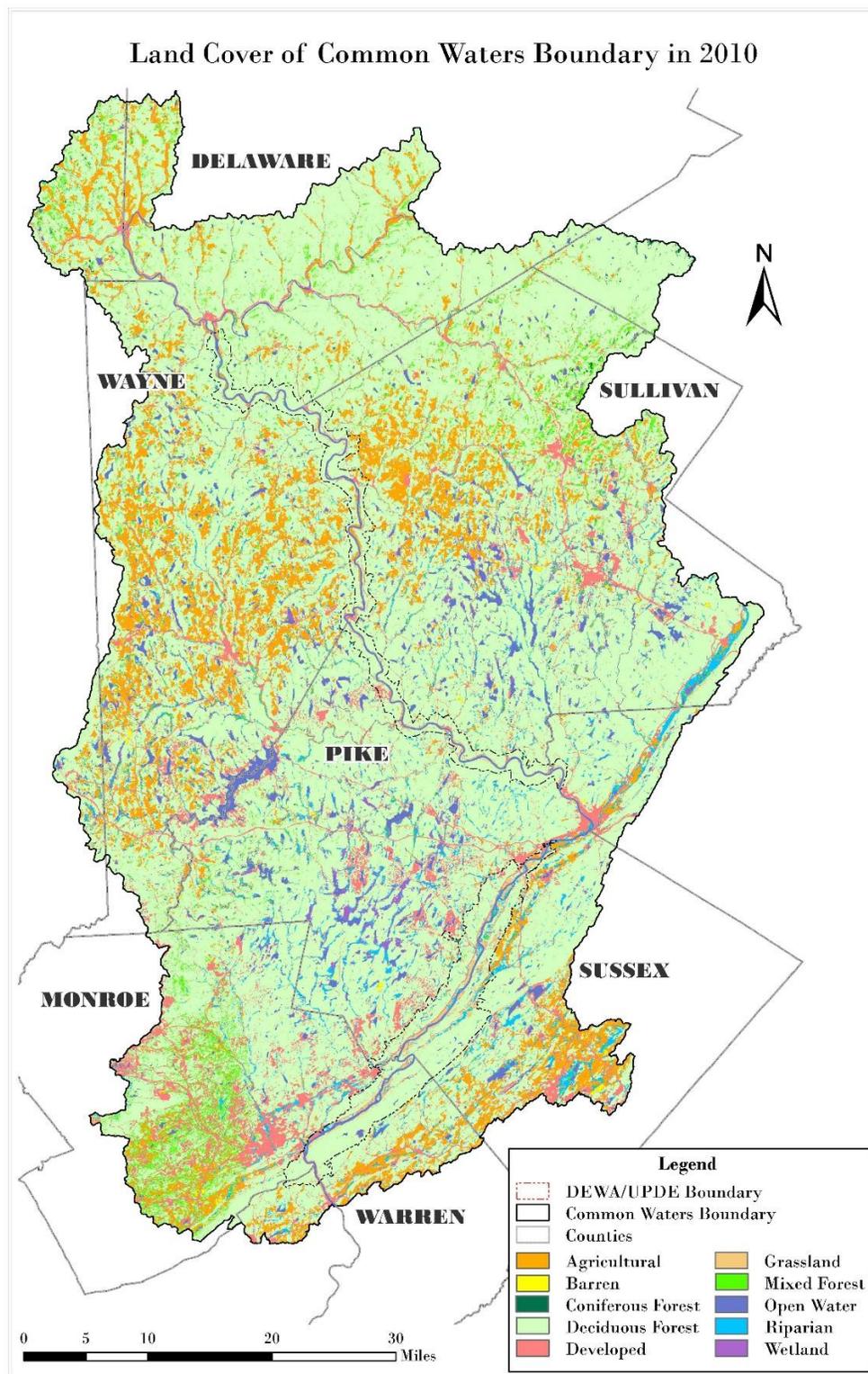


Figure F-1: Land Cover in the Upper Delaware Region. *Source: NPS DWGNRA 2013.*

Forest-type group	Stand-size class				Total
	Large Diameter	Medium Diameter	Small Diameter	Non stocked	
White/red/jack pine	68,372	11,078	--	--	79,450
Spruce/fir	--	8,699	--	--	8,699
Other eastern softwoods	--	--	3,091	--	3,091
Oak/pine	77,179	6,195	5,139	--	88,513
Oak/hickory	577,054	207,692	65,302	--	850,049
Oak/gum	7,605	--	--	--	7,605
Elm/ash/cottonwood	38,748	13,617	6,995	--	59,360
Maple/beech/birch	909,694	293,399	28,604	--	1,231,697
Aspen/birch	--	1,855	--	--	1,855
Other hardwoods	28,477	12,859	11,042	--	52,378
Nonstocked	--	--	--	22,599	22,599
Totals:	1,707,128	555,395	120,173	22,599	2,405,295
* Includes Pike, Wayne, Monroe Counties PA, Sussex & Warren Counties NJ, Sullivan & Delaware Counties NY					

Figure F-2: Acres of forest land by forest type group & stand size.
 Source: US Forest Service Forest Inventory Analysis 2011.

- Diseases, insects and an impressive array of invasive species are present in forests throughout the Upper Delaware region. Hemlock woolly adelgid and elongate hemlock scale, beech bark disease, emerald ash borer, Asian longhorned beetle, and sudden oak death threaten host species. In addition, forest tent caterpillars and gypsy moth are problematic, especially when combined with drought and other stressors.
- New York, New Jersey and Pennsylvania “home rule” status results in a myriad of local governments with the majority of control over land use planning and regulation. Because of this, local government involvement is pivotal to conservation of forest resources.

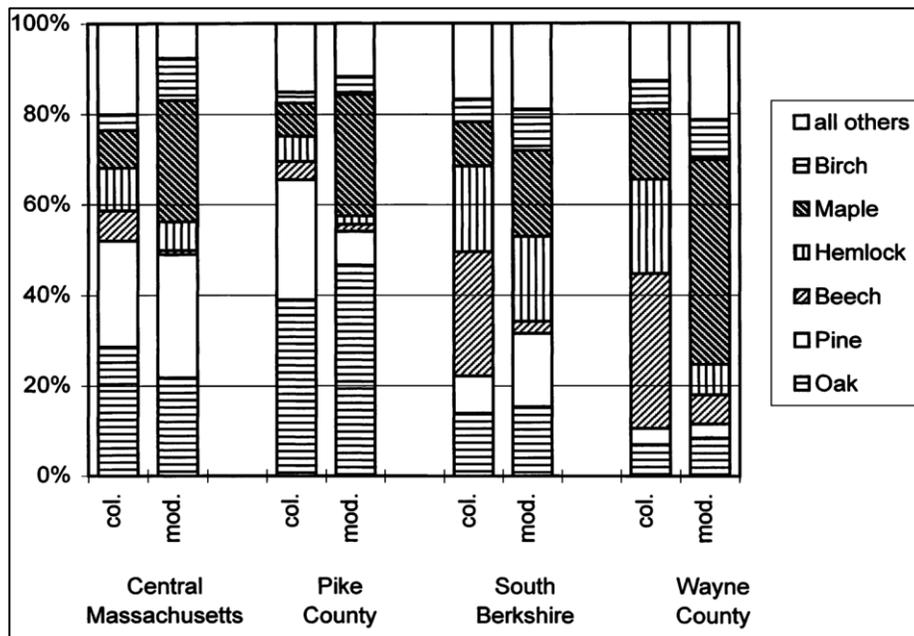


Figure F-3: Changes in percentages of 6 taxa in colonial vs. modern periods in regions including Pike & Wayne Counties, PA.
 Source: Burgi et al.2000.

A State-by-State Perspective

The Upper Delaware River watershed is considered a Multi-State Regional Priority Area by state forestry agencies in New York, New Jersey and Pennsylvania. The following descriptions are excerpted in part from the most recent State forest resource assessments: *Pennsylvania Statewide Forest Resource Assessment. Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry. 2010; Forest Resource Assessment & Strategy 2010-2015: Keeping New York's Forests as Forests. New York State Department of Environmental Conservation. 2010; Statewide Forest Resource Assessment and Resource Strategies. New Jersey Department of Environmental Protection. 2010.*

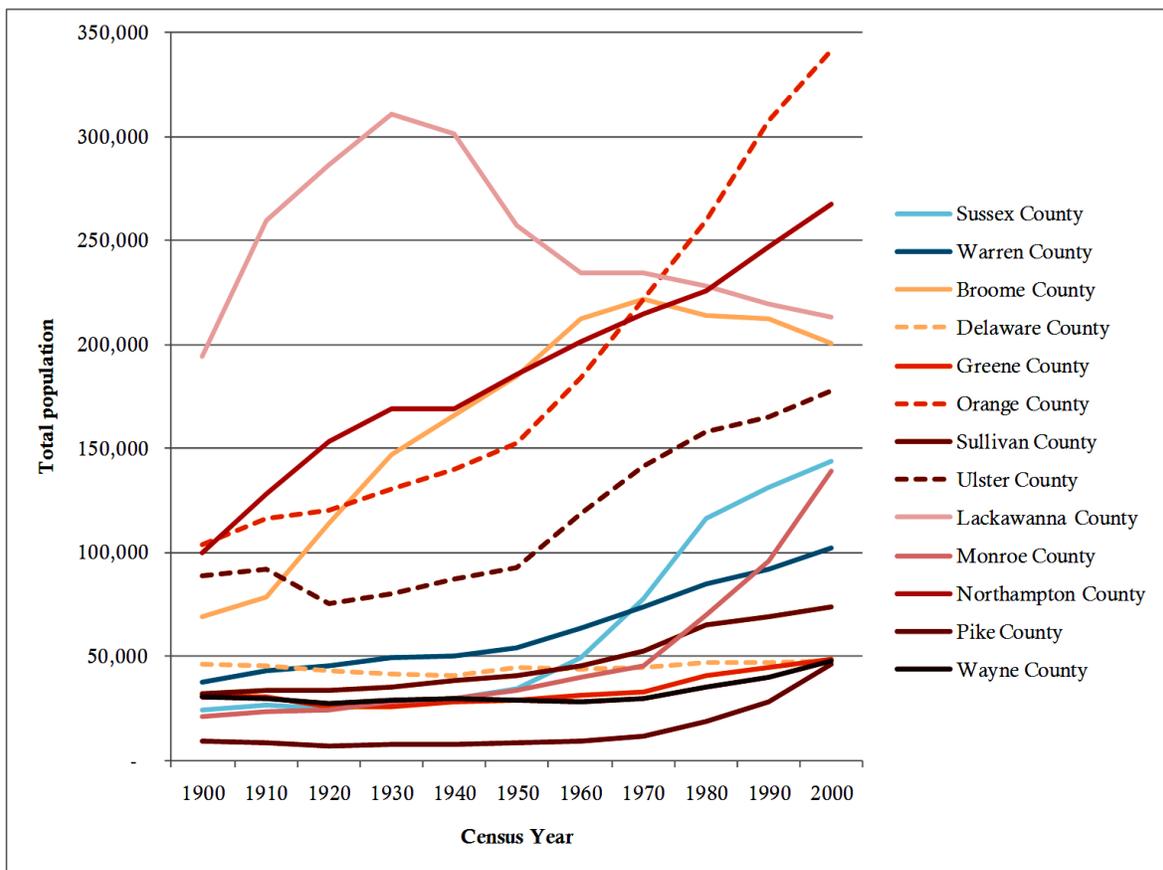


Figure F-4: Population growth contributes to forest parcelization and fragmentation in the Upper Delaware region. Source: National Park Service DWGNRA.

Pennsylvania

Pennsylvania forests cover approximately 60 percent of the Commonwealth. Oak/hickory and northern hardwood forests dominate in Pennsylvania. Oak/hickory forests include primarily oaks, maples, and hickories with mountain laurel and blueberry in the understories. Northern hardwood forests contain primarily black cherry, maples, American beech, and birch with understories of ferns, striped maple and beech brush. Hemlock and Eastern white pine are common to both forest types. The make-up of Pennsylvania's forest types is changing, with red maple, black birch, and white pine becoming more common while sugar maple, hemlock and the oaks are declining.

The majority of forests originated between 90 and 120 years ago, reflecting the widespread clearing and harvesting that occurred during the industrial revolution. Most forest stands are relatively uniform in structure and are dominated by sawtimber-sized trees. Pennsylvania has a shortage of both early-successional and old-growth forest habitats. Overall, the changes related to tree species diversity, forest structure, and age-class distribution are considered by the PA Department of Conservation and Natural Resources (DCNR) to be signs of an unsustainable condition. A number of factors are causing tree mortality, threatening regeneration, and reducing diversity—all of which affect the overall health and resiliency of the forest. These include harvest practices such as high-grading and diameter limit cuts, regeneration difficulties related to white-tailed deer browsing, lack of fire, competitive native and invasive plants, insects and disease outbreaks, climate change, and severe weather events.

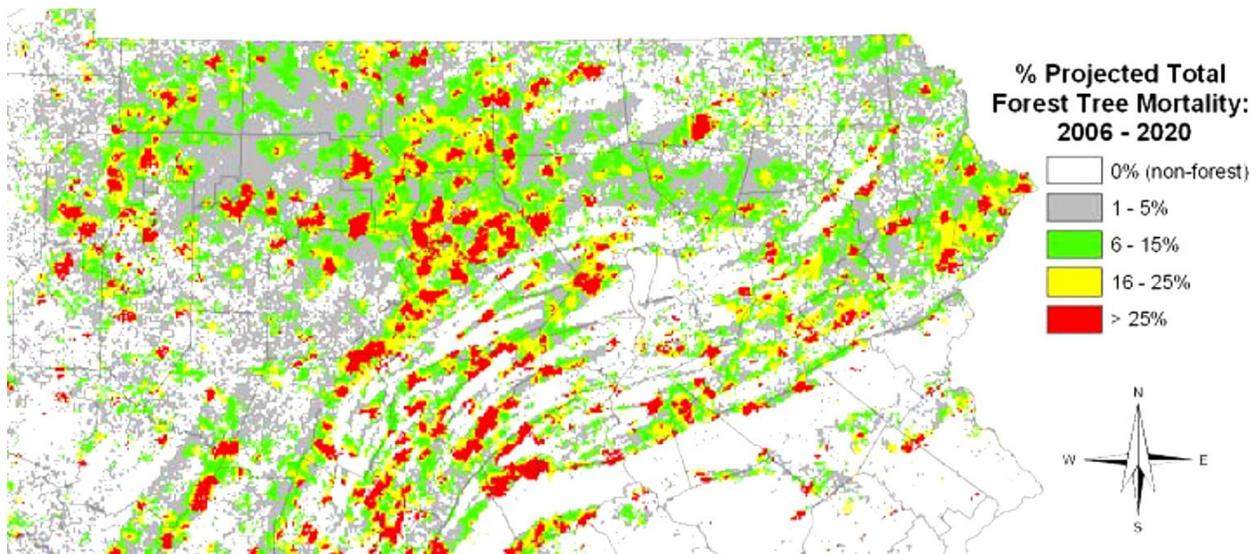


Figure F-5: Pennsylvania Insect & Disease Riskmap. Source: PA DCNR Bureau of Forestry 2010.

Pennsylvania contains 16.1 million acres of timberland, representing almost 97 percent of the state’s forest. While this percentage has decreased slightly since the 1950s, it has remained relatively constant for the past two decades. Economically, Pennsylvania’s hardwood forests are some of the most valuable and productive in North America. The forest products industry is an important component of many rural economies and timber provides an important economic value to forestlands, but is increasingly competing with other land uses like housing and commercial development.

The US Forest Service estimates that between 1989 and 2002, some 17 million metric tons of carbon dioxide equivalents (MMtCO₂e) have been sequestered annually by Pennsylvania’s forests, representing about 5% of the Commonwealth’s greenhouse gas (GHG) emissions.

Timberland is defined by the US Forest Service as forest land producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization by statute or administrative designation. **Timberland** is an important economic indicator as it provides a measure of accessibility to valuable hardwood resources.

Statewide, an estimated 28,000 acres of forest are lost annually to residential and industrial development; there is significant concern about forest conversion in urban and suburban counties experiencing heavy growth. The Northeast region of Pennsylvania (which includes Pike, Wayne and Monroe Counties in the Upper Delaware region) has the second largest expanse of remaining forestland. It has also experienced the highest levels of population growth in the state due to out-migration from the New York metropolitan area to the Pennsylvania/New Jersey border area. The Pocono Mountains area in this region has experienced a wave of primary-residence development following decades of second home development, both of which have contributed to increased forest fragmentation.

About 70 percent of PA’s forestland is in private ownership while public agencies own the remaining 30 percent. Forest conversion, fragmentation, and parcelization are cause for concern as forest ownership continues to change hands and larger tracts become divided into smaller, less contiguous units.

Recent expansion of natural gas drilling in the state and pipeline and overhead transmission line expansion for energy conveyance will likely accelerate forest fragmentation at higher rates in the next few years relative to the past 10-20 years.

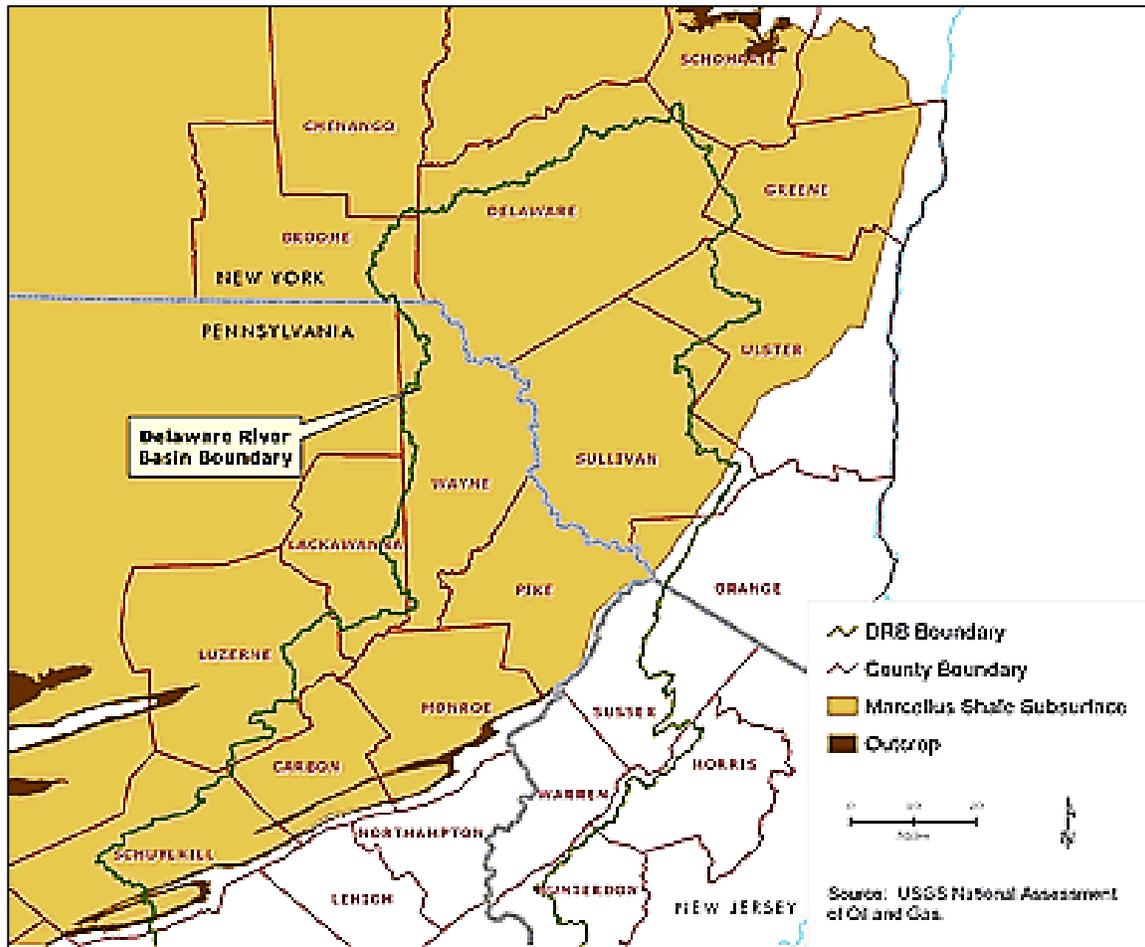


Figure F-6: Marcellus Shale in the UPDE Region.

Source: Delaware River Basin Commission <http://www.state.nj.us/drbc/programs/natural/>.

Marcellus Shale Projects

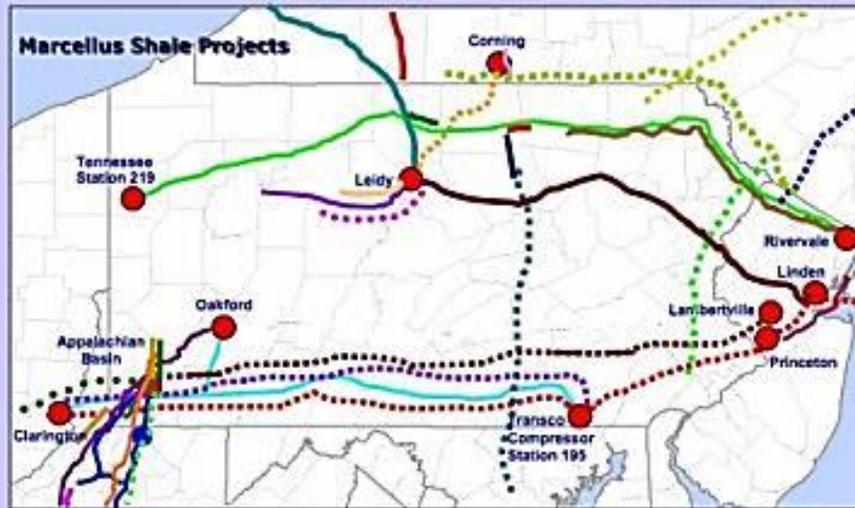


Figure F-7: Northeast Gas Pipelines – current and proposed.
Source: Federal Energy Regulatory Commission.

The Poconos counties in northeast PA stand out as an example where communities have expanded into previously undeveloped “wildland” areas at a record pace. Over the last few decades, expansion of these Wildland/Urban Interface (WUI) areas has significantly impacted emergency response and disaster management activities. The WUI creates an environment where fire can move readily between structural and vegetative fuels, increasing the likelihood that wildfires will threaten homes and people. In many areas, this situation has challenged local fire, police, and other emergency services. With the greatest danger of wildfires typically in the spring and autumn months, it is anticipated that the wildfire seasons in PA (and the rest of the Upper Delaware region) will be lengthened by the warmer winters and more drought-prone summers associated with climate change.

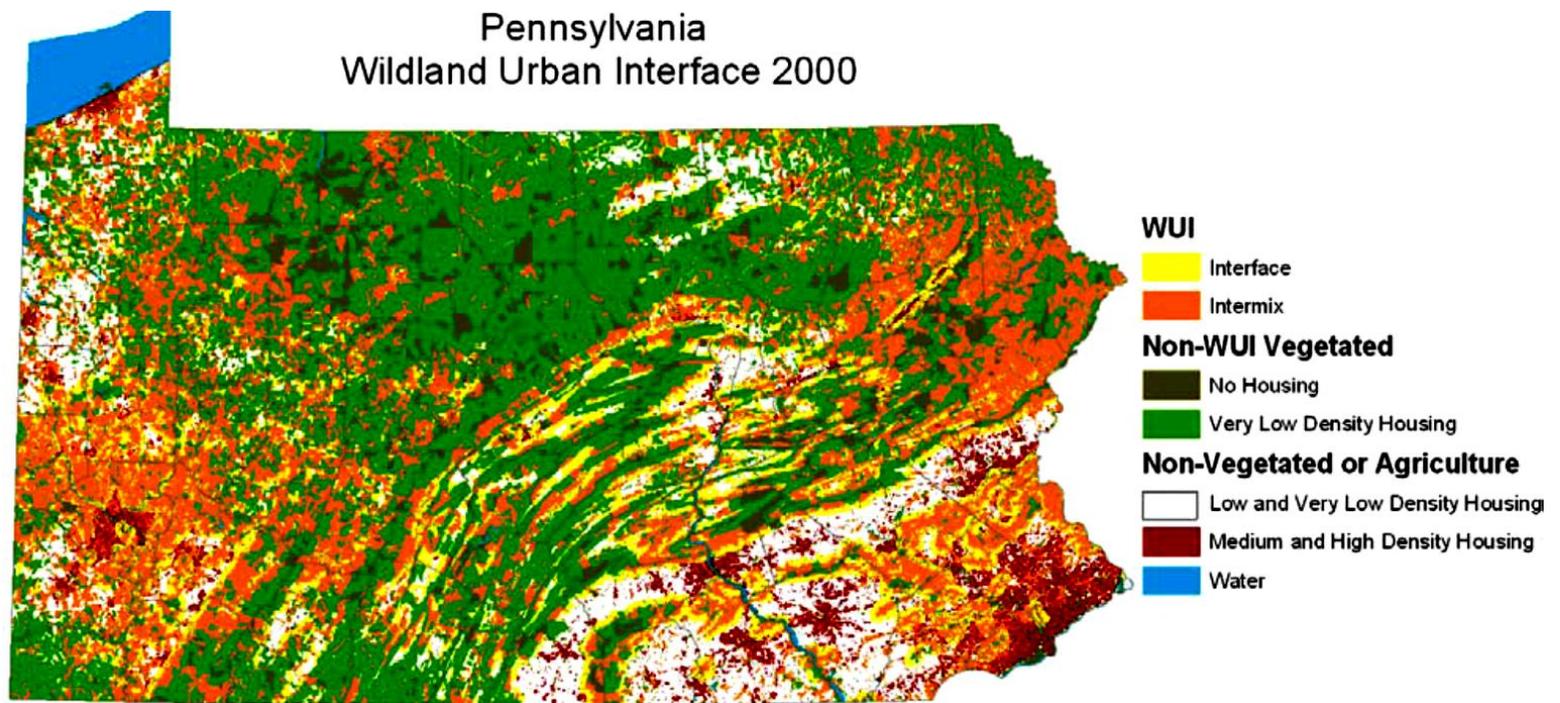


Figure F-8 Pennsylvania Wildland-Urban Interface (WUI) 2000. Source: PA DCNR Bureau of Forestry 2010.

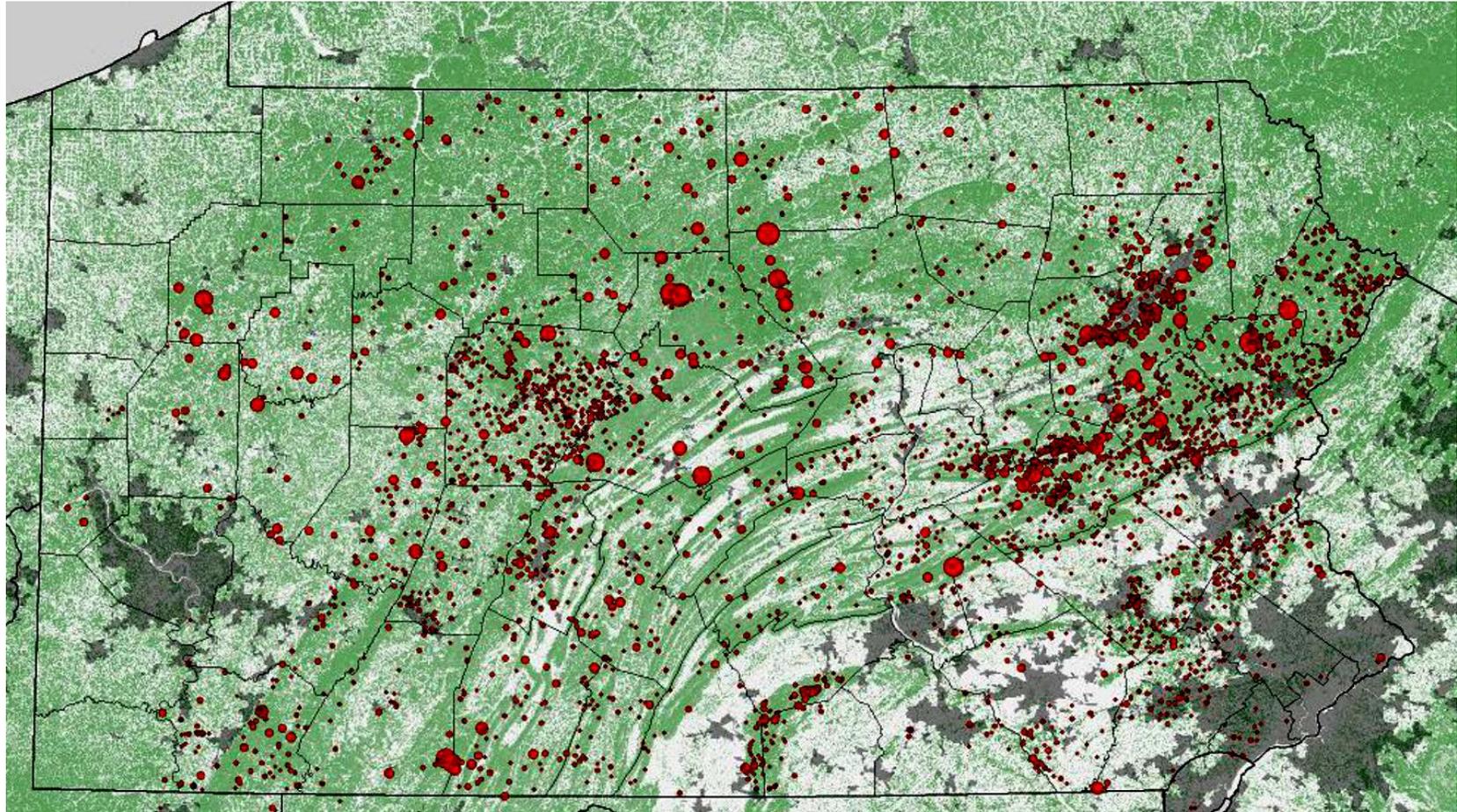


Figure F-9: PA Wildfires 2002-2008. *Source: PA DCNR Bureau of Forestry 2010.*

New York

In the 1880s less than 25% of New York State was forested. Today, forest cover in the state is estimated at 63%, of which approximately 84% is currently considered timberland.

New York forest land is dominated by the maple/beech/birch, or “northern hardwood” forest type (56%), followed by the oak/hickory group (18%). A majority of New York’s current forests are less than 120 years of age and often lack late successional habitat components such as large diameter dead standing trees, large diameter deadwood on the ground and large diameter biological legacy trees. New York’s forests are maturing; approximately 60% are in a large tree, or sawtimber size class; 28% are classified as poletimber; only 11% are in a stage where seedling and sapling size trees predominate.



Figure F-10: Current NY State forested areas > 5 acres. Source: NY DEC 2010.

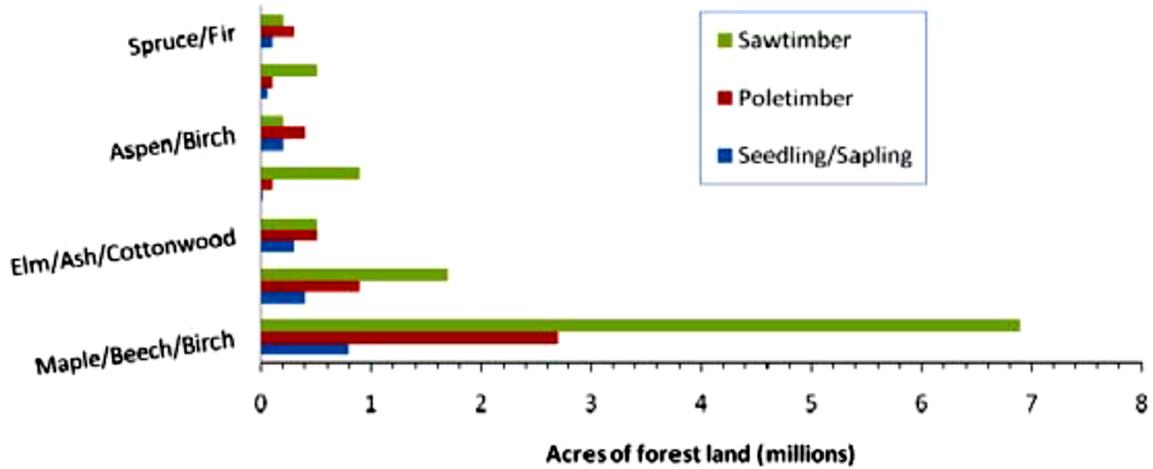


Figure F-11: Area of NY forest land by forest type groups and stand size class. *Source: NY DEC 2010.*

A little over 60% of timberland acres are considered to be poorly stocked or at medium stocking level indicating that the growth potential of the land is not being utilized. This may be due to harvesting practices that fail to consider post-harvest stocking as a priority and may lead to a decline in the availability of sawtimber in the future. Less than a fully stocked condition can also be detrimental in terms of optimum carbon sequestration.

An observed decline of saplings across the state and in commercially important species could lead to a reduction in overall production potential in the future. The decline is likely due to a number of factors, including: intensive deer browse; interfering vegetation such as beech and fern; and timber harvesting practices that fail to provide for adequate regeneration. Two important commercial species, sugar maple and northern red oak show decreases or no growth in the number of growing stock trees and other important species such as black cherry, eastern white pine and spruce indicate little increase in numbers, while red maple shows a sizeable 13% increase in numbers of trees over 5 inches.

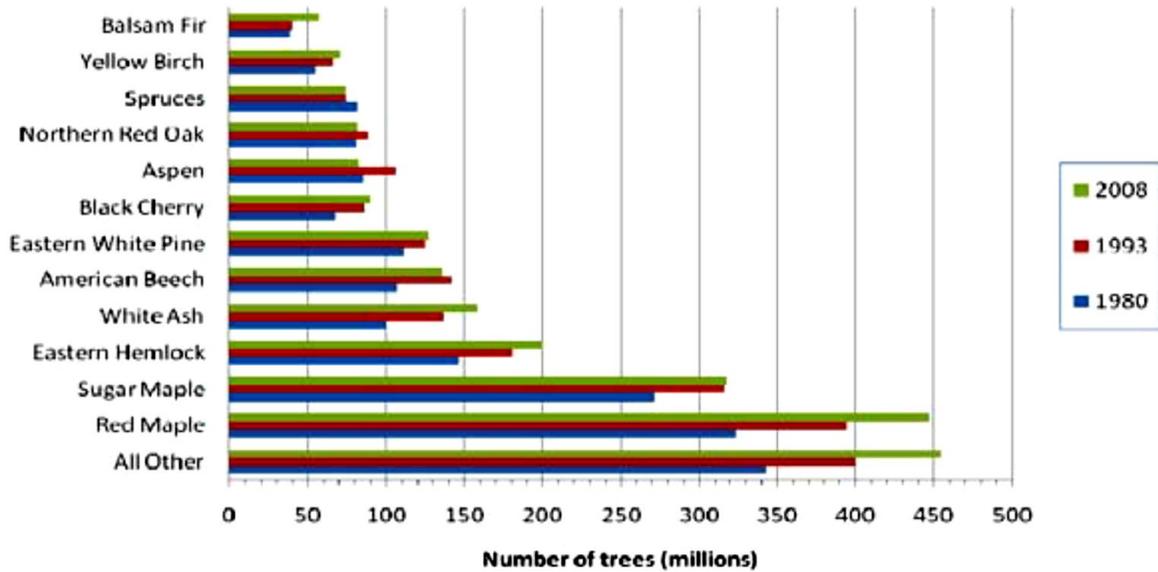
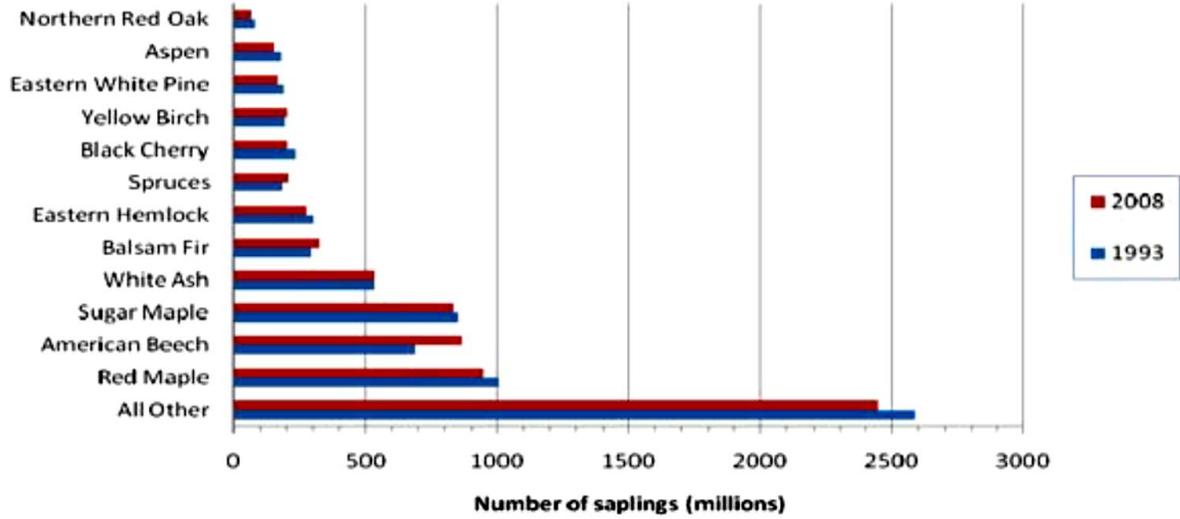


Figure F-12: Number of saplings (1-4.9" dbh) (top) and growing stock (5" dbh+) (bottom) trees by species on New York timberland during different time frames. *Source: NY DEC 2010.*

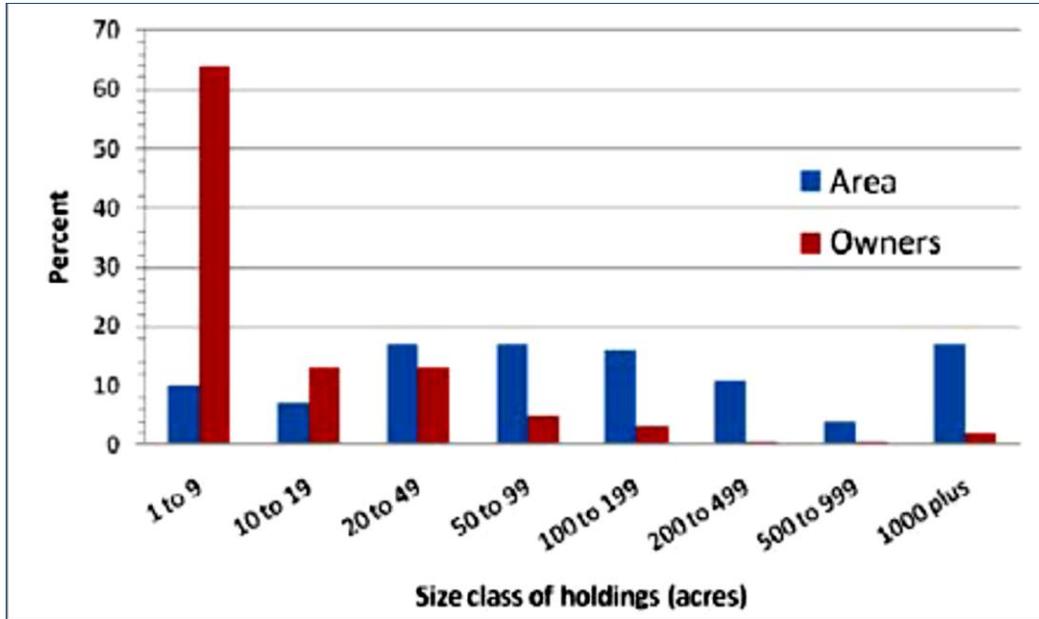


Figure F-13: Private forest land owners in NY by size of holdings, 2006.
Source: NY DEC 2010.

76% of forest lands in New York State are owned by private landowners. The size of forest parcels is decreasing and the number of landowners is increasing. This forest parcelization and fragmentation, mainly due to development, are concerns for the future sustainability of New York forests.

New Jersey

New Jersey forests cover about 42 percent of the lands in the state, representing primarily abandoned farmlands that reverted to forest since the 1940s. In the northern counties, northern hardwood, white pine, Eastern hemlock, mixed oak and a variety of other species including isolated stands of red spruce are part of the forest composition.

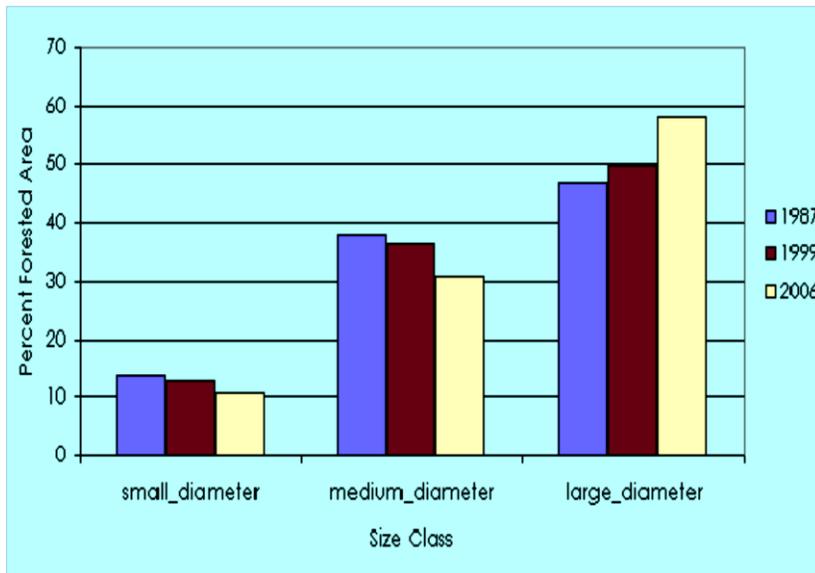


Figure F-14: Changes over several decades in area of NJ timberland by forest type-group. *Source: New Jersey DEC 2010.*

Trees in New Jersey’s forests are getting larger and the forests are relatively even-aged, with a mean age somewhere in the 60-79 year-old age class. Acreage in young stands is expected to decrease over time. The number of trees per acre of live trees 5 inches in diameter and above has been steadily increasing, just as forest size class and average diameter have increased. The amount of sawtimber available on timberlands statewide is increasing as well.

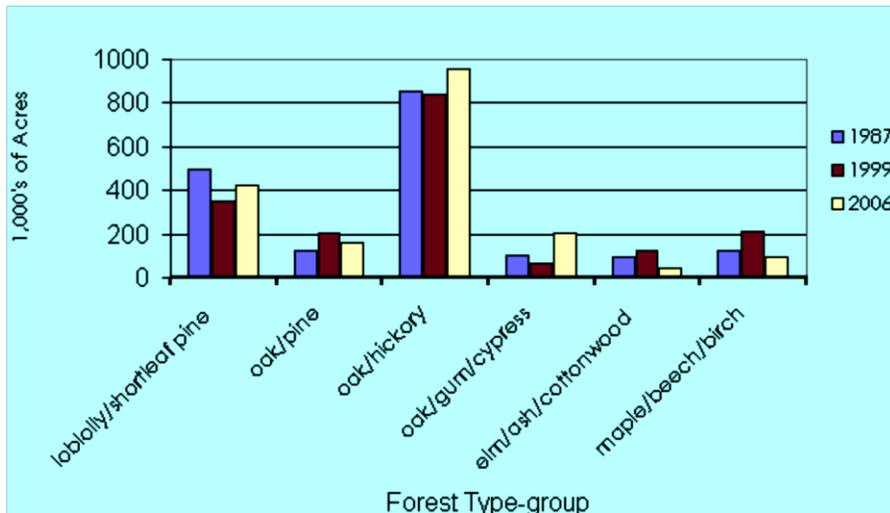


Figure F-15: Changes over several decades in size class distribution.
 Source: New Jersey DEC 2010.

About two-thirds of New Jersey’s forest lands are in private ownership. High densities of white-tailed deer browse seedlings and saplings, contributing to forest regeneration problems. Fragmentation due to urbanization is a concern, as are invasive species (flora and fauna, aquatic and terrestrial), insects and disease, pollution, and unsustainable land management practices.

Forest Climate Risk Findings

The forests of the Upper Delaware, a defining feature of the region’s landscape, result of a changing climate. Higher seasonal temperatures, the timing and type of precipitation, changing soil moisture patterns, the severity and frequency of extreme weather events and natural disturbances, and the proliferation of invasive plants, insect pests and diseases are among the challenges our forests will face.

Climate Change Aggravates Existing Forest Stressors

Even in the absence of climate change, there are many challenges already facing forests in the Northeast region. In its 2005 *Snapshot of*

Summary of Forest Climate Risks

- Loss of forest ecosystem services with declining forest cover and forest health - impaired flood attenuation and stormwater management functions, reduced pollutant filtration, reduced carbon sequestration
- More insects, invasive plants and diseases harmful to forests
- Reduced winter deer mortality and higher deer populations
- Changes in forest species composition
- Loss of bird and wildlife habitat, migratory corridors and breeding areas
- Longer fire season resulting in increased wildfire risks
- Tree mortality resulting from extreme weather events
- Additional population growth from climate refugees causing more forest loss

Compiled by UPDE Core Planning Group

Northeastern Forests, the US Forest Service described a number of threats to forest health in the primarily privately owned forest lands of the northeastern US. These reflect the challenges defined in the aforementioned State forest assessments and include: changing land uses – development, parcelization and fragmentation; invasive species – insects, plants and pathogens; and wildfire risk at the rural/urban interface. Such challenges are expected to be exacerbated by climate change, which has strong influence over factors such as the water cycle and plant growth that are critical to the health of forests (Rustad, et al. 2012).

Existing Forest Stressors Aggravated by Climate Change

- Fragmentation
- Parcelization
- Insects/diseases/invasives
- Forests even-aged/lacking in diversity
- Lack of regeneration due to deer and unsustainable harvesting practices
- Localized governance patterns and inconsistent land use controls

Changing Temperature and Precipitation Alter the Water Cycle

Higher temperatures and changing precipitation patterns have already changed the water cycle in the Northeast, as indicated by earlier snowmelt, earlier spring thaws, higher flood flows and shorter periods of ice cover on rivers, streams and lakes. These changes, in turn, affect soil moisture and water storage capabilities, nutrient cycling, frequency and length of droughts, rates of evapotranspiration by plants and freeze/thaw cycles, all of which impact forests in a number of complex ways. Climate models suggest that changes in the water cycle will become even more pronounced, with further shifts in winter precipitation patterns and the timing of spring runoff, summer low flow conditions and summer drying (Rustad, et al. 2012).

Forests and Fish

Forest cover in the Upper Delaware region contributes to maintaining stream temperatures and flows that are suitable for cold-water fisheries (trout) and other aquatic life. A 2010 publication *Rising Stream and Water Temperatures in the United States* (Kaushal et al. 2010) showed that the Upper Basin has seen relatively slow increases in stream temperatures from 1965 to 2007, while the lower basin has seen significant increases, especially near urban areas. Historical records from 40 Delaware River sites were analyzed and the most rapid rate of increase in water temperature was found in the Delaware River near Chester and Philadelphia, Pennsylvania. It is believed that forest cover in the Upper Basin contributed significantly to keeping stream temperatures cool even while air temperatures have increased.

Tree Species Composition Changes

Forest composition is a product of the soils, climate, topography, and periodic natural and human disturbances. Most tree species are adapted to particular temperature and moisture conditions. As these conditions change, habitats become unsuitable for saplings to grow, and species may be forced to migrate to higher latitudes or elevations where temperatures are more conducive to their survival. Some tree species or forest types may not be well-suited to future conditions, while others may have new opportunities for habitat in the region. However, the existing regeneration problems characteristic of Upper Delaware forests will also continue to play a role as tree species adapt to warmer, drier conditions.

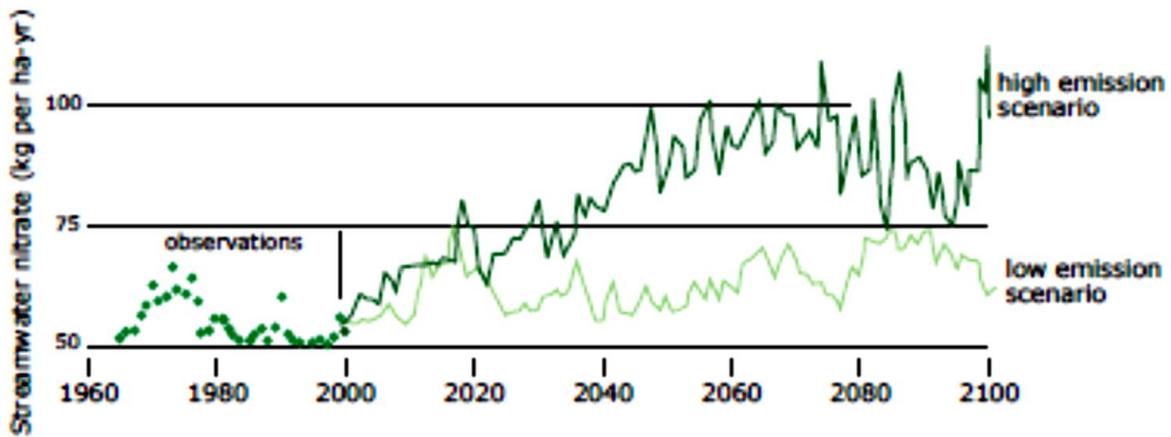


Figure F-16: Measured & projected nitrate export from forest soils to streams at Hubbard Brook Experimental Forest. Nitrate leaching increases markedly under the high emissions scenario.

Source: Rustad, et al.2012.

Under predicted temperature and hydrology changes, and barring some unforeseen major pest, white pine will likely increase dramatically in the region (Elison 2013). There are a number of factors favoring white pine: low deer preference, ability to develop in partial shade and wide adaptability to soils and site conditions. Under any of the climate scenarios, white pine will be well within its range in the Upper Delaware region, where it was much more predominant in colonial forests.

The oak species typically found in the Upper Delaware Region also remain in a favorable temperature regime under various climate scenarios. In some areas, such as the Delaware State Forest in Pennsylvania, deer pressure has reduced to the point that oaks are regenerating readily without fencing. Despite an increase in regeneration harvesting due to gypsy moth mortality, deer fencing was not employed in 2013 and it appears that most of the current oak mortality harvests have sufficient oak regeneration to replace the dead oak stand with a new young oak stand. This is a dramatic change from the last major mortality harvests in the 1980s that resulted in a great reduction in the oak component of the new stands and in some cases conversion to birch and red maple stands. Given this change, high-grading and diameter limit cuts may be a greater threat to oak regeneration than deer (at least on some State Forest Lands in northeastern PA) as those types of harvests seldom provide adequate light for young oaks to develop (Elison 2013).

Unsustainable Harvesting Practices

High Grading: A harvesting technique that removes only the biggest and most valuable trees from a stand and provides high returns at the expense of future growth potential. Poor quality, shade-loving trees tend to dominate in these continually high-graded sites.

Diameter-limit Cut: A selection method in which all marketable trees above a specified diameter are harvested. Diameter-limit cutting can lead to long-term degradation of the stand.

Source: NC State University
<http://www.ces.ncsu.edu/forestry/pdf/>

Although not common due to the region being on the northern extreme of its range, tulip poplar does occur at all but the coldest and least fertile parts of the region, and its regeneration has been increasing. The same site conditions that sugar maples prefer are also preferred by tulip poplar; it is plausible that if sugar maple declines as predicted, poplar will fill many of those sites (Elison 2013). However, tulip poplar is extremely fire sensitive, and the wildfires of the last century further limited its current distribution. This could become a limiting factor again with climate related changes in wildfire regimes.

Heat stress and decreased soil moisture are likely to negatively affect the productive ability of several tree types in the Northeast. Some of the trees currently common across the Upper Delaware region, such as maple, birch, and beech, could experience a significant northward shift in their growing region, particularly under higher emissions scenarios. With the Upper Delaware region's economy strongly tied to tourism and outdoor recreation, secondary impacts of changing species composition should be considered. Muted fall foliage displays could represent a significant change in traditional fall tourism peaks. A shifting and shortening of the season for maple sugar production is already disrupting this industry, which has some importance in the northern part of the region.

Decreased winter snow pack could also reduce the time frame available for winter timber harvests, which typically utilize snow-covered soils to reduce soil compaction and erosion from haul roads and skid trails. This could be a deterrent for some landowners to harvesting trees to supplement incomes or implementing management practices aimed at improving forest health and species diversity.

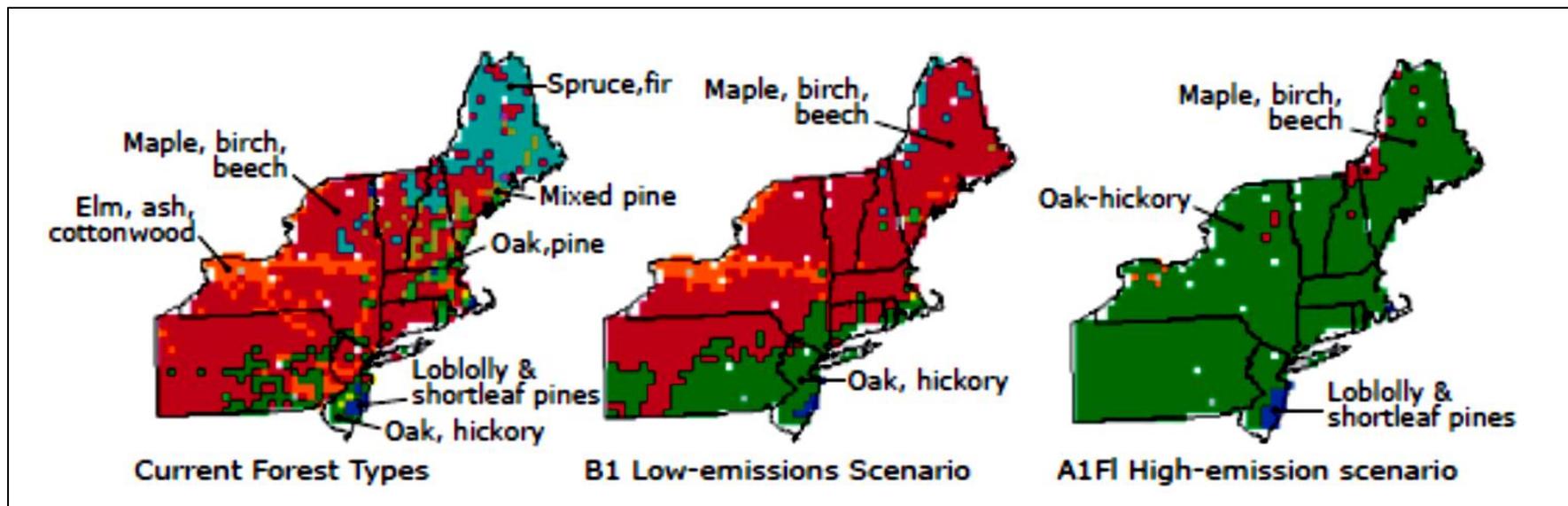


Figure F-17: Current & projected (2100) suitable habitat for major forest types under low and high emissions scenarios. *Source: Rustad, et al.2012.*

Invasive Species Expansion

While warmer temperatures would directly affect tree health, these conditions also increase the odds that certain harmful invasive species will thrive. There is evidence that invasive insect and plant pests and pathogens may be more adept at adjusting to changing climate conditions, further enhancing their ability to out-compete native species. (Paradis, et al. 2007). Their expansion will result in an overall loss of biodiversity and function of forest ecosystems and significantly increase the costs to landowners and land managers of treatment/management.

The hemlock woolly adelgid is an insect of particular concern in forests of the Northeast, as are the Asian longhorn beetle and gypsy moth. Population expansion of hemlock woolly adelgid is clearly influenced by temperature and as temperatures in the Northeast continue to rise, extensive range expansions of the adelgid are expected. In particular, higher winter temperatures and the severity of summer drought, both associated with climate change, were shown to significantly influence the mortality rates of adelgid-infected hemlocks (Eschtruth, et al. 2013). Ecosystem impacts from extensive hemlock die-off include higher soil and stream temperatures, accelerated nitrate runoff, increased soil erosion and water pollution, and changes in plant species distributions. As the distribution of hemlock changes, communities of many hemlock-dependent birds and aquatic organisms will also be affected (Paradis, et al 2007).

In the Delaware Water Gap National Recreation Area, where hemlock woolly adelgid mortality has been significant, tree species replacing the hemlocks through natural regeneration vary depending on site conditions and deer browse pressure, but in general deciduous species – especially black birch – are most common and widespread. National Park Service ecologists studying the problem emphasize that there is no "ecological equivalent" for eastern hemlock, which is why their decline and loss has such strong ecological impacts (Rich Evans, 2013).

Higher temperatures can also be a key driver of insect pest outbreaks on urban tree populations, which are often already stressed by urban heat island effects and lack of water and nutrients. Recently published findings indicate that the abundance of common scale insects (*P. quercifex*) is positively related to temperature even when controlling for other influences. Even small temperature differences predict changes of an order of magnitude in pest abundance (Meineke, et al. 2013). Street trees are a defining characteristic of cities, villages, hamlets and boroughs in the Upper Delaware region, some of which have invested significant time and money in street tree plantings and maintenance. Since urban warming is similar in magnitude to climate-related temperature increases predicted in the next 50 years, pest abundance on trees in urban areas can be expected to become more widespread and may also foreshadow outbreaks in natural forests as temperatures grow warmer.

Extreme weather events (including droughts, strong winds, and floods), which are linked to increasing temperatures and changing precipitation patterns, are projected to become more frequent, further increasing the exposure of forests to disturbances and making them more susceptible to pests and diseases. Deer browsing, already impacting tree regeneration and degrading forest understory in Upper Delaware forests, is expected to increase with warmer winters and reduced snow cover, which in turn could expose more winter vegetation for browsing, reduce winter mortality and allow deer populations to grow (Rosenzweig, et al. 2011).

Increased Wildfire Threat

An increase in the occurrence of wildfire is another projected consequence of climate related changes to the water cycle with significance to forests and community economics in our region. While this issue is typically associated with western forests, wildland-urban interface (WUI) areas are actually most prominent in the eastern U.S. where population density is higher (see map in Figure F-24). Under the right conditions, homes in any of these areas could be exposed to wildfire. So too could homes in more rural areas (in green) with considerable wildland vegetation, especially those with housing growth projected (Stein, et al. 2013).

Eastern fire regimes are being affected by climate-driven changes in drought frequency and growing season length, which will impact the timing and length of the spring and fall fire seasons (USDA Forest Service 2013). This, coupled with the acreage in the Upper Delaware region considered to be wildland-urban interface areas, indicates that fire suppression costs borne by State and local governments and fire damage losses and expenses suffered by homeowners are likely to rise.

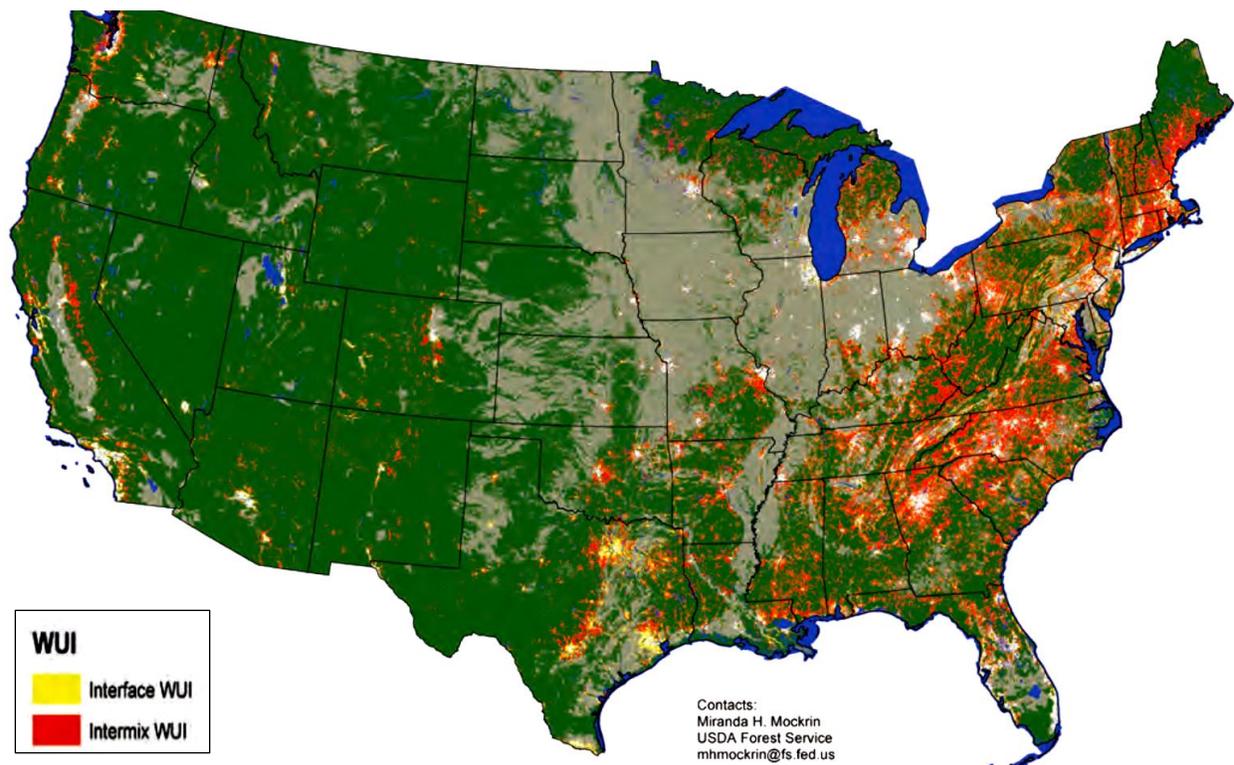


Figure F-18: 2010 Wildland Urban Interface (WUI). *Source: Stein et al. 2013.*

Additional Population Growth from Climate Refugees

Given the steady levels of population increases in most counties in the region, and the close proximity of the region to major metropolitan areas threatened by sea level rise, it is likely that the Upper Delaware region will see further increases in population as climate refugees move from more vulnerable coastal areas. While this in itself is not necessarily a negative impact, such population growth would result in more development pressure and likely add to forest parcelization, fragmentation, and overall forest loss.

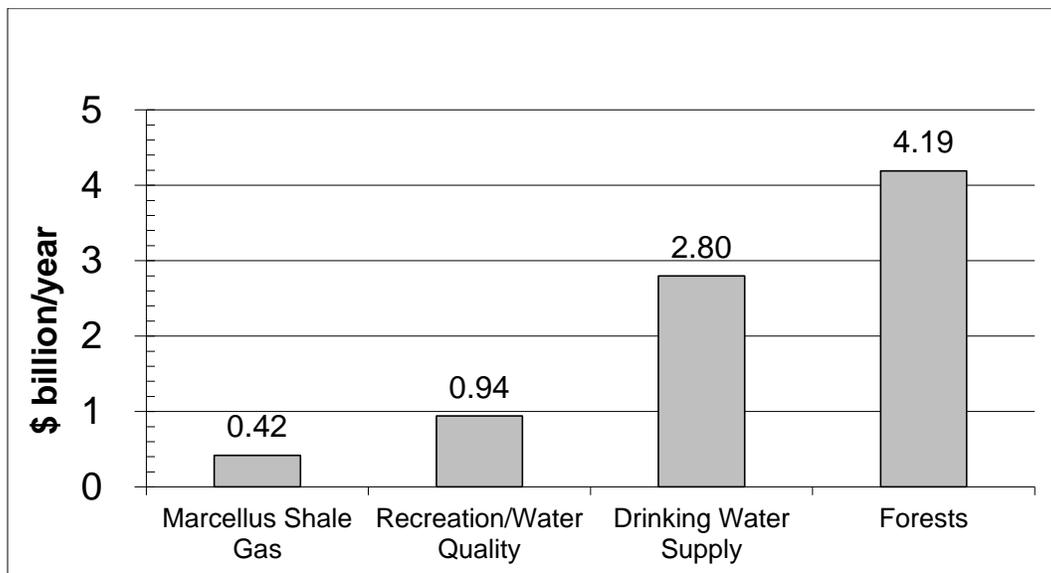


Figure F-19: Annual economic value of resources in the Upper Delaware River Basin.

Source: Kauffman 2013.

Loss of Ecosystem Services

In considering the risks of climate change to forests, it is important to keep in mind the connections between healthy forests and a range of ecosystem services that they provide. Forests support clean, abundant supplies of drinking water. In the Upper Delaware region, drinking water comes primarily from reservoirs and groundwater aquifers that are recharged by snowmelt and water captured, stored and filtered by forested lands. In addition, the forested watershed of the Upper Delaware River is critical to the drinking water supply of some 16+ million people living in metropolitan areas of the lower watershed. Forests also have a critically important flood control function in both the upper and lower Delaware River basin. This role is even more important with the increase in extreme weather events happening in the region right now and expected to worsen as average temperatures warm in the future.

A 2011 analysis by Kauffman, et al. examined the economic engine driven by the Delaware River Basin. The study concludes that the Basin as a whole contributes over \$25 billion in annual market and non-market value to the regional economy from sectors including recreation, fish and wildlife, public parks, water quality, navigation and ports, Marcellus shale natural gas (potential), agriculture, water supply and forests. Kauffman suggests that forests have by far the highest annual economic value to the Basin at \$5.13 billion, followed by water supply at \$3.82 billion (Kauffman, et al. 2011). Breaking those numbers

down for the Upper Basin, Kauffman demonstrates that a high percentage of the forest value for the entire basin resides in forests of the Upper Delaware region (Kauffman 2013).

The study also compares the value of forests to the region with the potential economic value of Marcellus shale gas resources. Using estimates that well pads disturb about 3 acres on average with an additional 6 acres for associated infrastructure (roads, water impoundments, pipelines), and projections of 20,000 natural gas wells that could be drilled by 2030 in the Upper Delaware Basin (if current Delaware River Basin Commission and New York State DEC drilling bans were lifted), Kauffman, estimates that 180,000 acres (280 mi²) or 10% of the forests in the Marcellus shale region could be disturbed with a loss in forest ecosystem services of \$366 million.

Kauffman also provides additional annual economic value estimates for a number of tourism and recreation related activities associated with Upper Delaware forests and waters (Figure F-19). Delaware Water Gap National Recreation Area, with its 5.6 million visits in 2010 topped Kauffman’s list at an estimated value of \$160 million. Wildlife and bird watching was a close second at an estimated \$142 million.

Economic Value	2010 (\$ million)	Sources
Marcellus Shale Gas ¹ (4.0 tcf @ \$2.68/1000 cf)	425	Coleman et al. 2011 (USGS), EIA 2012
Drinking Water (1,605 mgd @ \$4.78/1000 gal)	2,800	DRBC 2010, NJWSA 2011, Corrozi & Seymour 2008
Forests (2,057,492 ac @ \$2,036/ac)	4,189	NJDEP 2007
River Recreation	942	
Instream Use (7.9 million ac-ft @ \$10/ac-ft)	79	Frederick et al. 1996 (Resources for the Future)
Boating, Fishing, Swimming (WTP = \$139/person)	80	Parsons, Helm, and Bondelid 2003 (Univ. of Del.)
Paddling-based Recreation (147,664 participants)	86	Outdoor Industry Association 2006
Delaware Water Gap Recreation (267,000 visits)	41	Cordell et al. 1990 (USFS and National Park Service)
Canoe/Kayak/Rafting (204,000 trips, \$50/trip)	10	Canoe and Kayak Liveries 2012
Fishing (11-18 trips/angler, \$53/trip)	107	U. S. Fish and Wildlife Service 2008
Hunting (16 trips/hunter, \$50/trip)	114	U. S. Fish and Wildlife Service 2008
Wildlife/Bird-watching (8-13 trips/yr, \$27/trip)	142	U. S. Fish and Wildlife Service 2008
Shad Fishing (63,000 angler trips, \$102/trip)	6	Pennsylvania Fish and Boat Commission. 2011
Wild Trout Fishing	29	Maharaj, McGurrin, Carpenter 1998 (Trout Unlimited)
Del. Water Gap Natl. Rec. Area (5.6 million visits)	160	Stynes 2011 (MSU for National Park Service)
Skiing (9 resorts, 1.9 million ski visits, \$45/day)	88	Pennsylvania Ski Areas Association 2009

Figure F-20: Economic value estimates for tourism and recreation in the UPDE region.

Source: Kauffman 2013.

Policy and Practices Affecting Forest Conservation

Forestry is more than cutting and growing trees. Restoring and managing complex, ever changing systems to yield clean air and water, sustain rural communities, and provide peace and solitude requires passion, knowledge, and skill. This is the art and science of forestry... – The Forest Guild

Because a majority of the forest lands in the Upper Delaware Region are privately owned, a somewhat fragmented system of municipal land use regulations is a primary determinant of policies related to forest land use and forest management. The extent of comprehensive planning, zoning and subdivision ordinances, natural resource protection provisions, open space planning, etc. varies widely across the region, and it would be helpful to construct a region-wide comprehensive summary by municipality of the land use statutes that are most important for forest and water resources conservation.

One barrier to maintaining large forested tracts is the essentially agrarian tax system on which property taxes are based and the cash flow burden this places on landowners whose forests provide valuable, but often undervalued, community ecosystem services. Typically, property taxes are based on a parcel's "highest and best use" as opposed to current use. In an area where population growth and associated land development are occurring and the demand for land is high, tax assessments on undeveloped forest land can increase to the point where landowners otherwise committed to forest management may be forced to consider other options. This scenario is playing out in many Upper Delaware region communities, although the three states do have varying degrees of tax relief for forest landowners.

State agencies play an overarching technical assistance role, administer forest stewardship programs (which have seen declining funding in recent years) and manage state forest lands. There is some coordination among Federal and State forestry agencies; for example, forest pest management and fire suppression programs often have both Federal and State participation along with local partners. The Upper Delaware River watershed is considered a Multi-State Regional Priority Area by forestry agencies in New York, New Jersey and Pennsylvania.

Deer management responsibilities fall to state natural resource agencies; however, a Pinchot Institute for Conservation report found that many State deer programs operate with little or no data and that much of deer management tends to operate from values, such as recreational success associated with hunting, not science (Shissler and Grund 2009).

Potential Forest Solutions - Strategies for Climate Resilience

Arrange of cost effective strategies are available to foster climate resilience for forest lands. The table below begins to chart some potential strategies for maintaining the valuable forest resources in the Upper Delaware region and increasing the resiliency of forests to the added stress of climate change. These strategies broadly address loss of forest cover, declines in forest productivity and health, changes in ecosystem processes and reductions in the ecosystem services provided by forests.

Stressor	Solutions	Responsible Parties	Comments
Loss and or fragmentation of forest land through development	<ul style="list-style-type: none"> • Land use planning/zoning • Transfer of Development Rights • Land acquisition/easement purchase • Floodplain/riparian zone restrictions • Subdivision standards • Tax incentives to keep large tracts intact • Ecosystem service valuations for business case for conservation 	Counties/land trusts - easement purchases; municipal governments – land use/zoning/riparian buffers; federal legislators – tax credits	Politically difficult and/or expensive; use ecosystem services to make case and possibly find ways to pay or make politically tenable
Invasive Plant species	<ul style="list-style-type: none"> • Landowner education • Demonstration projects on public or select private lands of forest management techniques that deal effectively with invasive plants 	Land trusts (easement holders), private landowners, state/federal landowners	
Insects and disease – Hemlock Woolly Adelgid, Gypsy Moth, etc.	<ul style="list-style-type: none"> • Cooperation with federal and state forestry agencies to improve/expand research and treatment programs and development of resistant tree species • Surveillance for early detection and treatment • Reforestation with resistant tree species 	USFS, State forestry agencies, counties as local partner; private foresters, neighborhood associations, garden clubs, schools; agencies and landowners	Pesticide spray programs are expensive, may impact desirable species and are sometimes met with opposition from certain segments
Poor regeneration - white-tailed deer, harvesting practices	<ul style="list-style-type: none"> • Improved State deer management policies • Landowner education • Programs to pair landowners with forestry professionals for stewardship planning/implementation 	State game agencies; foresters/loggers	Educational workshops for key professional forestry practitioners
Forests even-aged, maturing, lacking diversity	<ul style="list-style-type: none"> • Landowner education about forest management options • Programs to pair landowners with forestry professionals for stewardship planning/implementation • Improved State funding for forest stewardship programs • Common Waters Fund capitalized by downstream water user investments • Better markets for forest products 	State forestry agencies, professional foresters, Common Waters Partnership, Delaware River water users	State forestry agency funding for forest stewardship is declining
Wildland Urban Interface risks (WUI)	<ul style="list-style-type: none"> • Land use regulation to limit housing in WUI • Reduce economic incentives for housing in WUI, such as by reducing subsidization of fire protection or increasing insurance costs (similar to FP) • Community education • Fire management / controlled burns 	State fire agencies, USFS, county emergency management officials, local volunteer fire departments	Need good economic analysis to help “sell” the idea to landowners and county; Reducing incentives might require change in state laws

Figure F-21: Potential forest solutions - strategies for climate resilience. *Source: UPDE Core Planning Group.*

Leverage Cooperative Conservation Efforts

There are noteworthy cooperative efforts in the Upper Delaware region aimed at protecting forests, water quality and water supply, educating landowners, improving communications and collaboration among planning and natural resource management agencies and organizations, prioritizing land conservation efforts, and providing connectivity among larger forested tracts. These endeavors are an excellent starting point and should be further cultivated to support climate adaptation strategies on a regional scale and build community resiliency.



Figure F-22: A Common Waters Fund riparian buffer planting along the Paulinskill River in Sussex County, NJ. Source: Susan Beecher.

The Common Waters Partnership is a regional partnership of public and non-profit organizations and agencies focused on supporting the development of sustainable communities and working landscapes in the Upper Delaware River watershed. Its focus is providing good scientific information at a regional level and encouraging cross-boundary communication. The partnership strives to facilitate information sharing through joint publications, shared web-delivery systems and establishment of a communications network across municipal, county, and state boundaries. This communications network has particular importance in the development and implementation of climate adaptation strategies for the multi-state, multi-county Upper Delaware region.

The Pinchot Institute for Conservation-administered Common Waters Fund works with a network of local partners and State forestry agency staff to provide funding to eligible landowners, qualified land trusts, and timber harvesting operators to help develop forest stewardship plans, implement forest

management practices that will improve forest health and protect water quality, assist with expenses related to placing a conservation easement on a property, and promote the use of portable timber bridges to reduce erosion and sedimentation on streams in priority areas. Operating with initial funding from the United States Endowment for Forestry and Communities, the program is seeking additional funding sources to continue this locally-driven private forest landowner support which is essential to maintaining healthy and climate resilient forests. Common Waters has been reaching out to companies, municipalities, and others who benefit from a healthy Delaware River to gain their support for forest conservation. However, the economic value of the Upper Basin's forests for protecting water quality and regulating flows is not well documented, especially in the context of climate change. Little *quantitative* information exists on the impacts of forest loss and climate change on local communities and on other stakeholders further downstream. Without this hydrological or economic information, it is difficult for local and downstream stakeholders to fully understand the need for and benefits of investing in climate adaptation. A focused study in a subwatershed of the Upper Basin which could demonstrate the value of protecting or restoring forests to lessen the impacts of climate change would be useful to better understand the relationship between rural forests and urbanized areas and to help raise interest in climate adaptation and gain support for forest conservation in the Upper Delaware region.

Land trusts are key players in the region, supporting forest conservation through education efforts that help connect people with the land, offering assistance with conservation easements and providing information about the financial benefits of land conservation. Land trusts also work closely with other natural resource and planning agencies to inform local planning efforts, prioritize land acquisition and easement purchases to provide connectivity and ultimately protect the most important forest landscapes. Local bond initiatives, such as those in Monroe and Pike Counties, PA that provide funding for open space preservation, have been critical in leveraging state and federal land conservation funding sources. This is a tool that could be explored in other counties or municipalities in the region as a funding source for open space conservation.

Forest landowner associations are an important resource providing private landowners information on forest stewardship, forest management practices and financial and technical support programs. The associations vary in size and activity, but unfortunately reach only a fraction of private landowners. Landowner associations, working with state forestry agencies and local partners, could be of assistance in promoting forest management techniques to improve overall forest health and diversity, deal effectively with invasive plants and insect problems, and foster forest stewardship with future generations of landowners.

Private hunting and fishing clubs own significant forested acreages in the Upper Delaware region and present another opportunity for focused education, outreach, forest health improvements and permanent land conservation initiatives. Many of the larger clubs have worked with professional foresters to develop forest management plans; however, lack of funding is often cited as a deterrent for plan implementation and plan development for smaller clubs. Given its land holdings in the region, this landowner group should be a priority for voluntary easement purchases and funding for stewardship planning and practices implementation that maintain climate resilient forests.

The Catskill Region Invasive Species Partnership (CRISP) is one of eight Partnerships for Regional Invasive Species Management (PRISM) in New York State. The formation of an organized body whose

primary focus is to understand and control invasives will become increasingly important in addressing expected changes in invasive species distribution, providing education, outreach and technical assistance and securing funds needed to take effective action. Building off a program that began in cooperation with CRISP, the National Park Service's Upper Delaware Scenic and Recreational River recruited volunteer "Watershed Stewards" who are stationed at river access points to help inform the public of invasive species issues and ways they can help to prevent their spread. Adding the Pennsylvania and New Jersey counties to create an Upper Delaware region-wide invasive species management area would aid in coordinating many existing efforts in this area and help prioritize those species and problem areas of greatest concern.

Forest Management Tools

Professional forester input and interactions with landowners and land managers will be essential to enhancing forest resilience during an expected long period of climate change. Research indicates that some currently utilized forestry practices can enhance carbon storage and forest resiliency in the face of climate change. In its 2007 report *Climate Change, Carbon, and the Forests of the Northeast*, the Forest Guild promotes the following practices as important in this regard:

- Use forest management plans and the supervision of a professional forester to guide harvests;
- Extend rotations or entry periods to promote carbon storage and ecological values;
- Manage for structural complexity of forests (i.e., leaving snags, coarse woody material, and, in multi-aged stands, high levels of post-harvest basal area);
- Retain trees as biological legacies after harvests;
- Use low-impact logging to protect soil and site productivity;
- Choose appropriate thinning regimes that concentrate growth on fewer, larger trees;
- Restore understocked stands to full stocking and productivity;

Excerpted from: **Forest Guild Policy Statement: Climate Change and Forests**

http://www.forestguild.org/publications/policy/Policy_Climate_Change.pdf

Forestry that uses nature as a model is a good approach for ensuring healthy ecosystems that are best able to adapt to a changing climate. Climate change is likely to exacerbate other problems that are already stressing forests including forest fragmentation, environmental pollution such as acid deposition, and invasion by exotic species. Therefore, forest management recommendations that enhance and maintain forest characteristics that confer resilience and resistance to stress and change must deal holistically with a full range of forest threats.

Identifying appropriate forest management options to aid in adaptation to climate change and attendant forest threats is difficult because of high levels of uncertainty and the impossibility of precise predictions for complex and chaotic systems. Even in the face of high levels of uncertainty, management decisions that improve ecosystem health will help forests resist the perturbations driven by climate change. Similarly, healthy ecosystems are more resilient, better able to respond to and recover from disturbances, which may become more frequent and more severe as time passes. Forestry that encourages a naturally diverse species mix will spread the climate change risks across multiple species.

- Avoid harvesting practices that degrade forest ecosystem health (i.e. high grading, whole tree harvesting on nutrient-impaired sites, liquidation cutting, and relying on short-term rotations that produce short-lived products) (Perschel, et al. 2007).

Daniel Stepanauskas, forester and Forest Guild Membership and Policy Council delegate offered these ideas. “The most critical element is to begin with both guarding and tailoring forest structure, and adjusting tree species composition to tolerate a warming climate with periodic increased soil moisture. Silvicultural techniques and harvest tree selections must be adjusted to allow and encourage trees at the northern edge of their ranges to move north. The converse must also take place, although at a less vigorous pace, whereby the species at the south edge of their ranges will need to be targeted for increased rates of removal. In areas such as heads of watersheds, seeps, and in all riparian zones, the harvest buffer zones need to be increased in size. The canopy closure in these zones will become ever more critical in our efforts to maintain normal water temperatures. The management goal of these riparian zones is to develop and maintain climax forests that can withstand a warming climate (Stepanauskas 2013).

Additional climate change tools and approaches for forest managers are described by Gunn, et al. (2009) and Swanston, et al. (2012). These are established forest management strategies that, given added effort and focus, can help reduce forest vulnerability to the multiple stresses associated with climate change. Some strategies that appear relevant for Upper Delaware region forests include the following:

- Maintain and enhance structural and species diversity
 - Promote diverse age classes
 - Maintain and restore diversity of native tree species through understory management and planting efforts
 - Retain individual trees of a variety of species to maintain their presence in a landscape and provide a potential seed source for species expected to be better adapted to future conditions
 - Restore fire to fire-adapted systems
- Support fundamental ecological functions, especially those related to soils and hydrology
 - Plan timing of logging operations to limit soil compaction
 - Retain coarse woody debris
 - Minimize road networks
 - Size culverts for increases in peak flows
 - Plan for seasonal operational limitations
 - Protect and restore riparian areas
- Reduce the susceptibility of forests to impacts of existing biological stressors (insects, disease, invasives, deer)
 - Reduce density of host species and increase vigor of remaining trees
 - Adjust rotation length to limit time that stands are vulnerable to insects and/or disease
 - Monitor for, rapidly respond to and prevent invasive species infestations
 - Manage deer browse through fencing or other barriers, “hiding” more desirable species in a mix of less desired ones, or strategically locating harvests to draw deer away from more vulnerable stands
- Promote landscape connectivity through landscape-scale planning and partnerships to coordinate forest conservation efforts

In an effort to address woolly adelgid-induced hemlock decline, the USDA Agricultural Research Service has been working for about 10 years on developing hemlock woolly adelgid resistant hybrids of native eastern and Carolina hemlocks with Chinese hemlocks. Chinese hemlock, (*T. chinensis*) has shown good environmental tolerance as well as resistance to the adelgid. The creation of hybrids between the eastern North American species and the Asian species is showing success in producing hemlocks with resistance to the adelgid as well as desirable form and habit, and adaptability to the eastern United States (Montgomery, et al. 2009). This offers a potential suitable replacement species for the lost native hemlocks which could be examined for replanting in those areas where hemlock mortality is widespread.

Hemlock loss in areas where native species are preferred or required presents challenges, as there are really no native species that are good substitutes for eastern hemlock (Rich Evans, 2013). Native evergreen tree species that have been considered for replanting in Delaware Water Gap National Recreation Area include white pine, eastern red cedar and red spruce. Of the three, red spruce is likely the most ecologically and visually similar to eastern hemlock, but it is very slow growing. White pine often occurs with hemlock, and can replace hemlock naturally (or with less effort to plant) and more quickly than red spruce, but it doesn't create the shade or habitat structure of eastern hemlock. Eastern red cedar is perhaps the least suitable of the three potential replacements. In riparian areas, planting or encouraging native evergreen shrubs like rhododendron and mountain laurel would likely be better options.

Ongoing work at the privately owned Milford Experimental Forest (MEF) in Pike County, PA may offer an option for improving both forest diversity and carbon sequestration on privately owned forest lands. The Pinchot Institute for Conservation is collaborating with the U.S. Forest Service to research the effectiveness of large-scale chestnut reintroduction at MEF. The American chestnut, *Castanea dentata*, was once known as “king of the forest” for its rapid growth, large stature, and vast abundance. In a single year, an American chestnut can grow up to five feet in height and two inches in diameter and can sprout vigorously from the stumps of felled trees. The chestnut's natural range, which extended from southern New England and New York southwest to Alabama, makes it a species less sensitive to the temperature and hydrologic changes associated with climate change. A number of institutions, including the American Chestnut Foundation, have been using somewhat different methods to bring blight resistance to the American chestnut. A Purdue University study showed that the growth rate, size and longevity of a new hybrid of the American chestnut, along with the high quality wood products typically produced, let them store more carbon, and at a faster rate than any other hardwood (Wallheimer 2009). In addition to functioning as a demonstration site for American chestnut reintroduction, MEF has the potential to serve as a “living classroom” that could be utilized to track indicators of climate change locally or to demonstrate other management practices that can enhance carbon storage and forest resiliency in the face of climate change.

Deer Management

Deer populations, identified by State forestry agencies and forest landowners as a deterrent to forest regeneration and expected to expand with a warming climate, should be managed proactively to address broader natural resource management issues and to promote healthy forest ecosystems. In some State Forest lands of northeastern Pennsylvania, deer numbers appear to be declining and regeneration improving since changes such as bonus tags and ability of hunters to kill more than one deer per year were instituted (Brad Elison, 2013). Wildlife management agencies can better utilize science-based

research and data collection and analysis to manage deer populations and to stay ahead of any population increases associated with changing climate conditions. In order to accomplish this, state governments will need to focus on and resolve both political/social barriers and management agency funding issues.

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Figure F-23: A snapshot of the forest industry of the Upper Delaware Region.
Source: Delaware Highlands Conservancy.

ShopLocalSaveLand.com 1

Support Forest-Dependent Industries

In the Upper Delaware region, travel and tourism is a significant driver of the economy. The region’s abundant natural and social amenities offer many recreational opportunities and the public land resources are a primary draw for pleasure travelers. Travel and tourism-related employment in the region averages a healthy 20% of overall private employment.

While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when visitors move families and businesses to communities they first visited as tourists. Finding mechanisms to support and grow this industry, while conserving the forest and water resources that support it, is a crucial strategy for creating sustainable and climate resilient communities.

Although a relatively small economic driver overall in the Upper Delaware Region, the forest industry is nonetheless an important source of local jobs and manufactured products that, based on the estimates of underutilized forest productivity in the region, could, see future growth.

Delaware Highlands Conservancy's *Shop Local Save Land Guide to Wood Products, Professionals, and Resources* highlights a wide variety of forest industry services and primary and secondary manufactured products currently available/produced in the Upper Delaware region. Additional focus on developing new markets and promoting and expanding utilization of these locally grown forest products and services could incentivize more landowners to sustainably manage forests for longer-term productivity.

Improve Tax Incentives

In New York State, the Real Property Tax Law (RPTL) 480a program is an example of how State tax policy can support the maintenance of large forested tracts of land. The goal of the law is to encourage commercial forestry by correcting tax inequities, thus encouraging forest management and decreasing incentives for conversion of forest lands to other uses. The law does not recognize other values of forest land, such as recreation, wildlife habitat, carbon sequestration, etc. The benefit to landowners for enrolling in RPTL 480-a is a reduction of eighty (80%) percent of the assessed value of the eligible acreage. The landowner, upon harvesting timber, must pay a six percent (6%) yield tax (or stumpage payment) to the County which, in turn, reimburses the municipality from which the stumpage was cut. There are some provisions of the law which are seen as disincentives to participating in the program; as a result, a small percentage of qualified lands are enrolled. Implementing reforms to the law that would address these issues would likely increase participation by landowners and reduce resistance from local municipalities (Cornell Extension 1993 and The Adirondack Council 2004).

Pennsylvania's *Clean and Green* program allows forest landowners a limited property tax reduction with the goal of encouraging landowners to maintain their land in a forested use. Assessed values under the program are based on a rather complex formula which includes the average yield of six forest types, estimated separately for four price regions, regional stumpage prices, estimated management costs, a discount rate, income tax rates, and local assessment ratios and millage rates.

New Jersey's Forest Stewardship Act of 2010 created a program whereby forest lands can receive reduced property tax assessments by actively managing their woodlands to promote forest health and sustainability. Considered progressive, the law recognized that the value of forests to the State goes beyond traditional commodities such as firewood and lumber. It directs the New Jersey Department of Environmental Protection to create a new forest stewardship program, authorizes funding for forest stewardship plan development and practice implementation and prohibits local governments from enacting laws that would interfere with Forest Stewardship Plan implementation. It also directs the State, to the extent possible, to purchase wood products derived from lands that have a Forest Stewardship Plan. Recently, New Jersey's Governor conditionally vetoed the component of the legislation that called

for the development, review, and adoption of Forest Stewardship Plans that follow Forest Stewardship Council standards, the leading standards in the world for forest management. This action was seen as a setback by some conservation organizations. (NJ Audubon 2013)

Other Policy Tools

The Delaware River Basin Commission (DRBC) was formed in 1961 when President John F. Kennedy and the governors of Delaware, New Jersey, Pennsylvania, and New York signed concurrent compact legislation into law creating a regional body with the force of law to oversee a unified approach to managing a river system without regard to political boundaries. The four governors for each respective state still serve as representatives as well as the Division Engineer of the North Atlantic Division, U.S. Army Corps of Engineers, who serves as the federal representative. The Compact's signing marked the first time since the nation's birth that the federal government and a group of states joined together as equal partners in a river basin planning, development and regulatory agency. DRBC programs include water quality protection, water supply allocation, regulatory review (permitting), water conservation initiatives, watershed planning, drought management, flood loss reduction, and recreation. The existence of this agency presents a unique opportunity for a landscape approach at protecting forest lands and water resources in the basin. Its Interstate Flood Mitigation Task Force, for example, developed comprehensive consensus recommendations to address flood impacts along the Delaware River and its tributaries (see Appendix 2). In addition to its existing efforts in water resources planning and protection, the DRBC could utilize available ecosystem services valuation data along with the important ecological flow data being developed in conjunction with the Nature Conservancy to make the case for member states' and the federal government's investment in maintaining and improving the Basin's headwater forests.

Another organization in the basin that has great potential for implementing strategies to reduce climate risks is the Upper Delaware Council (UDC). The UDC is a non-profit agency comprised of 13 municipalities, two states (NY and PA), the Delaware River Basin Commission and the National Park Service. It is designed to act as a forum for local, state and federal government to resolve issues in the 74 mile stretch of the federally designated Upper Delaware Scenic and Recreational River. UDC was developed to reinforce the partnership in river management that is called for in the Scenic Rivers authorizing legislation, and to allay the many concerns that local residents had concerning the extent of federal land acquisition and the intrusion of federal regulations into the lives of residents. The UDC also encourages member towns to adopt land use regulations that conform to established land and water use guidelines that are based on management principles and objectives set forth in the U.S. Wild and Scenic Rivers Act. Alternatives are generally provided for meeting those objectives so each community and level of government can respond in a way particularly suited to its needs while preserving and enhancing the characteristics that caused the Upper Delaware to be included in the National Wild and Scenic Rivers System. The UDC could play an important role with the National Park Service Upper Delaware Scenic and Recreational River in updating the land and water use guidelines and providing outreach to municipalities and private landowners to promote land use policies that conserve forests and water resources, address wildland-urban interface risks and implement strategies for climate resiliency.

Water Resources - Current Conditions and Trends

"When the well's dry, we know the worth of water."
– Benjamin Franklin

The Delaware River mainstem is the longest undammed river east of the Mississippi, flowing for 330 miles from the confluence of the east and west branches in Hancock, New York, south through Pennsylvania, New Jersey, and Delaware to the Atlantic Ocean. Its 13,539 square-mile watershed is only about 0.4% of the land area of the continental U.S., but it supplies water to 5% of the nation's population — some 16 million people — including residents of New York City and Philadelphia (*Basin Information*, DRBC 2013).

The Upper Delaware region, in the northern reaches of the Delaware River Basin, has its own distinct characteristics. It is approximately 4500 square miles in area and includes lands in southwestern New York, northeastern Pennsylvania and northern New Jersey along with two nationally significant Wild and Scenic Rivers System segments – the Upper Delaware Scenic and Recreational River and Middle Delaware Scenic and Recreational River. As the least developed section of the last major river on the Atlantic Coast undammed the entire length of its mainstem, the Upper Delaware's largely ecologically intact, free-flowing character supports exceptional water quality, high quality fish and aquatic insect populations, a diversity of in-stream habitats and a myriad of recreational opportunities.

For the purposes of this planning document, the Upper Delaware region is defined as depicted in Figure W-1 below, following the same watershed boundaries as the Common Waters Partnership's Common Waters Fund priority areas (www.commonwatersfund.org). The region includes the jurisdictions of 7 counties across three states as follows: Sullivan and Delaware counties in New York; Wayne, Pike and Monroe counties in Pennsylvania; and Sussex and Warren counties in New Jersey.

Land Cover

The watershed is heavily forested and predominantly rural in nature. Agricultural areas make up approximately ten percent of land cover in the region. Developed areas, primarily villages, boroughs and planned residential communities, comprise about 7 percent of the land cover.

HUC 8 Watersheds in the Upper Delaware region include the following:

02040105	Middle Delaware-Musconetcong
02040101	Upper Delaware
02040102	East Branch Delaware
02040103	Lackawaxen
02040104	Middle Delaware-Mongaup-Brodhead

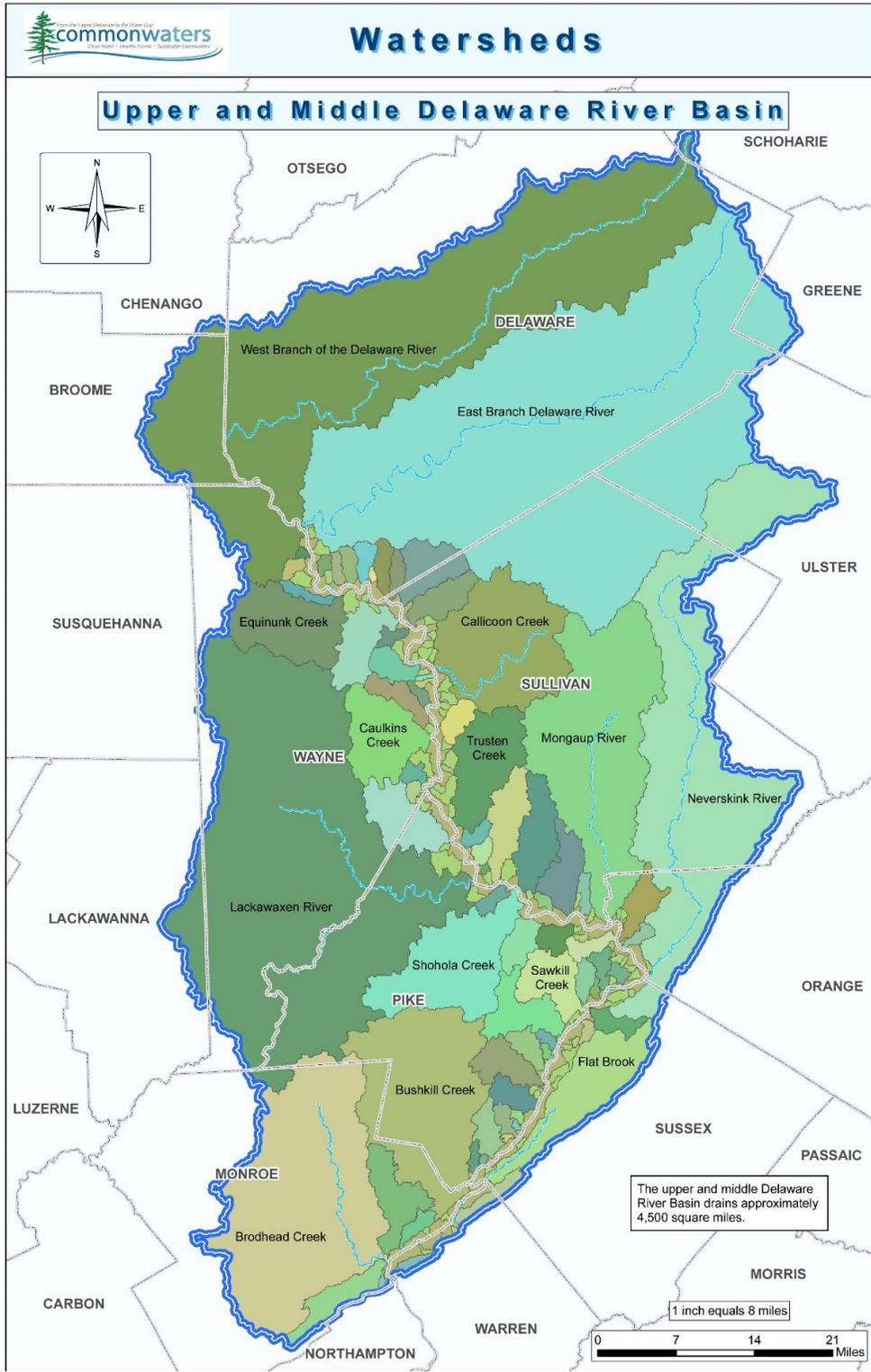
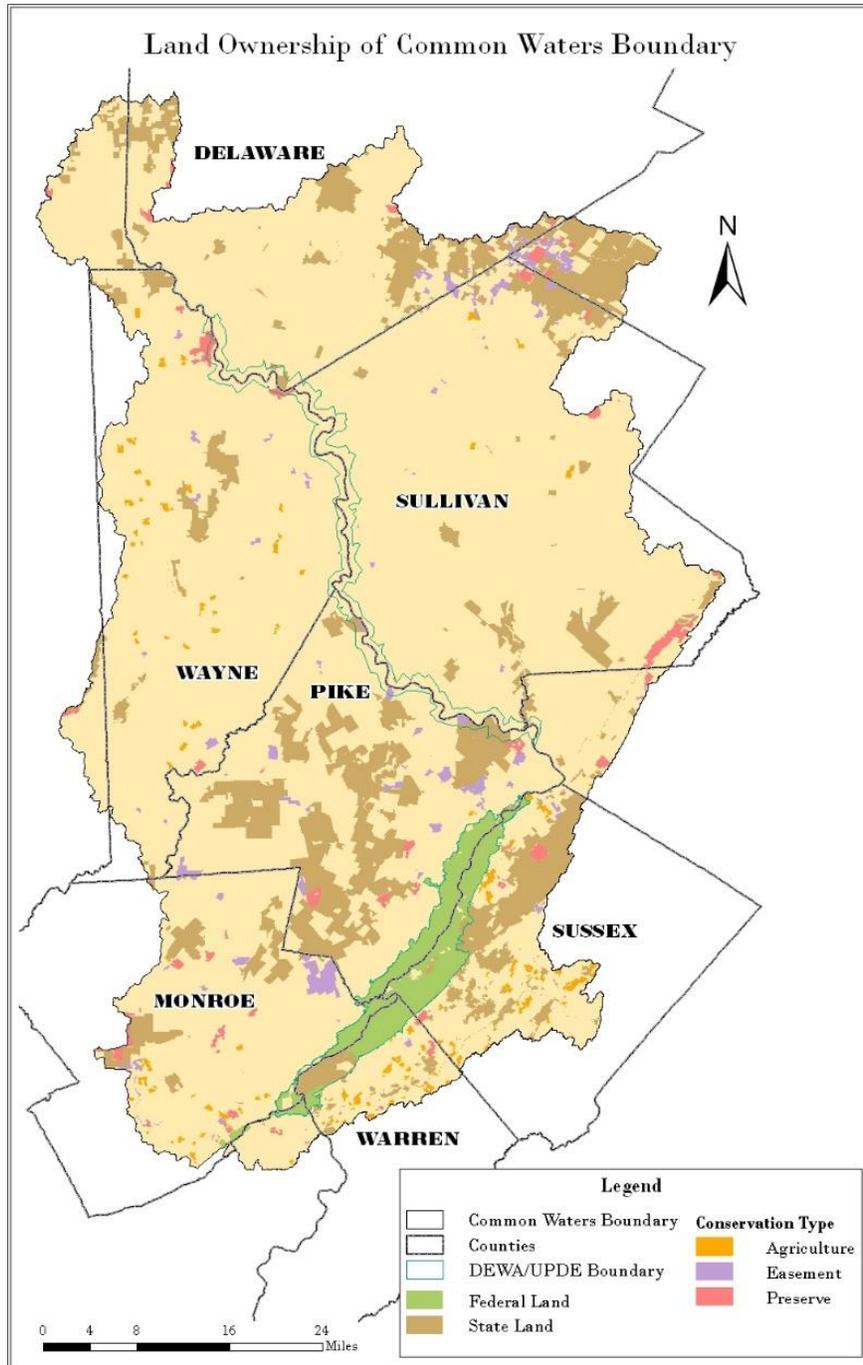


Figure W-1: Watersheds of the Upper Delaware Region.
 Source: NPS, DWGNRA 2013.



Ownership	Acres	% of Common Waters Area
Federal	61,970.63	2.81%
State	360,488.89	16.33%
Conservation	74611.57	3.38%
Private	1,711,078.11	77.49%
Total	2,208,149.20	100.00%

Figure W-2: Federal, State and Protected Conservation Lands in the Upper Delaware Region.

Source: NPS DWGNRA 2013.

Land Ownership

Although land ownership in the region is predominantly private (about 78%), there are considerable acreages of Federal and State owned lands, about 3% and 16% respectively, and “conservation” lands preserved by easement or deed restriction (about 3%).

Ecological Health

The northern reaches of the Upper Delaware watershed are largely ecologically intact; DRBC estimates that over 70% of freshwater wetlands and stream corridors in the Upper Basin retain their natural forest cover and function (DRBC 2013).

The topography in the northernmost part of the region is characterized by a relatively narrow floodplain as the river flows through a valley framed by steep mountains. River gradient is high compared to other mainstem reaches. The middle and lower reaches of the Upper Delaware region feature a lower gradient, more expansive floodplains and abundant wetlands complexes. Overall characteristics include:

- excellent water quality, resulting from the predominantly forested landscape;
- healthy riparian areas and substantially intact floodplains that sustain high quality fish and aquatic insect populations, including native brook trout and rainbow and brown trout;
- an abundance of freshwater mussels, including the federally endangered dwarf wedgemussel;
- diverse native aquatic plant communities, including pollution-intolerant threadfoot riverweed;
- spawning habitat for migratory fish, including American shad and American eel (National Park Service 2012).

In its 2011 assessment *Delaware River Basin Priority Conservation Areas and Recommended Conservation Strategies*, the Nature Conservancy identified and mapped priority ecosystems in the Delaware River Basin. Among those identified in the Upper Delaware region were: floodplain complexes – those with the most potential for floodplain functionality; headwater stream networks - the most physically intact and least altered, with high percentage of natural cover and low percentage of impervious cover; and non-tidal wetlands embedded within both headwater and riverine systems – those meeting certain criteria for size, abundance, or density. The condition of these ecosystems was also assessed, based on aquatic connectivity, flow regime, landscape condition, size, and resiliency. The mapped priority ecosystems, abundant in the Upper Delaware region and supporting a great diversity of habitats and species, are illustrated in Figure W-3 (The Nature Conservancy 2011).

In recognition of the unique natural systems it supports, the Upper Delaware region includes two federally-designated Scenic Rivers segments, the 73 mile Upper Delaware Scenic and Recreational River and the 40 mile Middle Delaware Scenic and Recreational River along with the nearly 70,000 acre Delaware Water Gap National Recreation Area. The region is within a short drive (approximately 100 miles) of the New York Metropolitan Area. Given its close proximity to the major metropolitan areas of Pennsylvania, New York and New Jersey, the wild and scenic characteristics of the Upper Delaware region offer vast opportunities for a wide array of outdoor recreational experiences for millions of people. Some of these opportunities, available within the federal, state and municipal public lands located throughout the region, include hunting, fishing, swimming, recreational boating, nature viewing, hiking and biking.

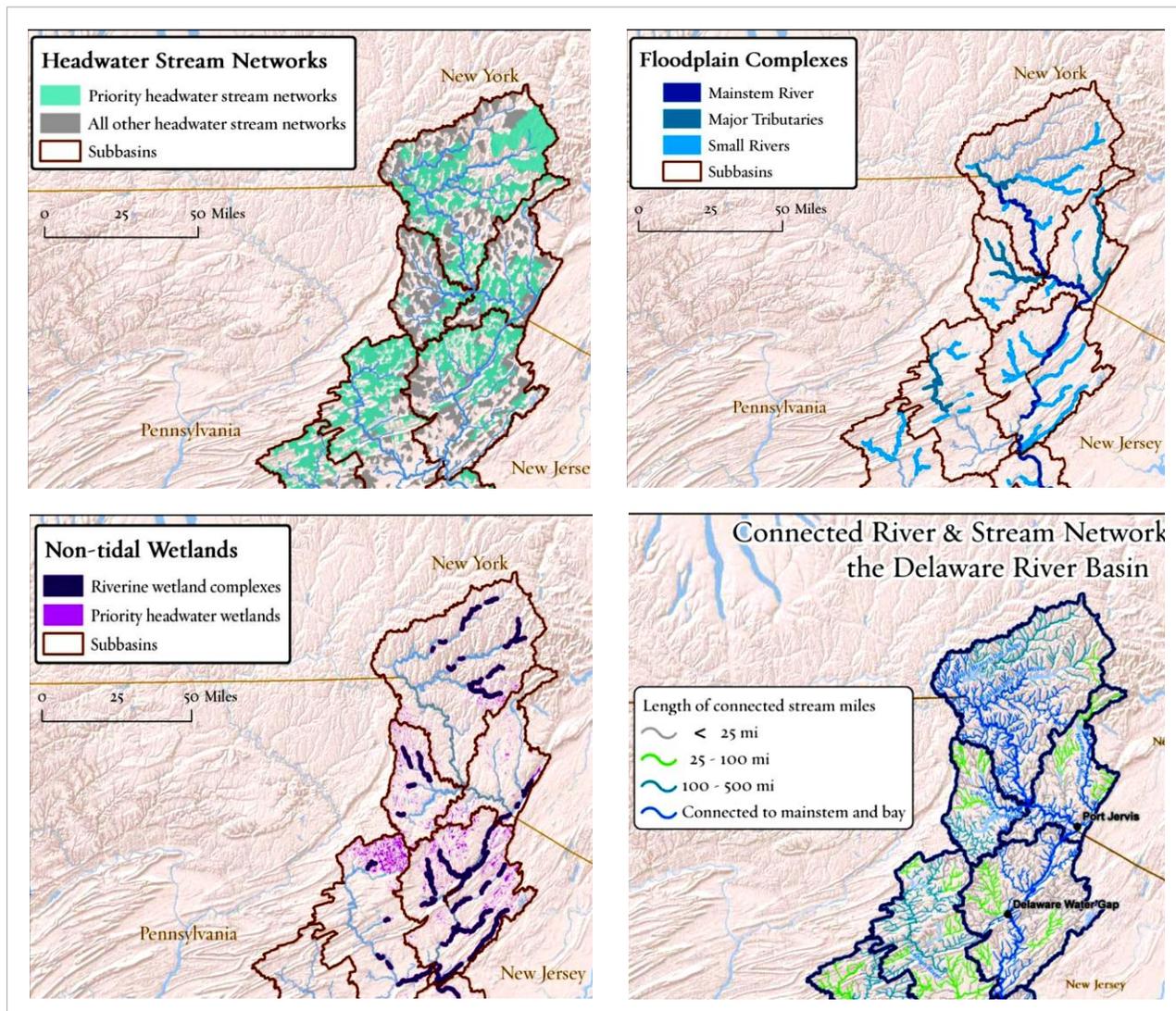


Figure W-3: Priority ecosystems of the Upper Delaware region. *Source: The Nature Conservancy 2011.*

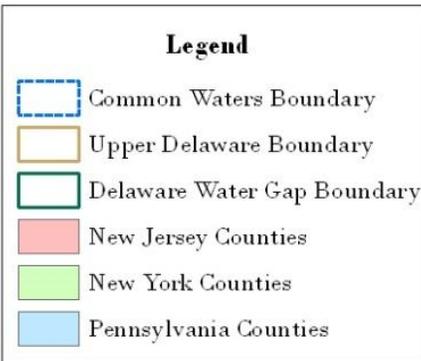
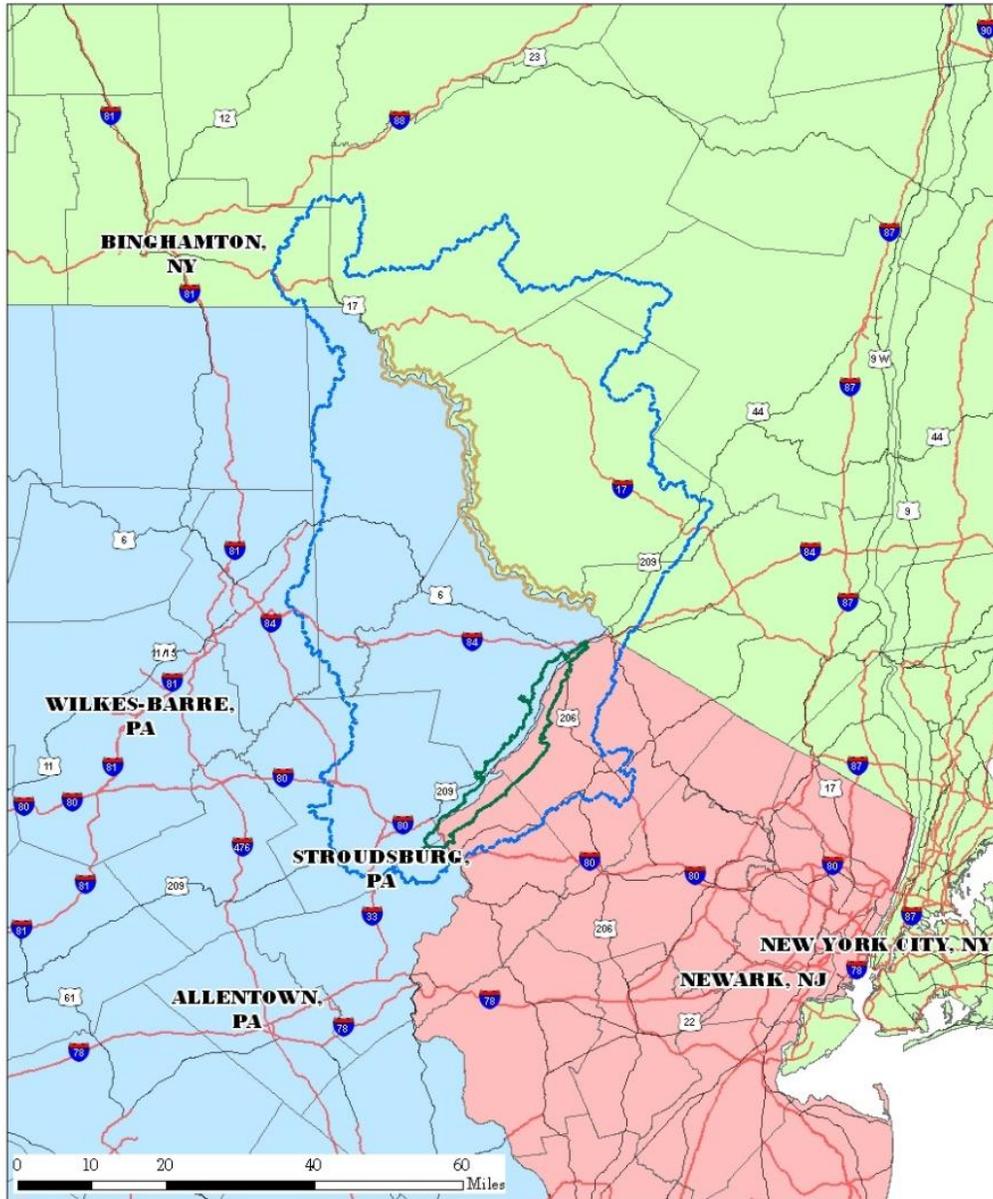


Figure W-4: Proximity of the Upper Delaware region to major transportation corridors and Metropolitan NY. Source: NPS DWGNRA 2013.

Water Quality

Water quality in the Upper Delaware region is generally considered to be exceptional, both along the mainstem of the Delaware River and within the tributary streams. This water quality is vulnerable to climate impacts in a number of ways. Extreme precipitation events add significant sediment and other pollutants to water resources. Outbreaks of waterborne diseases caused by pathogens such as *Giardia* and *Cryptosporidium* have been linked to heavy rainfall and surface runoff. Higher water temperatures can deplete oxygen and contribute to algae blooms. Many existing water quality stressors may be exacerbated by conditions associated with a changing climate.

What do the Special Protection Waters Regulations Mean to Water Quality? In 1992, DRBC implemented the Special Protection Waters (SPW) program, which established regulations to "keep clean water clean" in the upper sections of the watershed, portions of which had been designated by the federal government as part of the National Wild and Scenic Rivers System in 1978.

DRBC's SPW regulations were amended in 1994 to also include non-point source pollutant loadings carried by runoff. The regulations were enacted to protect existing high water quality in the Upper Delaware River Basin deemed "to have exceptionally high scenic, recreational, ecological and/or water supply values" (Special Protection Waters, DRBC 2013). The authority for this designation was supported by the anti-degradation provisions of the Clean Water Act, which is still the basis today for increased protection for high quality waters around the country. Within the drainage area to Special Protection Waters, DRBC approval is required for new and expanding industrial and municipal wastewater treatment plants that discharge a daily average rate of 10,000 gallons per day or more. In the rest of the basin, the review threshold is 50,000 gallons per day. The regulations discourage new and increased discharges of wastewater to the designated waterways by prohibiting new wastewater treatment facilities and substantial alterations to existing facilities unless all non-discharge and load reduction alternatives and natural treatment alternatives (such as land application) have been fully evaluated and deemed technically and/or financially infeasible. The regulations further require that the minimal level of wastewater treatment will be "Best Demonstrable Technology" and that discharges within the drainage area to waters classified as SPW must demonstrate no measurable change to existing water quality at established water quality control points (Administrative Manual, DRBC n.d.). This is a commendable level of protection for water quality and is likely a key reason that the waters of the Upper Delaware continue to be of relatively high quality today.



Figure W-5: DRBC-Designated Special Protection Waters (in yellow) in the Upper Delaware Basin.
Source: Special Protection Waters, DRBC 2013.

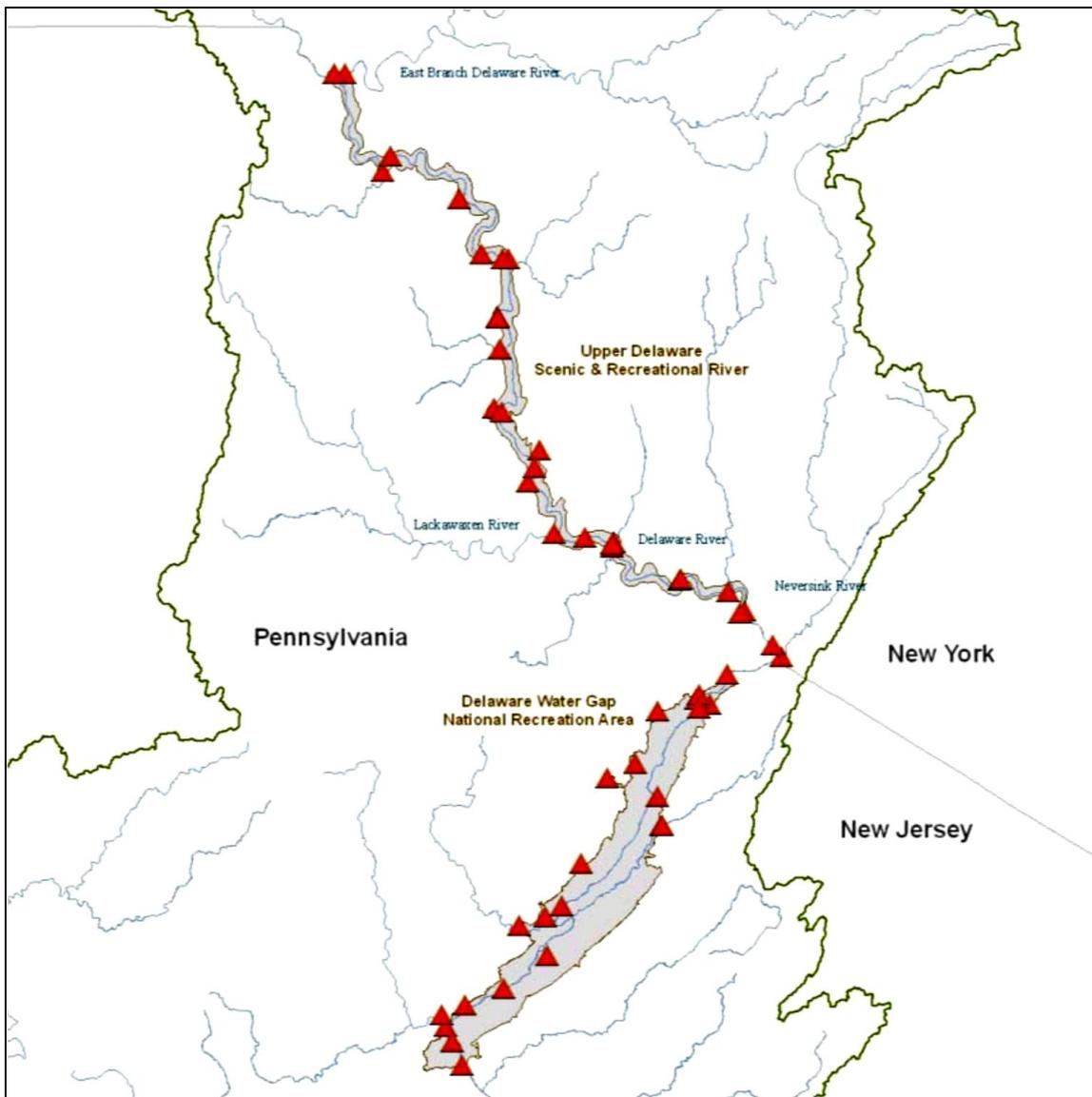


Figure W-6: Water Quality Control Points within Upper Delaware region Special Protection Waters. *Source: Special Protection Waters, DRBC 2013.*

Projects located in the drainage area of Special Protection Waters that are subject to DRBC review must also have a Non-Point Source Pollution Control Plan (NPSPCP) that has been approved by the Commission. The NPSPCP describes Best Management Practices to be used at the project site and within the service area to control increases in non-point source pollutants resulting from the project. In many cases, DRBC accepts the states' NPDES Permits for Stormwater Discharges Associated with Construction Activities as meeting the requirement for an NPSPCP (Administrative Manual, DRBC n.d.).

The Scenic Rivers Monitoring Program (SRMP), a long-standing partnership between the DRBC and the National Park Service (NPS), is responsible for monitoring and managing water quality in the Special Protection Waters of the Upper Delaware. Numerous sites are sampled annually between May and

September and analyzed for nutrients, dissolved oxygen and other conventional pollutants, solids, bacteria, macroinvertebrates, periphyton and flow (Scenic Rivers Monitoring Program, DRBC 2013).

The Delaware River is one of 15 study units included in the U.S. Geological Survey National Water-Quality Assessment (NAWQA) program. Some of the major factors that influence the water quality in the basin as defined by NAWQA include:

- Relation of land use to nonpoint sources of contaminants.
- Effects of natural settings on the distribution, fate, and effects of contaminants in water, sediment, and biota.
- Relations between stream flow and loadings of nutrients, contaminants, and pathogens.
- Effects of nutrients and habitat on algae and macrophytes in streams, lakes, and estuaries.
- Distribution of toxic substances, particularly polychlorinated biphenyls (PCBs), and trace elements in surface water, ground water, and biota.
- Presence of human pathogens and pesticides in drinking-water supplies and recreational waters.
- Effect of dams, impoundments, and diversions on water quality, and on the health of fish and benthic invertebrate communities.
- Development of management strategies for protecting areas of existing high water quality.
- Effects of on-lot septic systems and reduced stream flow caused by groundwater withdrawals on water quality and ecological communities.
- Distribution of natural radioactivity in domestic ground-water supplies.
- Effects of ground-water/surface water interactions on water quality (Delaware River Basin, USGS 2013).

In its 2008 *State of the Delaware River Basin Report*, DRBC listed the following major influences on stream and river water quality: runoff and point-source discharges from agricultural and urban areas; persistent contaminants associated with past human activities (mercury, PCBs) and; impoundments and diversions of water. In the Upper Basin, dissolved oxygen concentrations routinely exceed DRBC's minimum criteria and were either relatively constant or improving. Averages for total suspended solids are in the lower ranges in the Upper Basin *except after storm events*. There are fish advisories for some waterbodies and the mainstem river within the Upper Basin. Pesticides such as atrazine and metolachlor are found in surface and groundwater within the watershed, but in generally low concentrations and below the drinking water standards. Nitrogen and phosphorous levels are generally in the "good" range and are considered either constant or improving (DRBC 2008).

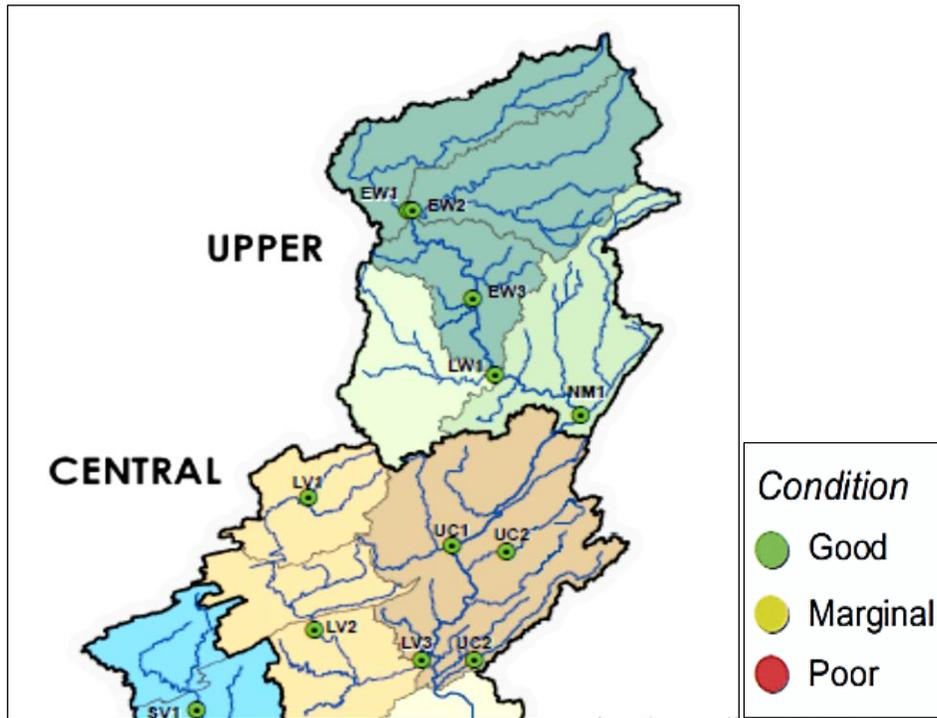


Figure W-7: Dissolved oxygen condition at select sites in the Upper Delaware region. Source: DRBC 2008.

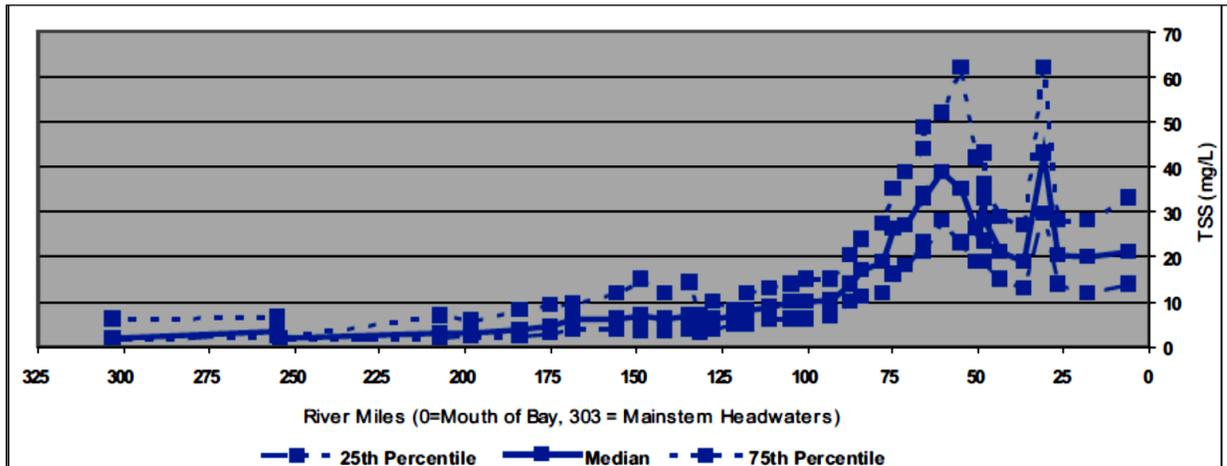


Figure W-8: Suspended solids by river mile with comparatively low TSS in the headwaters. Source: DRBC 2008.

Atrazine

Surface Water

● Not Detected

● Detected

Groundwater

▲ Not Detected

▲ Detected

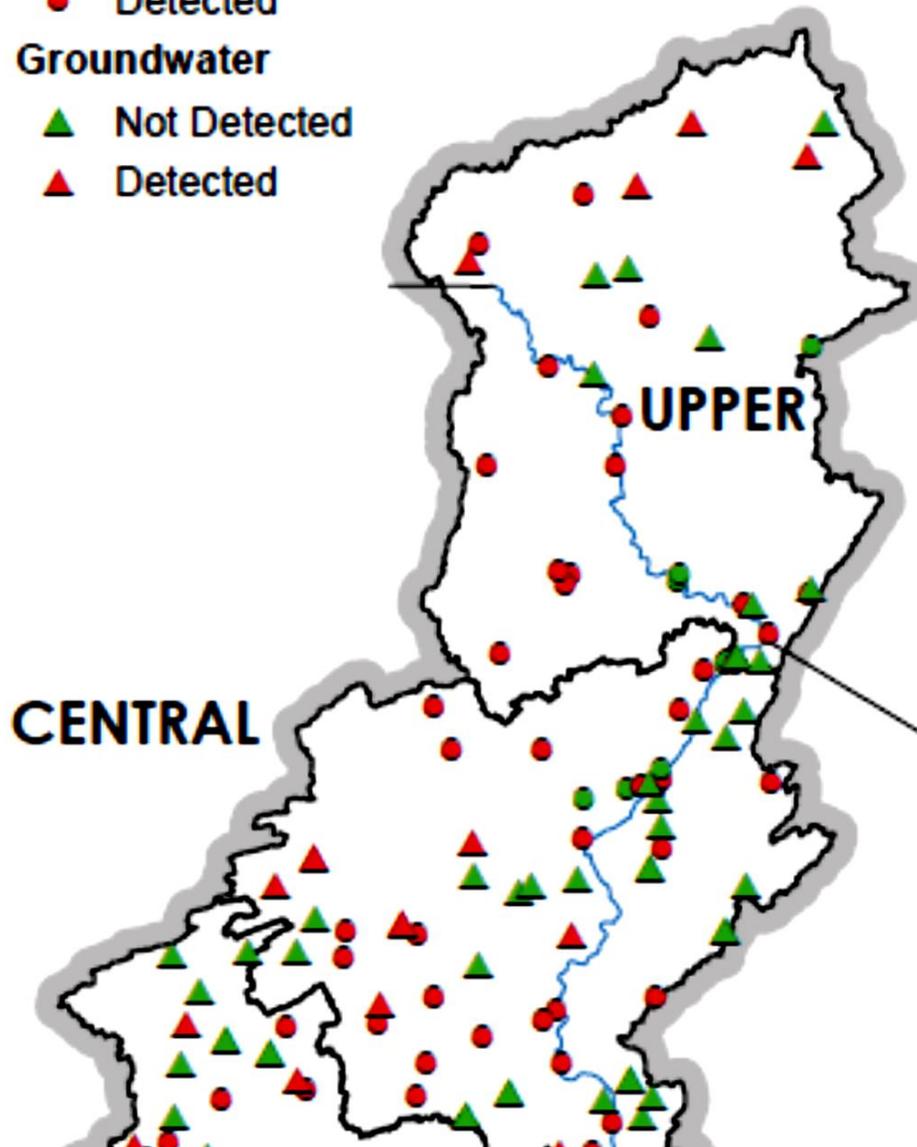


Figure W-9: Pesticide detection at selected sites in the Upper Delaware region.

Source: DRBC 2008.

Upper & Central Region Stations	DO (mg/l)	N (mg/l)	P (mg/l)	TSS (mg/l)	Legend Green Numbers = Good Blue Numbers = Fair Red Numbers = Poor ↑ = Improving ● = Constant ↓ = Degrading
	SHORT	TERM	SINCE	1990	
EW1 West Br. Delaware R. Hancock, NY	10.4 ●	0.4 ●	0.01 ↑	6 ●	
EW2 East Br. Delaware R. Hancock, NY	9.9 ●	0.2 ●	0.01 ●	5 ●	
EW3 Hancock Narrowsburg, NY	Insufficient data				
LW1 Lackawaxen R. at Lackawaxen, PA	12.6 ↑	0.2 ●	0.02 ↑	6 ●	
NM1 Delaware River at Port Jervis, NY	10.7 ↑	0.2 ●	0.02 ●	5 ●	
UC1 Brodhead Cr. at Del. Water Gap, PA	12 ↑	0.5 ●	0.05 ↑	2 ●	
UC2 Paulins Kill at Blairstown, NJ	10 ●	1.0	0.02 ●	7 ●	

Figure W-10: Trends in water quality at selected sites in the Upper Delaware region. *Source: DRBC 2008.*

About 90% of stream miles within the Upper Delaware River region are listed as unimpaired based on the states' 303(d) lists (statewide inventories of impaired and threatened waters as required by the Clean Water Act). New Jersey has the largest amount of impaired stream miles and New York the least. In the Pennsylvania portions of the region, the largest class of stream impairments is for segments with a fish consumption designated use. The second largest class of impairments is for segments with an aquatic life designated use. In the New Jersey portions of the region, the largest class of stream impairments is waters designated for aquatic life. The second largest class of impairments is for the designated use of potable water.

Are the Fish Safe to Eat?

Certain chemicals tend to concentrate in fish in amounts many times greater than the amounts in the water. Eating these fish exposes the consumers - fish, birds, animals, and humans - to chemicals that may, over time, pose health risks.

Advisories, primarily to limit the number of fish eaten in some time period, exist on many streams, rivers, and lakes in the Upper Delaware region. Mercury (from coal-burning power plants) and PCBs (once widely used as coolants and lubricants in transformers, capacitors, and other electrical equipment) are the most frequent reasons for the advisories. For more information and links to state-issued fish consumption advisories, visit <http://www.nj.gov/drbc/quality/fish/>.



	Total (mi)	Impaired (mi)	Unimpaired (mi)	Impaired (% streams)	Unimpaired (%streams)
Upper Region (NY and PA)					
EW - East/West Branch					
EW1 West Branch (Cannonsville)	651	58	593	8.9%	91%
EW2 East Branch (Pepacton)	583	25	559	4.3%	96%
EW3 Mainstem (above Narrowsburg)	552	52	500	9.5%	91%
LW - Lackawaxen	685	5	680	0.8%	99%
NM - Neversink - Mongaup	841	38	802	4.6%	95%
Central Region (PA and NJ)					
UC - Upper Central Watersheds					
UC1 Pennsylvania Tributaries	812	15	797	1.9%	98%
UC2 New Jersey Tributaries	814	226	618	26.8%	73%

Figure W-11: Upper Delaware region 303(d) listed Impaired Streams and Watersheds (in red-map (above) and by stream miles – table (next page)). Source: Kaufmann, et al. 2008.

In its 2012 *Delaware River and Bay Water Quality Assessment*, DRBC compared a number of key water quality parameters with applicable DRBC water quality criteria and evaluated the extent to which waters are attaining designated uses for aquatic life, drinking water supply, recreation, and fish. The Upper Delaware region includes four DRBC Water Quality Management Zones/Assessment Units. Each zone is managed for specific water uses, stream quality objectives and effluent quality requirements.

Figure W-13 provides a summary of the assessments within Upper Delaware units. Significant reaches of the rivers and streams in the basin appear to be impacted by pollutants and non-supportive of their designated uses. According to the report, however, meaningful assessment is hindered by the requirement to assign a “not supporting designated use” criterion even where data shows less than 10 percent exceedance of standards (*Delaware River and Bay Water Quality Assessment*, DRBC 2012). While primary contact recreation is supported in all zones of the Delaware River, advisories to limit fish consumption generally stem from unsafe levels of mercury or polychlorinated biphenyls (PCB) which are known to bioaccumulate in predatory fish. Mercury and PCB concentrations are variable in the basin; however, there has been improvement in PCB concentrations compared to historic levels at Port Jervis, NY and Milford, PA (PA Fish and Boat Commission 2011).

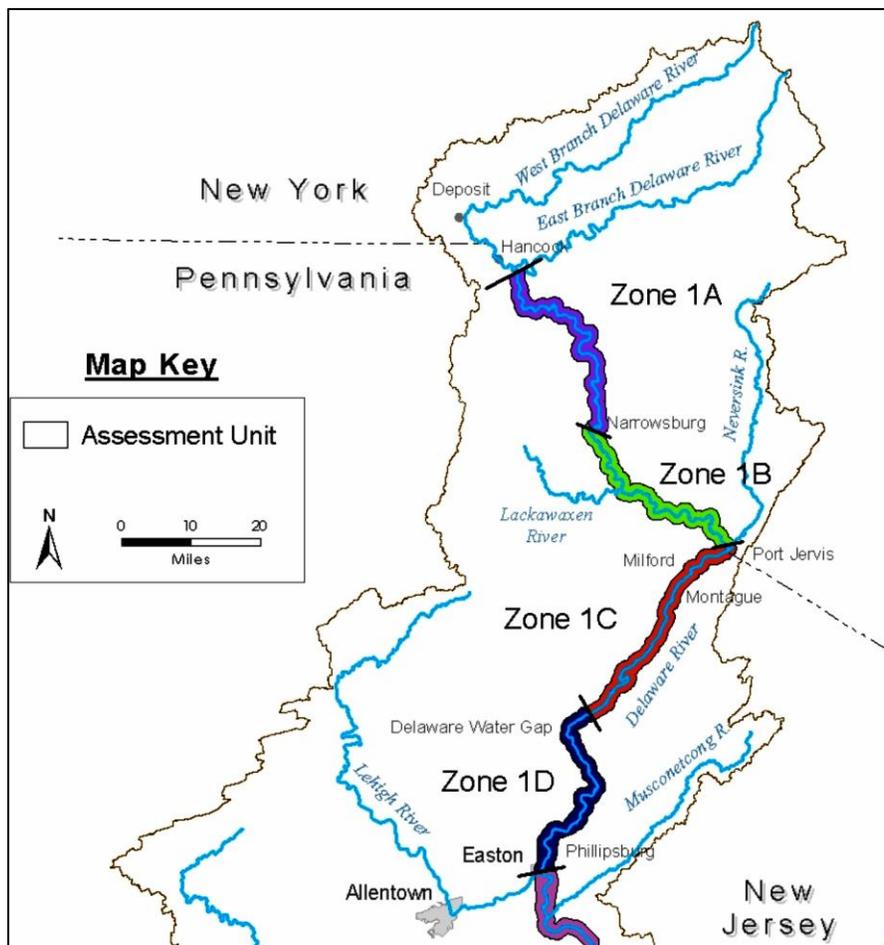


Figure W-12: Delaware River Water Quality Management Zones/Assessment Units. Source: *Delaware River and Bay Water Quality Assessment*, DRBC 2012.

Reservoirs and Other Impoundments

The Upper Delaware region is richly endowed with lakes, ponds and reservoirs which serve as drinking water supplies, provide flood control, and support significant sectors of the economy including real estate, recreation, tourism, agriculture, hunting and fishing, power generation and manufacturing. In many planned residential communities, lakes serve as the community focal point, boosting property values and providing a variety of scenic and recreational amenities to residents. In the New York State portion of the Upper Delaware region, there are over 200 freshwater lakes, ponds, and reservoirs (188 “significant” encompassing 24,932 acres), including the Pepacton Reservoir (5,185 acres), Cannonsville Reservoir (4,605 acres), and Neversink Reservoir (1,469 acres) (*Delaware River Watershed*, NY DEC 2013). There are a nearly 200 lakes in the New Jersey part of the region, the majority of which are located in Sussex County. Many are the natural product of glaciation. The larger lakes are heavily used for recreation and the lands surrounding many of them have been developed with seasonal and year round dwellings. Significant water quality risks exist in some areas from septic systems and runoff from lawns and impervious surfaces. NJDEP monitoring data for these lakes show that most are classified as eutrophic (Kelly and McGinnis 2001). Among the largest lakes are: Lake Hopatcong (largest lake in the state at 2658 acres), Culvers Lake (692 acres), Merrill Creek Reservoir (650 acres) and Swartswood Lake (505 acres). On the Pennsylvania side of the river, Pike County is home to over 100 lakes, including the 5,700-acre Lake Wallenpaupack (shared between Pike and Wayne counties) and 1137-acre Shohola Lake, an important waterfowl management area. Wayne County and Monroe County in PA are listed with 173 and 117 lakes, respectively (Fishing Works 2013). As in the rest of the region, many of these lakes are important regional or community recreational resources which also serve as a hub for both vacation and full-time residential communities.

Zone (AU)	Aquatic Life		Drinking Water		Recreation		Fish Consumption	
	2012	2010	2012	2010	2012	2010	2012	2010
1A	NS ^A	NS	NS ^A	S	S	S	NS	NS
1B	NS ^A	NS ^A	NS ^A	S	S	S	NS	NS
1C	NS ^A	ID	S	S	S	S	NS	NS
1D	NS ^A	NS ^A	NS ^A	S	S	S	NS	NS

Notes:

- A – Rate of exceedance is less than 10%
- ID – Insufficient Data
- NS – The assessment does not support the designated use.
- S – The assessment supports the designated use

Figure W-13: Summary of the Upper Delaware River 2012 Assessment.
Source: Delaware River and Bay Water Quality Assessment, DRBC 2012.

A number of large dams were constructed on major tributaries in the Upper Delaware region in the early to mid-1900s to provide water and electricity for nearby population centers, and river flow today is

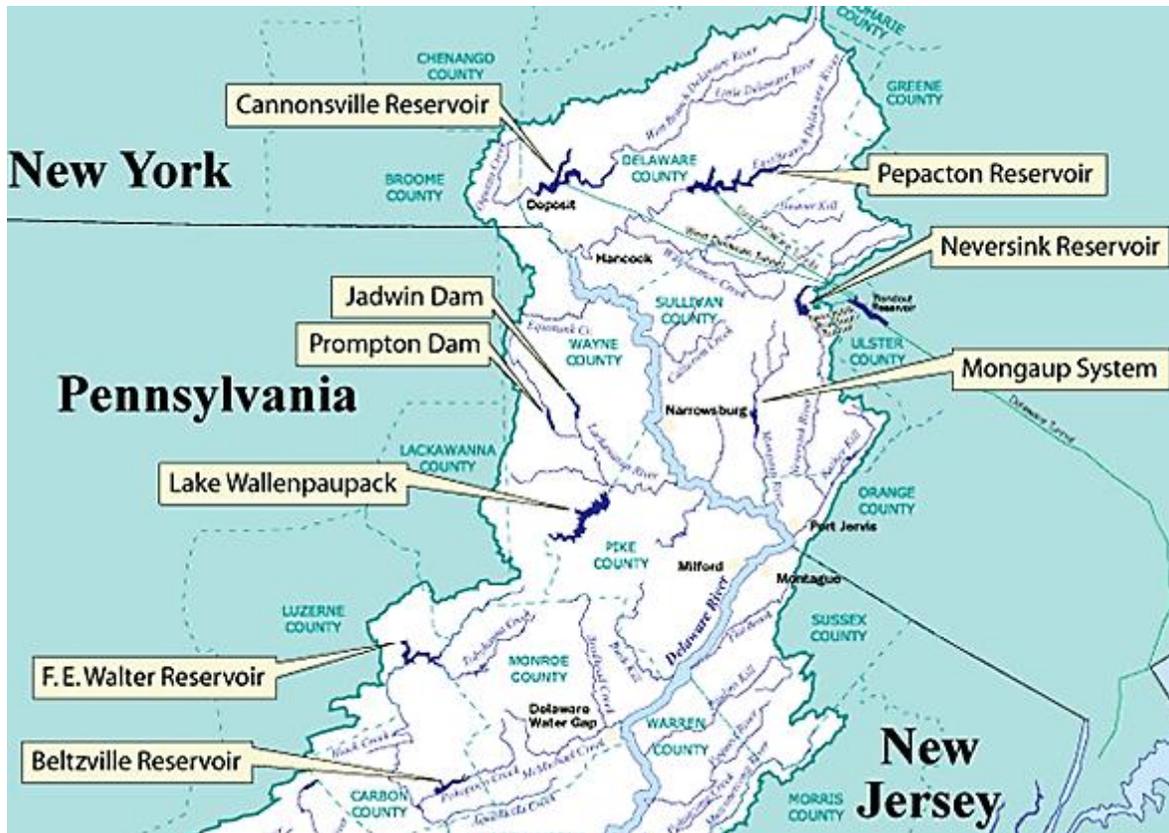


Figure W-14: Major reservoirs in the Upper Delaware region.

Source: DRBC 2013 (<http://www.state.nj.us/drbc/hydrological/reservoirs/>).

altered significantly by the associated reservoirs. These include three New York City water supply reservoirs on the West Branch Delaware (Cannonsville), East Branch Delaware (Pepacton) and Neversink rivers. Management of water diversions and releases for the NYC reservoirs, which have a significant impact on natural flow regimes of the basin, are governed by U. S. Supreme Court rulings in 1931 and 1954. Sixty-eight percent of the permanent storage capacity in all tributary reservoirs in the entire Delaware River Basin is held in these three New York City water supply reservoirs. Other reservoirs in the Upper Basin include Lake Wallenpaupack, owned by Pennsylvania Power and Light and managed primarily for hydroelectric power, the Jadwin and Prompton flood control reservoirs and the Mongaup System of five reservoirs and three hydroelectric stations.

The Delaware River Basin Compact creating the DRBC gives the commission broad powers to plan, regulate, allocate, and manage water resources in the basin. However, these powers are limited in that they cannot adversely affect the provisions of the 1954 Supreme Court decree without the unanimous consent of the decree parties (four states and NYC). Through the efforts of the DRBC, working with the decree parties and other stakeholders, considerable progress has been made in the past decade in managing all of the reservoirs in the Upper Basin to balance human and ecosystem needs and adjust to changes in river conditions (*Hydrological Information: Reservoirs*, DRBC 2013).

Water Supply

While the Delaware River basin as a whole is primarily dependent on surface water as a source of potable water, the Upper Delaware region is particularly dependent on ground water (nearly 80%) and domestic wells specifically (43%).

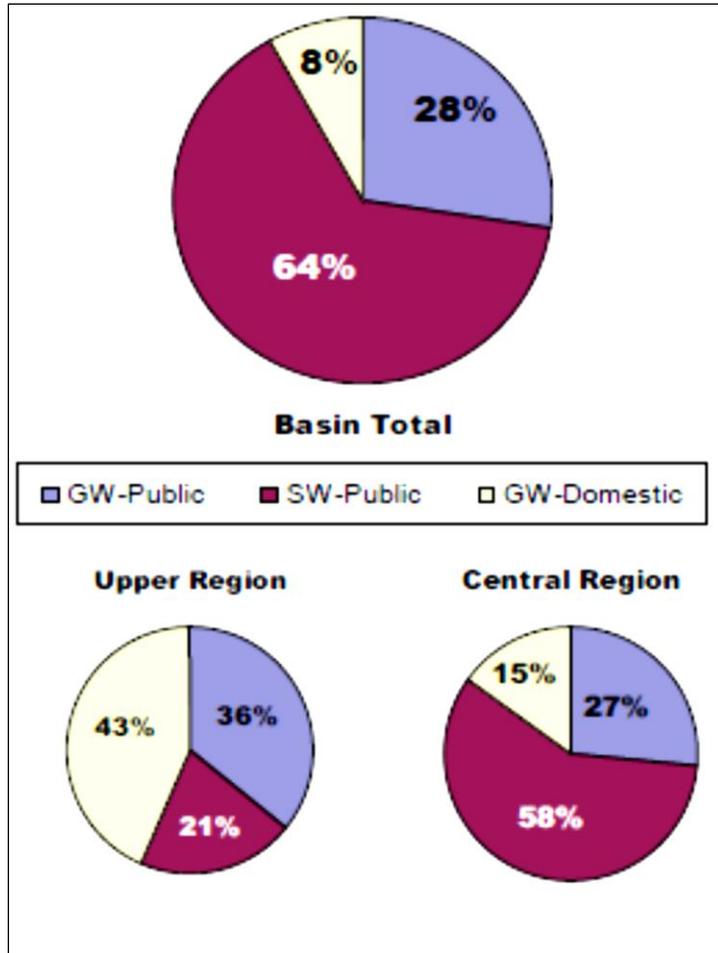


Figure W-15: Sources of potable water supply in the Upper Delaware region compared to the total basin.

Source: State of the Delaware River Basin Report, DRBC 2008.

Estimated per capita water use in various parts of the Delaware River watershed is illustrated below, and ranges from approximately 120 gallons/person/day in the northern reaches of the Upper Delaware region to approximately 90 gallons/person/day in the southern part of the region.

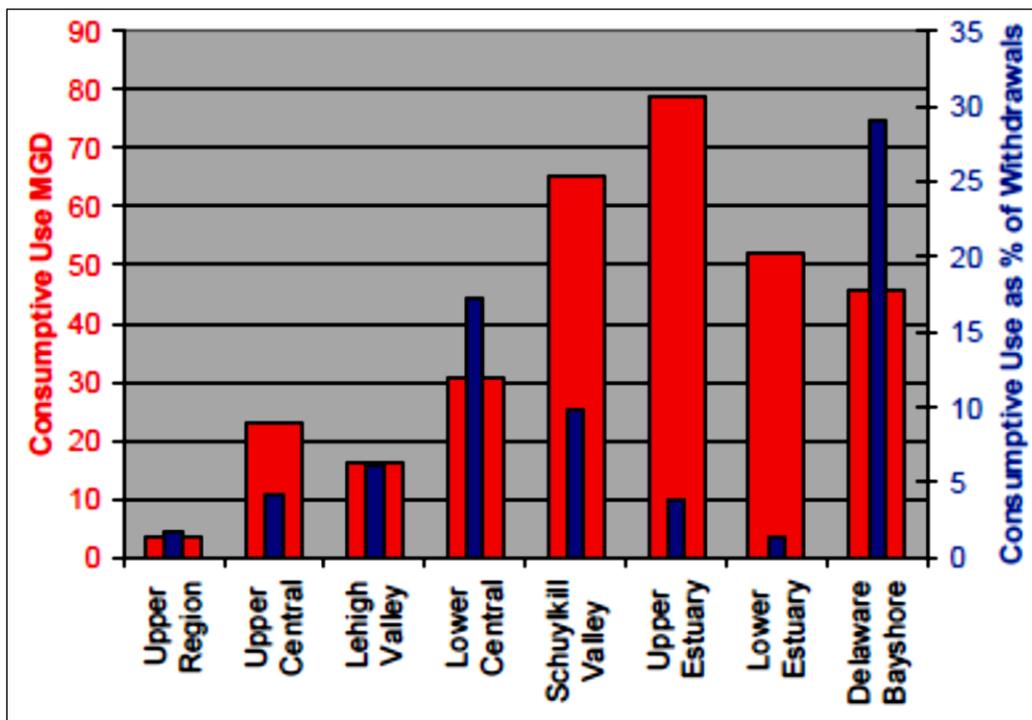
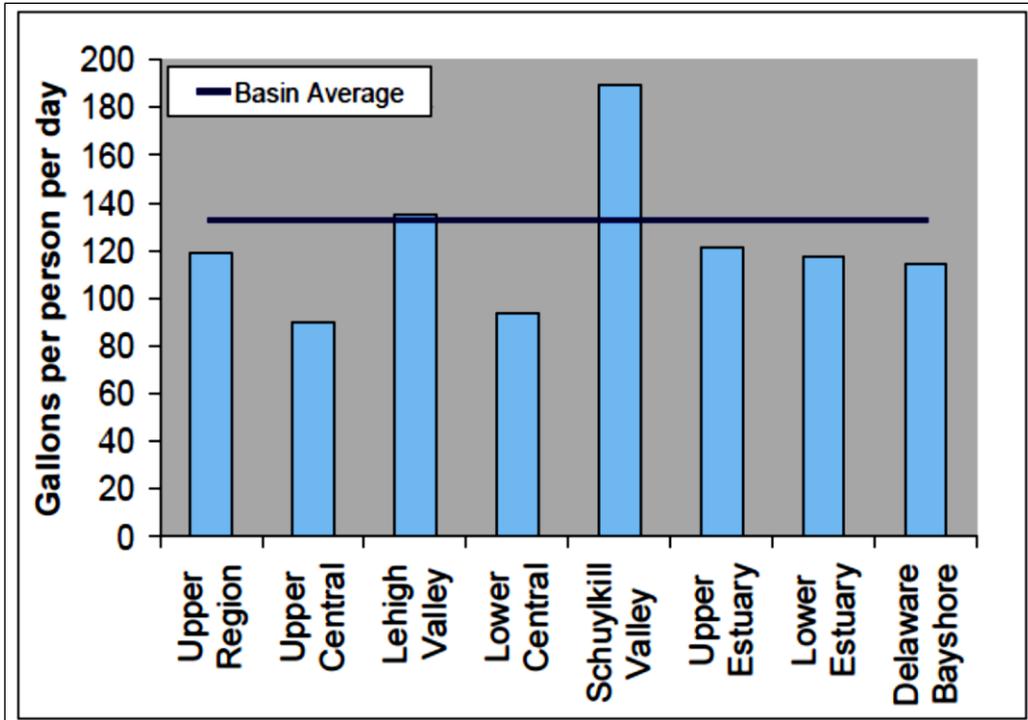


Figure W-16: Regional per capita and consumptive water use in the Delaware Basin.

Source: State of the Delaware River Basin Report, DRBC 2008.

A study conducted by the US Geological Survey (USGS) during 2003-2005 examined groundwater availability by watershed, and compared availability with current use (1996-2000) in the Delaware River Basin for the 2-, 5-, 10-, 25-, and 50-year annual base-flow recurrence interval values. The recurrence intervals are considered to be relative indicators of climatic difference; the 2-year-recurrence value represents wetter years, and the 50-year-recurrence value represents drier years. For the drier 50-year recurrence interval, ground-water use in the Upper Delaware watersheds ranged from 0 to 7 percent of available ground water, indicating that availability far exceeds use in the Upper Basin watersheds. This is in contrast to some areas in the lower basin where use is a much higher percentage of groundwater availability (Sloto and Buxton 2006).

Another U.S. Geological Survey study, a reconnaissance assessment focusing on groundwater quality in Pike County, PA, documented current conditions in the principal land use types and geologic units in the County. The analyses included major ions, nutrients, selected trace metals, volatile organic compounds (VOCs), selected organic wastewater compounds, gross alpha-particle and gross beta-particle activity, uranium, and radon-222. Overall, the study indicated that groundwater quality in Pike County is relatively good with no constituents exceeding any established primary water-quality standards. The low levels of human-made organic compounds and relatively elevated concentrations of chloride and related constituents (boron and nitrate) detected indicate that human activities have influenced groundwater quality in some parts of the county (Senior 2009).

By far the most significant water use in the Upper Delaware region is the export from the watershed of an average of 650 million gallons per day (mgpd) (out of a total 1637 mgpd) for New York City's drinking water supply.

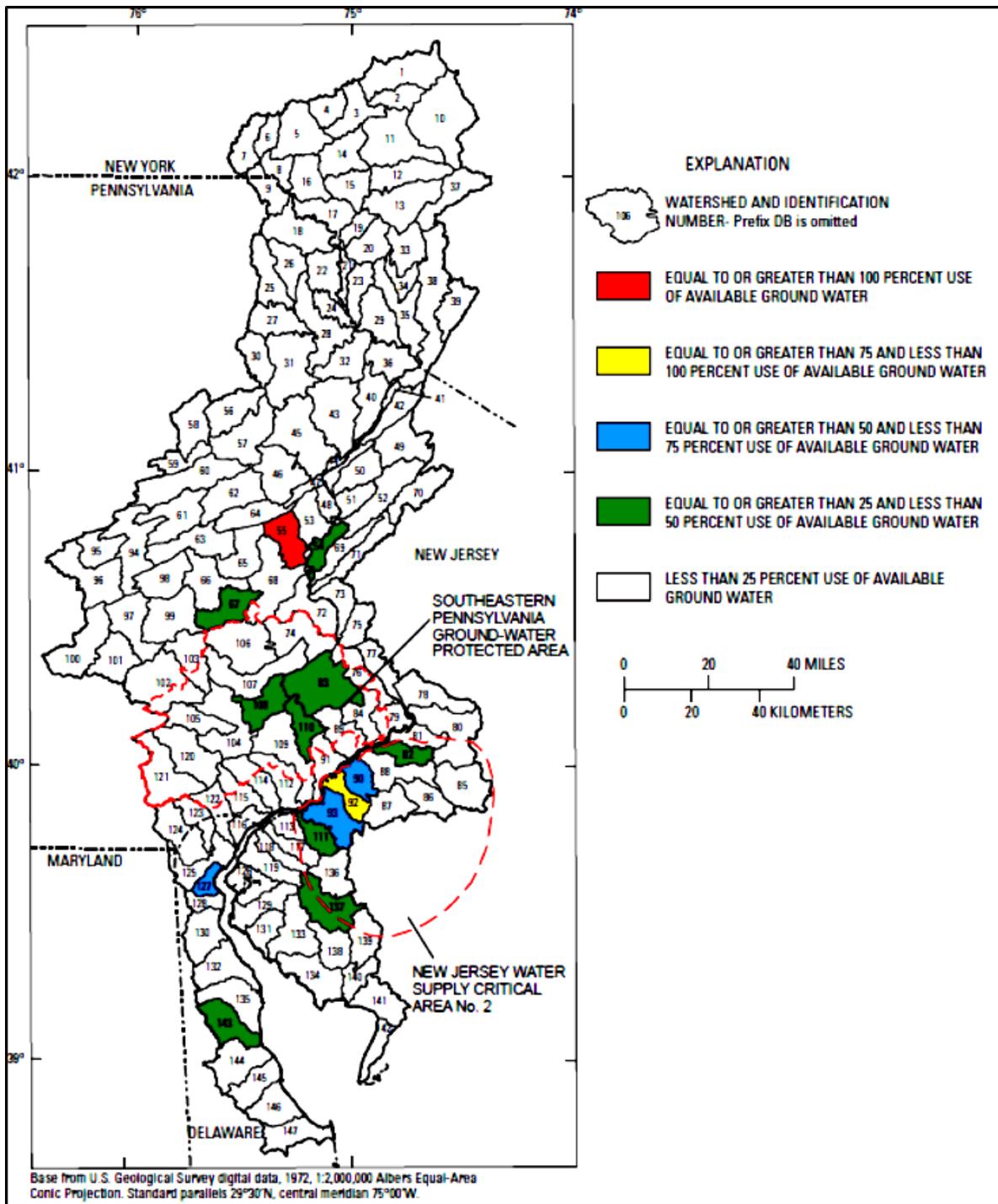


Figure W-17: Percentage of groundwater use in the Delaware River basin for the 25-year annual base flow occurrence. *Source: USGS (Sloto and Buxton 2007).*

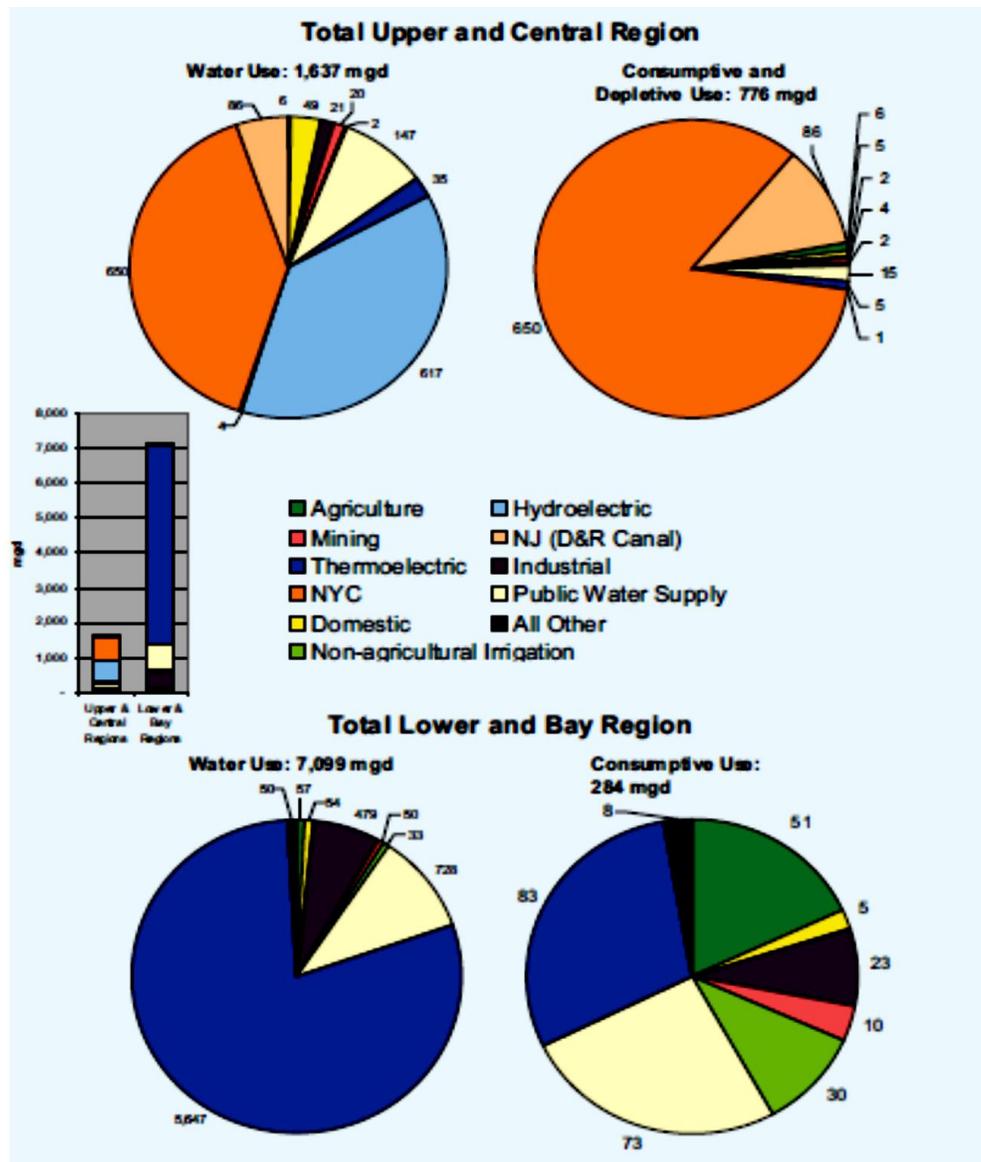


Figure W-18: Comparison of regional water withdrawals, exports and consumptive use. Source: *State of the Delaware River Basin Report DRBC 2008*.

Hydroelectric power generation is the second highest user of Upper Delaware water, averaging just over 500 mgpd, with public and domestic water supply at about 200 mgpd. Consumptive use in the Upper Delaware region averages about 776 mgpd; the overwhelming majority of that use is for New York and New Jersey drinking water supply. This can be contrasted with water use and consumptive use in the lower reaches of the basin, where water use and consumptive use average around 7100 mgpd and 284 mgpd respectively with thermolectric generation by far the most significant water user (DRBC 2008).

While the available data demonstrate ample groundwater availability compared to demand in the Upper Basin, the impacts of consumptive water uses on ecological stream flow present more complex challenges that stress aquatic species and habitats, as discussed in the *Current Water Resources Stressors* section below.

Current Water Resources Stressors

Population Growth and Associated Land Use Changes

Population growth has been significant in recent decades, particularly in the southern part of the region where some counties have consistently been among the fastest growing within their states. Many residents of the region regularly commute to work in metropolitan New York and New Jersey. Added to this growth pressure is the rate of seasonal/vacation home ownership, which, according to the 2010 Census, in some counties exceeds 30% of the existing housing stock. In contrast to the recent growth trends in the southern part of the watershed, the northern areas, especially Delaware County, have experienced slower growth.

Based on satellite derived maps, between 1984 and 1995, urban land cover (which correlates very closely to impervious cover) increased by 54% and between 1995 and 2005, urban land cover increased by 77% (Jantz and Morlock 2011).

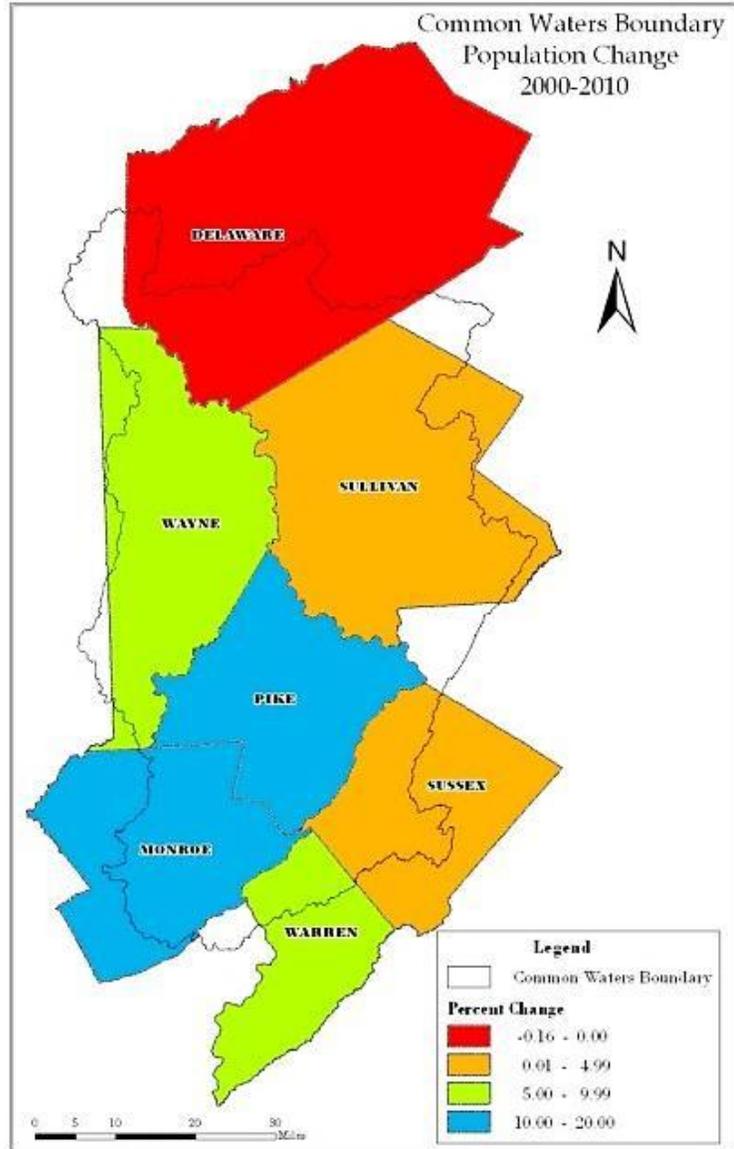


Figure W-19: 2000 – 2010 population change by county.
Source: NPS DWGNRA 2013.

There is a critical need to understand the relationship between land cover and water quality and quantity, and population growth and development within the Delaware River watershed.

– Delaware River Watershed Source Water Protection Plan,
Philadelphia Water Department / June 2007

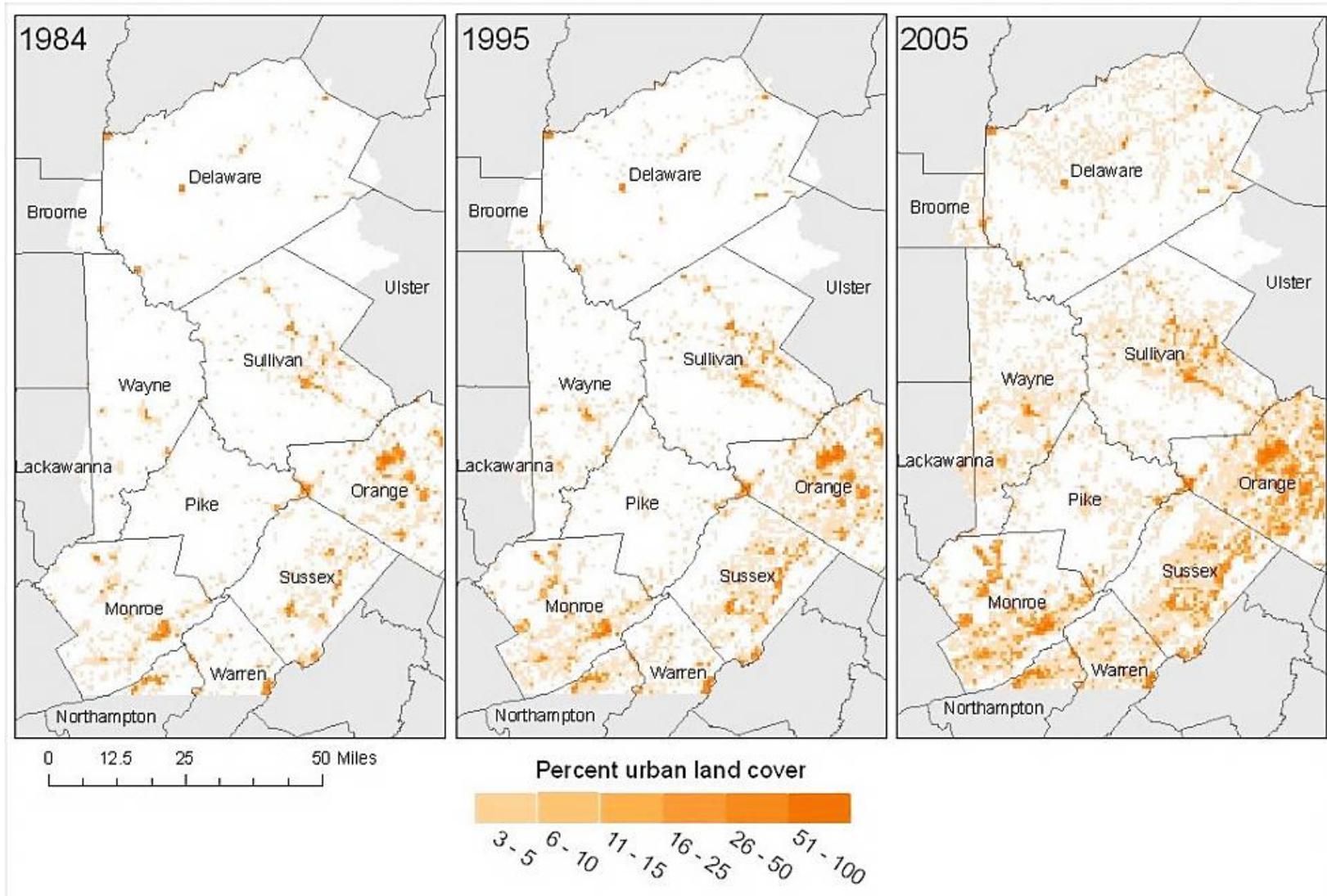


Figure W-20: Changes in urban land cover, which correlates very closely to impervious cover, from 1985-2006. *Source: Jantz & Morlock 2011.*

The US Forest Service’s *Forests, Water and People* analysis identified private forests in the Northeast that are most important for providing clean safe drinking water that citizens can afford. The same analysis also identified those forests which are most vulnerable to land development. In their ability to provide drinking water to the most people, the watersheds in the Upper Delaware region scored very high. These were also the watersheds that ranked high in terms of development pressure. The southern part of the region (identified as the Middle Delaware-Mongaup-Brodhead HUC 8 watershed) averaged in the top one percent of the 20 state study area’s watersheds for development pressure (see Figures W-21 and W-22).

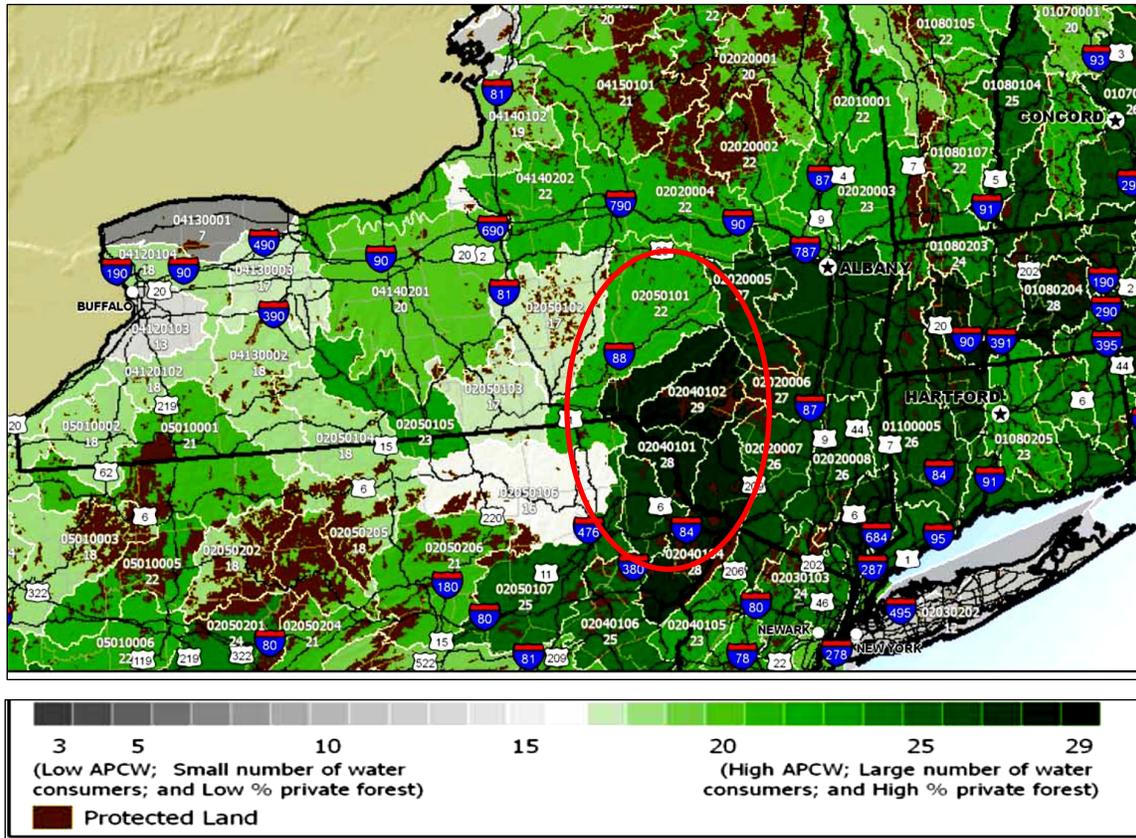


Figure W-21: Importance of watersheds and private forests for drinking water supply.

Source: Barnes, et al, 2009.

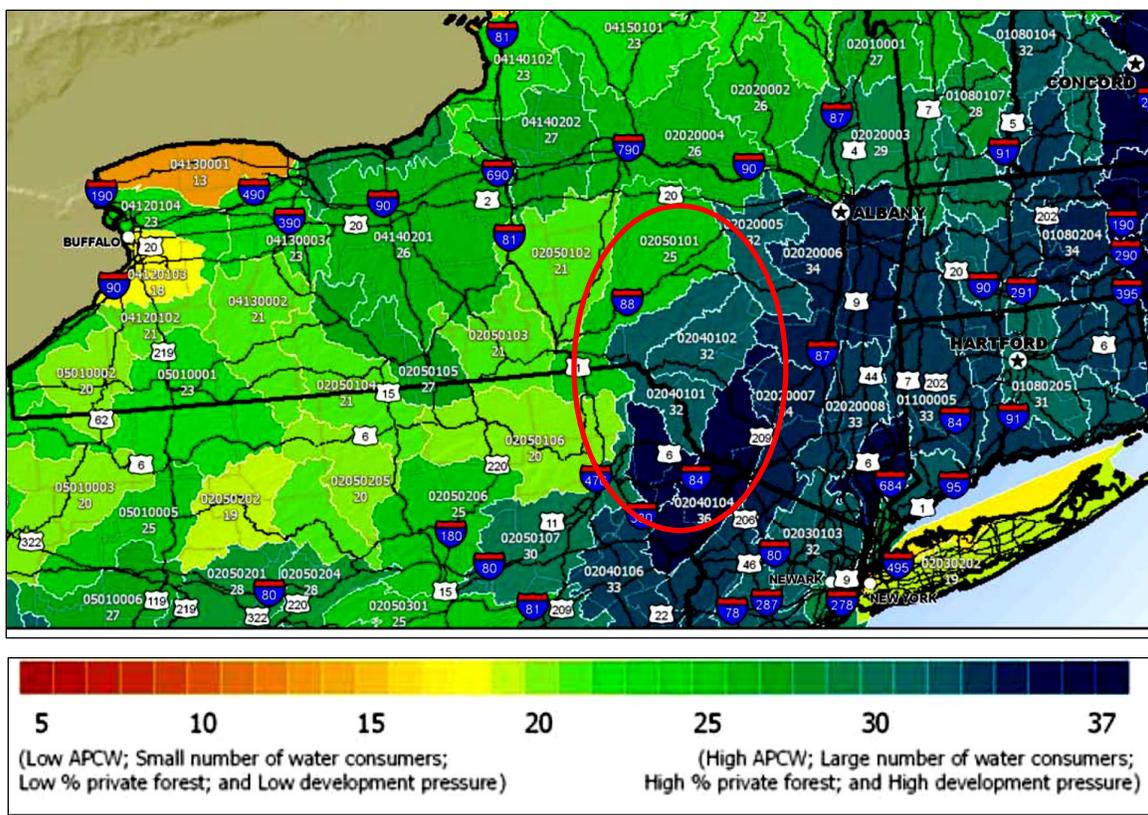


Figure W-22: Development pressure on private forests in drinking water supply watersheds.
Source: Barnes, et al. 2009.

Flow Management and Competing Demands

One of the most challenging stressors to Upper Delaware region water resources lies in the approximately 50 percent of the Delaware's headwaters diverted to New York City's municipal water supply system, which is a net loss to the watershed. The withdrawals and releases that accomplish this diversion can cause profound changes in the natural flow of the river and threaten the survival of freshwater animals like mussels, crayfish and amphibians - among the species most at risk in the United States - and the health of the entire river system, including a world class trout fishery. (The Nature Conservancy 2011)

Disputes over flow management have a long history in the Upper Delaware basin, going back as far as the early 1900s. Two Supreme Court Decrees, in 1931 and 1954, provided for allocation of waters between the Basin states and water supply exports by New York City, as well as a requirement that releases from the City's reservoirs support a minimum daily mean flow of 1750 cubic feet per second (cfs) at Montague, New Jersey. Later revisions made by agreement of the Decree parties, known as the "Good Faith Recommendations", allowed for supplemental releases during drought conditions to support fisheries in the Upper Delaware and better manage flows during more severe droughts than were envisioned under the Decree (Flow and Drought Management, DRBC 2013).

Flow issues identified in the Upper Basin in *Strategy for Resolution of Interstate Flow Management Issues in the Delaware River Basin* (2004), a report prepared for the Delaware River Basin Commission include:

- Effects on trout habitat in the East and West Branch of the Delaware River, the Neversink River, the upper reaches of the main stem Delaware River, the Lackawaxen River and the Mongaup River;
- Shad and smallmouth bass habitat for the East Branch Delaware and main stem Delaware, respectively;
- Recreational boating for the main stem Delaware River, the Lackawaxen River and the Mongaup River;
- Water quality of the Special Protection Waters of the Upper Delaware - DRBC regulations require that the existing high water quality be maintained;
- Turbidity, in the West Branch and Upper Delaware main stem.

Water quality during low flow conditions was defined as a major concern in the heavily populated lower basin, where inflow can affect salinity intrusion, waste assimilation, and the quality of surface water supplies. Taste and odor problems at public supply intakes and their relationship to reservoir releases during low flow periods were also noted (HydroLogics, Inc, et al. 2004).

In a further refinement of Delaware River flow management, the decree parties agreed in 2007 to a “Flexible Flow Management Program” (FFMP) which has been fine-tuned several times since. In 2010, fisheries biologists from the Pennsylvania Fish and Boat Commission and New York State Department of Environmental Conservation Division of Fish, Wildlife and Marine Resources stressed that maintenance of suitable flows from fall through spring on Upper Delaware streams is important for fish spawning and overwintering habitat, egg incubation and fry hatching, and for providing access to spawning tributaries. The agencies suggested that the FFMP release schedule was not providing acceptable year-round flows for habitat protection, and that temperature in certain segments of the mainstem was frequently exceeding desirable levels (NY DEC et al. 2010). Additional recommendations for improving the FFMP have been provided by Trout Unlimited, among others (Trout Unlimited 2008). The current FFMP, in effect through May 31, 2014, is, according to DRBC, intended to meet water supply demands, protect fisheries habitat downstream of the NYC reservoirs, enhance flood mitigation, and repel the upstream movement of salt water in the Delaware Estuary.

The Delaware Watershed Conservation Coalition (which includes leading local, regional and national conservation organizations) has called for inclusion of a permanent thermal stress relief program for the Upper Delaware River in the rules for reservoir releases. Brook trout generally prefer water temperatures between 50 and 65 degrees F. Working off the consensus that daily maximum water temperatures above 75 degrees Fahrenheit create severe stress for trout, the Coalition is looking to establish limited cold water releases during heat waves.

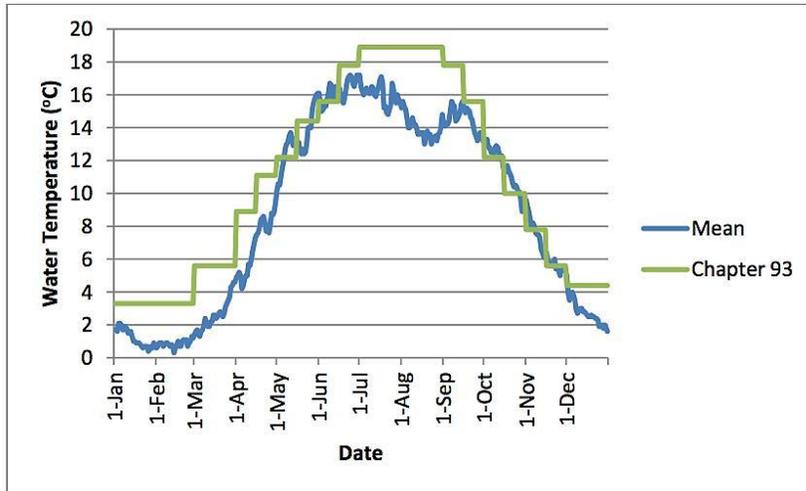
Thermal stress of the Upper Delaware River ecosystem has been an ongoing problem, especially during the month of July, and relief has been less than pro-active. The three graphs below show mean daily water temperature at three points along the tributaries and mainstem of the Upper Delaware River compared to suitable water temperature for cold-water fisheries. All sites show that during the summer months, water

temperature exceeds the suitable range for cold-water fisheries. Even though NYC reservoirs are releasing cold water in the streams during summer months, mean daily water temperatures are not suitable for cold-water fisheries, especially brook trout.

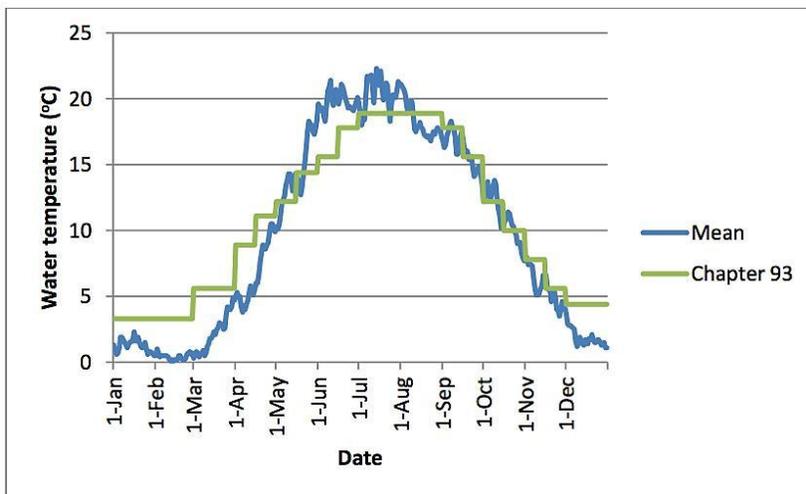
Over the last decade the upper main stem of the Delaware has experienced an average of 12 days of severe thermal stress to trout per summer, with the worst summer (1995) having 23. The summer of 2010 had 18 stress days, 2011 had 3 stress days and 2012 had 14 stress days (Kolesar, et al. 2013).

The Nature Conservancy, in cooperation with the DRBC, is currently working to describe the flow needs of aquatic ecosystems within subwatersheds of the Delaware River Basin. The Delaware River Basin Ecosystem Flow Study, expected to be completed in 2013, will likely offer additional flow recommendations aimed at protecting the species, natural communities, and key ecological processes of the Upper Delaware and help inform future decisions about water withdrawals and reservoir releases.

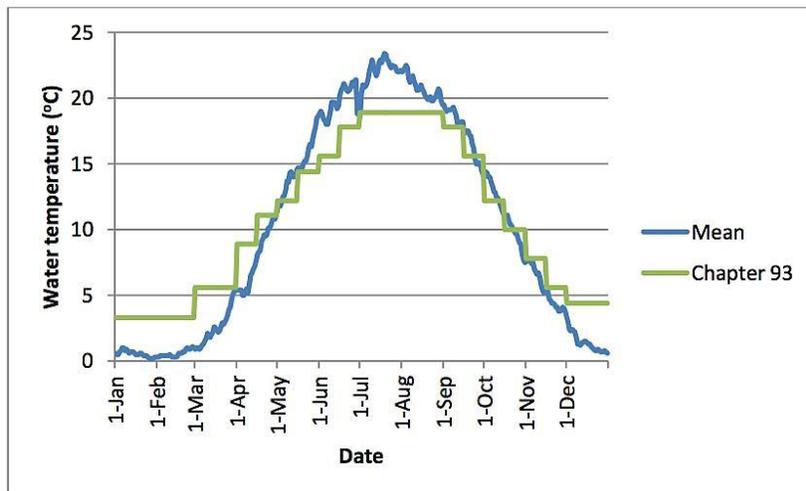
Demand for instream uses is projected to continue to increase and, given the current water stressors, the financial and environmental obstacles for adding storage facilities and the projected impacts of climate change on water temperatures, stream flows, drought and evapotranspiration, the competition for available water and the complexities of flow management in the Upper Delaware region are likely to become an even greater challenge in the future.



West Branch Delaware River at Hancock, NY for the period of record from October 1996 to September 2008.



Delaware River at Lordville, NY for the period of record from October 1992 to September 2008.



Delaware River at Callicoon, NY for the period of record from October 1974 to September 2008.

Figure W-23: Mean daily water temperature (°C) values for three locations in the Upper Delaware watershed compared to the PA Chapter 93 temperature criterion for Cold Water Fishes.

Source: Pennsylvania Fish and Boat Commission 2011.



Figure W-24: Cannonsville Reservoir at normal (top) and at 6.5% capacity (below) (Dec. 2001). *Source: Drought, NY DEC 2013.*

Natural Gas Drilling

Although not currently a factor in the Upper Delaware watershed, the risks to water resources of natural gas drilling are being considered by the Delaware River Basin Commission, which has identified three major areas of concern:

- Gas drilling projects in the Marcellus Shale or other formations may have a substantial effect on the water resources of the basin by reducing the flow in streams and/or aquifers used to supply the significant amounts of fresh water needed in the natural gas drilling process.
- On-site drilling operations may potentially add, discharge or cause the release of pollutants into the ground water or surface water.
- The recovered "frac water" must be treated and disposed of properly.

DRBC has proposed draft regulations to address those concerns, and until those regulations are finalized and adopted as rulemaking by DRBC, there is a moratorium on drilling activity in the watershed. In the



Figure W-25: Marcellus shale deposits in areas of DRBC Special Protection Waters. Source: Natural Gas Drilling, DRBC 2013.

meantime, DRBC staff has been working to better characterize baseline conditions in this portion of the watershed before the onset of natural gas development activities.

In response to needs identified by the DRBC and other stakeholder groups, including Federal, State and local governments, NGOs, academics, and others, the Delaware River basin was designated a USGS WaterSMART Water Census Focus Area, which will facilitate a comprehensive technical assessment of water availability in the basin using the best available tools. Expected outcomes include:

- Improved water-use and water-supply information
- A surface-water hydrologic model of the Delaware Basin capable of evaluating impacts of land-use change, climate change, and changes in water demand
- Development of ecological-flow science in tributaries and on the main stem of the Delaware (National Water Census, USGS 2013)

Climate-Related Water Risks

Climate Risks Exacerbate Existing Water Stressors

In a January 2010 presentation at a Union of Concerned Scientists-sponsored event, DRBC Executive Director Carol Collier highlighted the vulnerability of the Delaware River Basin's headwaters and the critical role that headwater forests play in maintaining water quantity and quality. She described a number of existing water resources stressors that would be exacerbated by climate change:

- Increasing and often competing demands for water resources
- Increased impervious cover
- Loss of forests/forest fragmentation
- Water quality impacts with land use changes

In the same presentation Executive Director Collier also highlighted potential climate change impacts on water supply and infrastructure and outlined proposed actions needed to protect the water resources of the Delaware River Basin (Collier 2010). Climate-related impacts of concern included:

- Loss of snow pack
- Prolonged droughts
- Increased evapotranspiration
- Fewer but more intense storms
- Infrastructure exposure - water and sewer lines, wastewater treatment facilities

Summary of Climate-Related Water Risks

- Water quality and habitat degradation
- Streambank erosion
- Flooding and stormwater runoff
- Stream flow fluctuations: earlier peak stream flows/higher winter and lower summer and fall flows
- Thermal stress to fisheries/loss of cold water fisheries
- Enhanced algae growth and lake thermocline changes
- Additional population growth from climate refugees resulting in more development pressure/impervious surfaces increase
- Increasing competition for less available water
- Increased evapotranspiration from reservoirs reducing water storage
- Seasonal impacts to groundwater-dependent water supplies
- Rising sea levels downriver and demands on Upper Basin water to mitigate salt water intrusion

Compiled by UPDE Core Planning Group

Risks Associated with Extreme Weather

Increases in extreme weather events – heavy downpours accompanied by strong winds, flooding, nor’easters, hurricanes, drought and heat waves – are perhaps the most tangible evidence of a changing climate for people of the Upper Delaware region. These events are already causing considerable disruptions and are predicted to worsen in the coming decades.

In the Northeastern United States, rainfall is expected to become more intense and periods of heavy rainfall are expected to become more frequent (Frumhoff, et al. 2007) even under lower emissions scenarios. Notable trends in the Northeast include:

- Extreme precipitation events are happening more frequently
- The biggest storms are getting bigger
- Extreme storms are responsible for a larger percentage of annual precipitation
- Projected future temperature increases for the region will drive even more frequent and more intense precipitation events

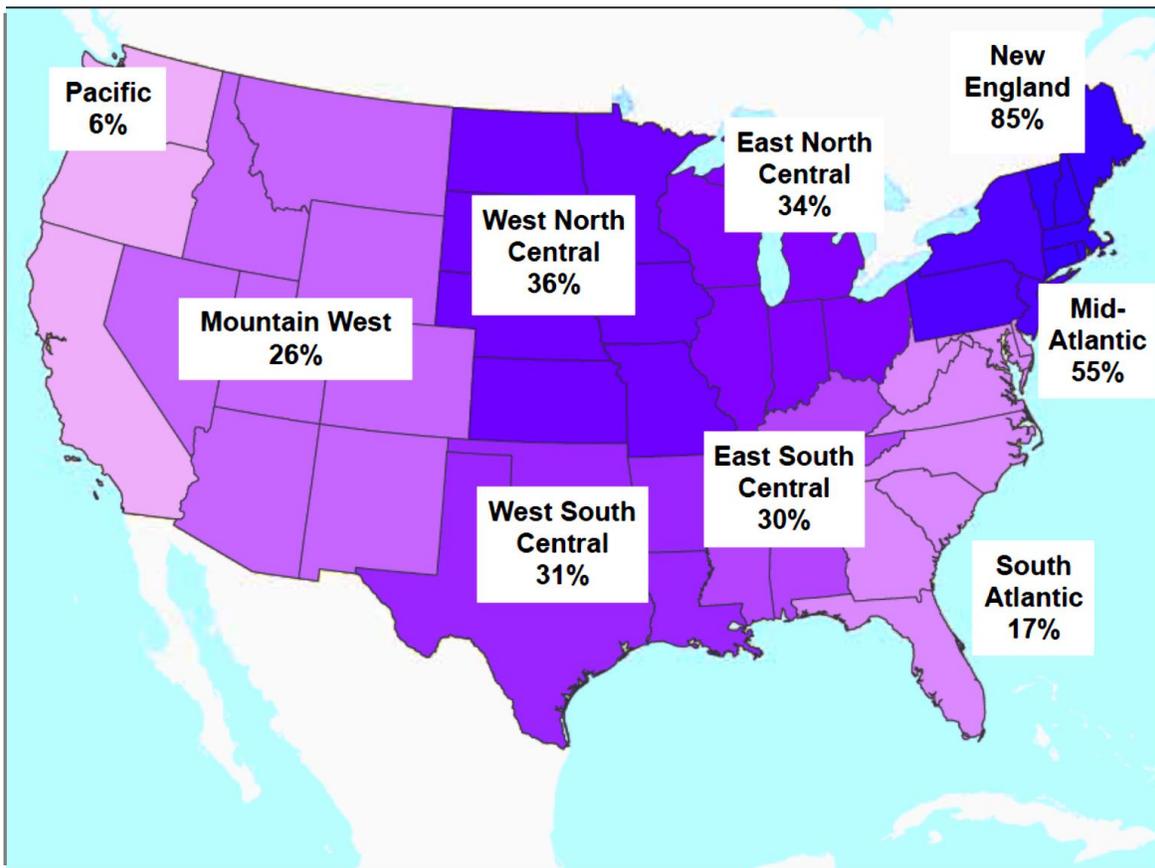


Figure W-26: Observed upward trends in extreme storm frequency 1948-2011.

Source: Madsen & Willcox 2012.

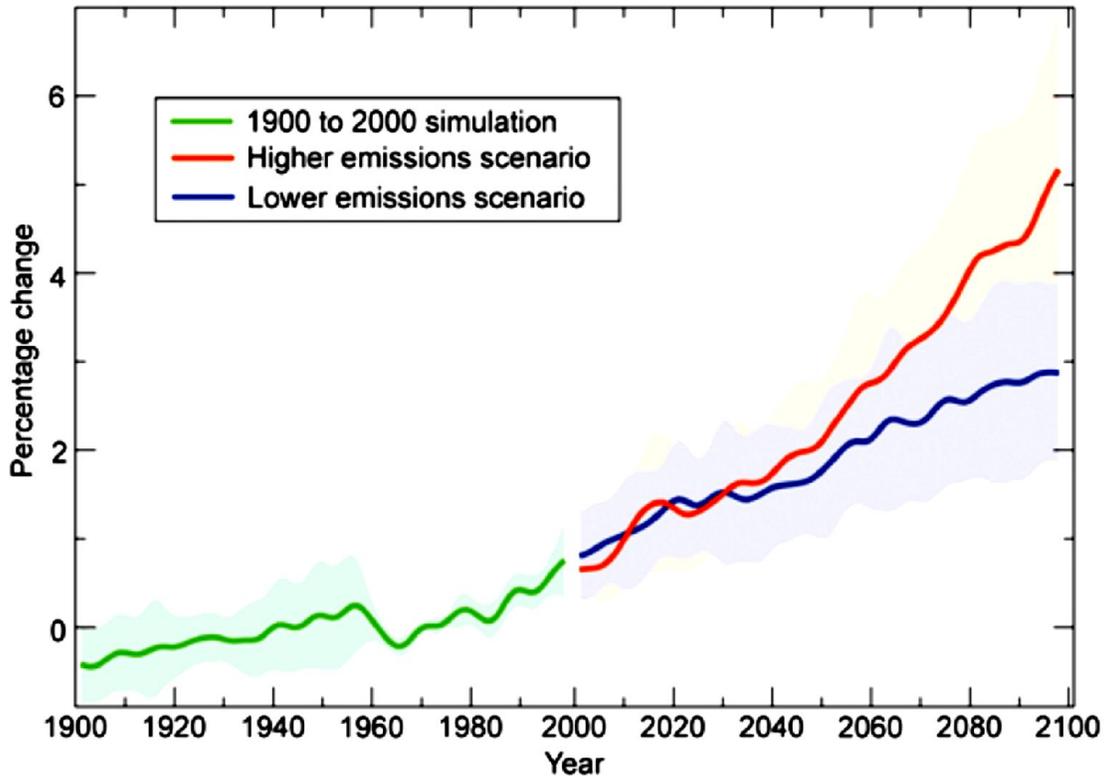


Figure W-27: Projected future increases in the heaviest 5% of precipitation events; more emissions produce greater changes. *Source: Madsen & Willcox, 2012.*

Water Quality and Habitat Degradation - With greater frequency and intensity of heavy precipitation come substantial amounts of stormwater runoff that carry sediment, nutrients and other pollutants from land to streams, lakes and rivers. Streambank erosion and stream channel changes put streamside properties at risk where riparian zones have been compromised. The flooding that sometimes follows heavy rainfall events may overwhelm sewage infrastructure and cause discharge of raw or undertreated sewage to waterways. In lakes, nuisance algae growth and lake thermocline changes reduce dissolved oxygen levels and impact aquatic species and recreational uses.



Figure W-28: A sediment-laden Lackawaxen River in Pike County, PA after heavy rains. *Source: Pike County Conservation District, n.d..*

In some Upper Delaware region communities, a common emergency response following extreme precipitation and flooding events is to “clean out” or dredge and channelize stream beds with a perceived goal of reducing future flood impacts by increasing channel capacity and water conveyance. These

actions, unfortunately, often have unintended consequences. Straightening and deepening channels, clearing of woody debris and boulders, and armoring banks drastically changes hydrology – floodwaters flow faster and with more energy and low flows are lower than in more natural channels where structural features and floodplains serve to dissipate flood energy. These often costly projects, both in term of dollars and long term impacts, disconnect streams from their natural floodplains, destroy critical habitat for fish and other wildlife, destabilize channels and banks, aggravate erosion and sedimentation, and make downstream properties more vulnerable to flooding (Danforth 2012) .



Figure W-29: Flooding in Rockland NY, 2006.

Source: USACE 2013 .

Flooding, Infrastructure and Property Damage - Serious flooding (particularly the record flood of 1955) was one factor leading to the creation of DRBC in 1961. However, over the next 40 years the Delaware River and those inhabiting the watershed experienced more droughts than floods. This hydrologic pattern appears to have changed. In September 2004, April 2005, and June 2006, three major floods occurred along the main stem Delaware River, repeatedly damaging property and disrupting tens of thousands of lives. These were the worst floods to hit the main stem since 1955. The last known occurrence of three main stem floods of such magnitude within so short a time frame was during the period from 1902 to 1904. (Flood Loss Reduction, DRBC 2012).

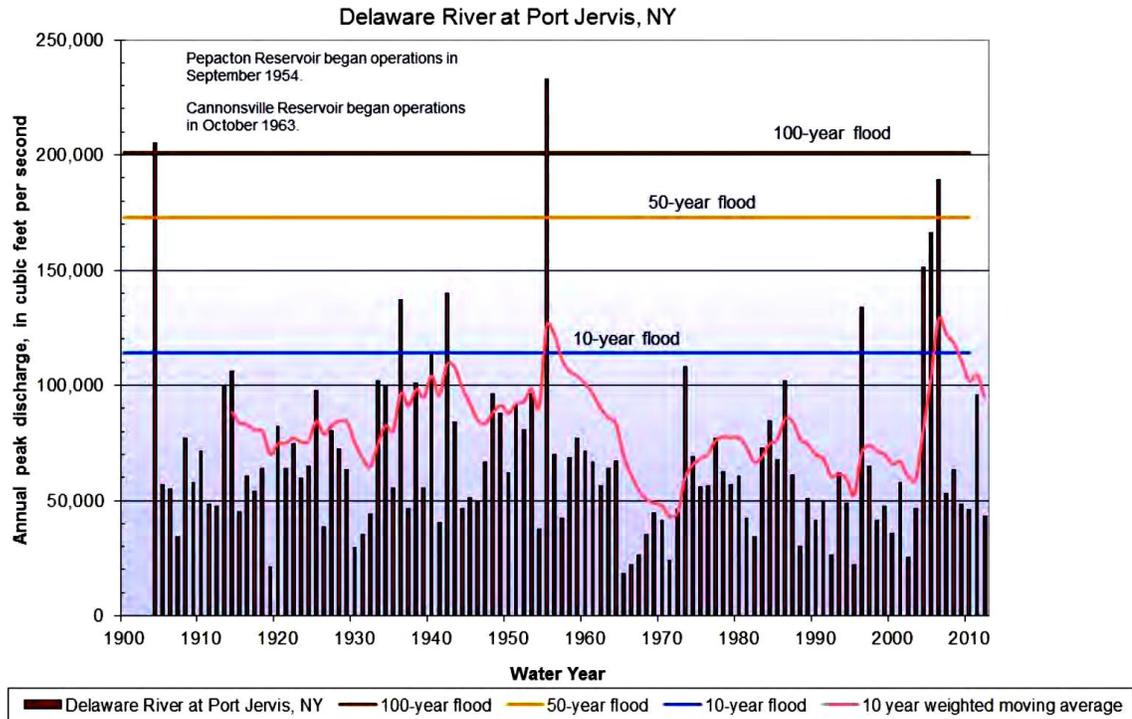


Figure W-30: Flood peaks & flood frequency on the Delaware River at Port Jervis NY 1900-2011.
Source: Thomas Suro, USGS 2009.

On the heels of these three floods, the four basin states governors asked DRBC to convene the Delaware River Basin Interstate Flood Mitigation Task Force, which made a number of recommendations for improving flood preparedness and decreasing flood losses (see Appendix 2). These flood events were very costly for Upper Delaware communities, some of which were among the top ten counties in numbers of flood insurance claims *for all three events* (Comparative Analysis, DRBC 2007).

Since the DRBC Interstate Flood Mitigation Task Force report was issued, a Floodplain Regulations Evaluation Subcommittee, reporting in 2009, found that “the regulations currently in place for addressing development in the floodplain have not successfully reduced flood damages, in fact they have allowed new development, redevelopment, and expansion of existing development to continue and the result has been a continued increase in flood damages” and increasing populations at risk. The Subcommittee further determined that minimum floodplain management regulations, administered by FEMA through the National Flood Insurance Program and often used as a template for state and local floodplain regulations, do not adequately identify risk or prevent harm. This is illustrated in Figure W-34, which shows numbers of properties with repetitive flood losses and the significant costs associated with those losses.

The regulations currently in place for addressing development in the floodplain have not successfully reduced flood damages, in fact they have allowed new development, redevelopment, and expansion of existing development to continue and the result has been a continued increase in flood damages....

– DRBC Floodplain Regulations Evaluation Subcommittee

Comparative Analysis of the National Flood Insurance Program (NFIP) Claims in the Upper Delaware River Basin for September 2004, April 2005 & June 2006 Flood Events <i>(This table has been modified to show counties in the Upper Delaware Region)</i>			
September 2004 – Ivan: 1,313 Closed Claims; ~\$46 Million (data as of 02/28/07)*			
Counties Most Affected	Claims (#)	(%) Total	Total Paid (\$)
Warren, NJ	180	13.71%	\$5,544,398
Sullivan, NY	60	4.57%	\$1,298,775
Delaware, NY	57	4.34%	\$1,094,442
Monroe, PA	45	3.43%	\$2,423,678
April 2005 Event: 1,977 Closed Claims; ~\$73 Million (data as of 02/28/07)			
Counties Most Affected	Claims (#)	(%) Total	Total Paid (\$)
Warren, NJ	234	11.84%	\$10,281,973
Sullivan, NY	93	4.70%	\$1,435,457
Delaware, NY	70	3.54%	\$891,654
Monroe, PA	46	2.33%	\$2,898,655
Pike, PA	37	1.87%	\$689,567
June 2006: 3,045 Closed Claims; ~\$107 Million (data as of 02/28/07)			
Counties Most Affected	Claims (#)	(%) Total	Total Paid (\$)
Delaware, NY	278	9.13%	\$10,835,288
Warren, NJ	208	6.83%	\$8,380,201
Sullivan, NY	197	6.47%	\$7,544,181
* Closed claims amount and estimated monetary amount is based on the top ten counties with the highest number of claims per flood event in the Delaware River Basin. Only counties in the Upper Delaware Region are shown.			
Notes:			
1. Claims were mapped and summaries compiled using Lat/Long coordinate points provided by FEMA. On occasion, the Lat/Long location does not match the FEMA assigned community name for specific claims.			
2. Information was compiled by DRBC staff. April 2007.			
3. The analysis does not represent uninsured flood damage.			

Figure W-31: Upper Delaware region counties ranked among the top ten counties with the highest number of claims for all three major flood events in 2004, 2005 and 2006. *Source: Comparative Analysis of Flood Insurance Claims, DRBC 2007. Table modified by N. Phanit 2013.*

Since the DRBC Interstate Flood Mitigation Task Force report was issued, a Floodplain Regulations Evaluation Subcommittee, reporting in 2009, found that “the regulations currently in place for addressing development in the floodplain have not successfully reduced flood damages, in fact they have allowed new development, redevelopment, and expansion of existing development to continue and the result has been a continued increase in flood damages” and increasing populations at risk. The Subcommittee further determined that minimum floodplain management regulations, administered by FEMA through the National Flood Insurance Program and often used as a template for state and local floodplain regulations, do not adequately identify risk or prevent harm. This is illustrated in Figure W-34, which shows numbers of properties with repetitive flood losses and the significant costs associated with those losses.

County	State	Number of Repetitive Properties	Total Payouts for Repetitive Properties	Average payouts per year
Warren	New Jersey	225	\$24,543,943	\$846,343
Sullivan	New York	94	\$6,427,868	\$221,650
Delaware	New York	72	\$4,197,593	\$144,745
Monroe	Pennsylvania	45	\$8,972,739	\$309,405
Pike	Pennsylvania	27	\$1,405,386	\$48,462
Wayne	Pennsylvania	21	\$1,471,365	\$50,737
Sussex	New Jersey	5	\$279,726	\$9,646
TOTAL		489	\$47,298,620	\$1,630,987

Note: A property is considered a repetitive loss property when there are 2 or more losses reported which were paid more than \$1,000 for each loss. The 2 losses must be within 10 years of each other and be at least 10 days apart. Losses from 01/01/1978 – 02/28/07 that are closed are considered.

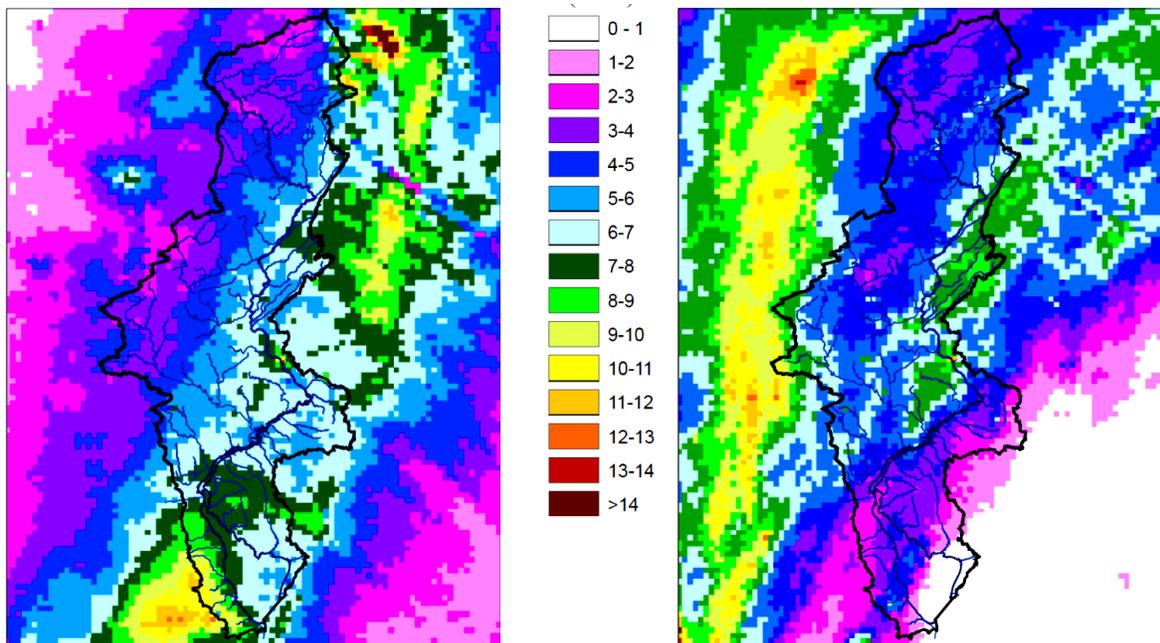
Source: Analysis of Repetitive and Severe Repetitive Loss Properties in the Delaware River Basin, DRBC, April 2007, pg.8

Figure W-32: Analysis of repetitive flood losses in the Upper Delaware region from 1978-2007.
Source: Comparative Analysis of Flood Insurance Claims, DRBC 2007.

Moving ahead a few years, August 2011 was the wettest August on record based on data collected since 1872 for Philadelphia. At the end of August 2011, after a particularly wet month, Hurricane Irene moved up the east coast, delivering 3 to 7 inches of rainfall to the Upper Delaware region. Moderate and Major flooding were observed on the East Branch Delaware and Neversink Rivers, respectively. Other Upper Basin flood forecast locations were at Action or Flood Stage. Within a few days, Tropical Storm Lee brought an additional 5 to 7 inches to the already rain-soaked region. High streamflow conditions and runoff from Tropical Storm Lee resulted in moderate flooding at several locations in the Upper Basin, primarily on the West and East Branches of the Delaware River. Much of the main stem also experienced moderate flooding (Flood Summary, DRBC 2011).

The National Weather Service has defined categories of flooding for forecast purposes based on the severity of potential impacts to property and the public. These categories are Action, Flood, Moderate and Major, with more severe flooding occurring in the Moderate and Major categories.

Through the first week in November 2011, precipitation averaged 63 inches in the upper and middle basin, which is 25 inches above normal. During the same time frame, storage in the NYC Delaware reservoir system was at 93.9 percent usable capacity. The median storage for early November is 68.2 percent usable capacity. In early November, the salt line was located at river mile 64. The normal location



Provisional data provided by the Mid-Atlantic River Forecast Center.

Figure W-33: Precipitation totals in the Delaware River Basin from Hurricane Irene (left) and Tropical Storm Lee. Source: Flood Summary, DRBC 2011.

The summer of 2013 proved to be another challenging season of heavy precipitation events in the Upper Delaware region. In just one event on June 30th, the Borough of Hawley, PA was deluged with nearly five inches of rain in a three hour period, causing local officials to declare a state of emergency and block off all roads into and out of town for hours.

While no one particular weather event can be directly attributed to climate change, this type of extreme weather is exactly what has been predicted by numerous climate models and it is clear that extreme precipitation events and related stormwater runoff and flooding are having an increasing impact on communities in the Upper Delaware region. Implementing the recommendations of the DRBC Flood Mitigation Task Force and the Floodplain Regulations Evaluation Subcommittee would be “no regrets” actions to reduce the impacts of flood events on both the built and natural environments. Given the current information showing an increase in extreme precipitation events and the forecasts that such trends will continue, these actions would also contribute substantially to reducing the risks faced by Upper Delaware communities (and downstream flood prone areas as well) and helping them become more resilient in the face of climate change.



Figure W-34: June 30, 2013 deluge, Hawley, PA. Source: WNEP-TV.

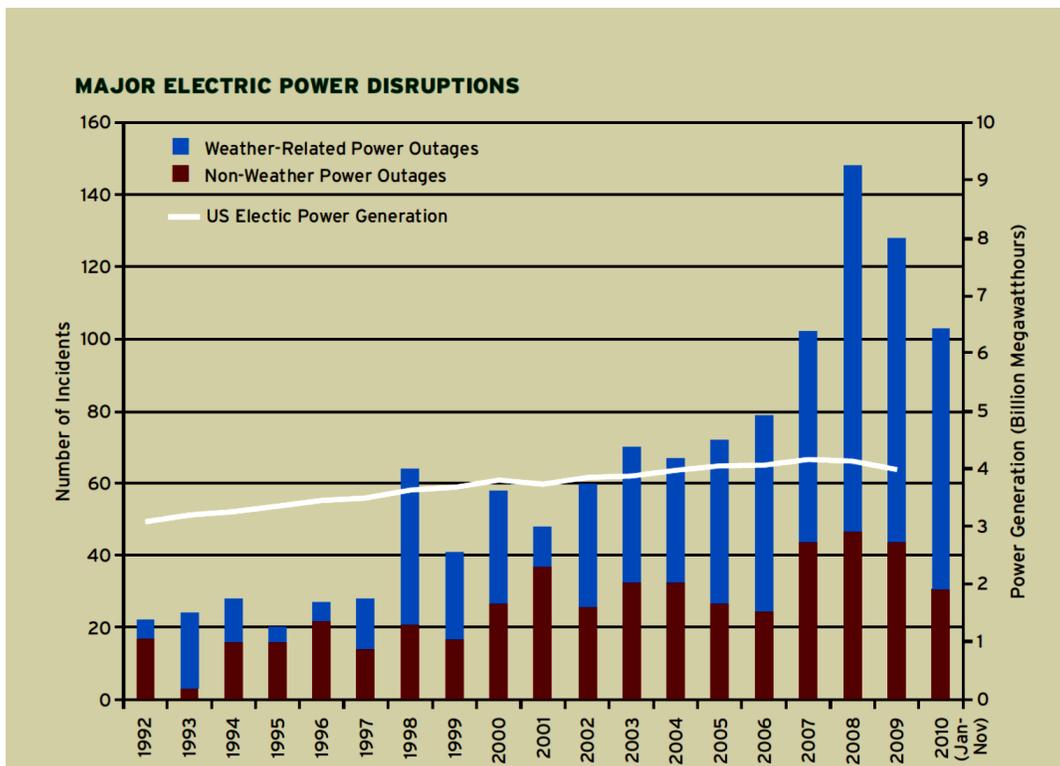


Figure W-35: Upward trend in weather-related power disruptions in the US and southern Canada. *Source: National Wildlife Federation 2011.*

Hydrologic Changes

It is projected that under the A2 emission (high emissions) scenario, there will be approximately 20 fewer frost days per year by 2050 and 40 fewer frost days by 2100. Although snowfall is highly variable from year to year, warmer winters are projected to cause a reduction in the depth, range and projection of snowpack. These losses of snowpack in combination with more winter precipitation falling as rain will likely result in increases in winter flooding and decreases in snowmelt runoff during the spring (Najjar, et al., 2012). Earlier peak stream flows could result in lower summer and fall flows, which would exacerbate temperature stress problems during that time period for trout and potentially impact recreational boating during peak tourism periods. With increased temperatures come increased rates of evaporation from reservoirs reducing water storage capabilities.

Sea Level Rises and the Salt Line

Sea levels in the Delaware Estuary have risen by about one foot in the last century, a doubling of the rate of increase over that for the last 15 centuries. Over the next century, sea level rise is projected to be at least an additional 3 feet. While rising sea levels may seem a distant problem for the Upper Delaware region, rising sea levels create a serious concern here for flow management, since they move the Delaware River’s “salt line” up the river, threatening Philadelphia’s water supply and mandating releases from reservoirs in the Upper Basin to augment flow and push the salt line down river. Depending on the time of year, supply demands, reservoir levels and weather conditions, these releases can mean extreme

shifts in flow or reductions in water available for release at critical times to support aquatic ecological needs. Overall, the Upper Delaware region can expect more competition for less available water.

Impacts to Fisheries and Other Vulnerable Aquatic Species

The future of trout is dim with predicted wild trout losses of 53 percent to 97 percent in the Appalachian Mountains. An important cold-water game fish in the region is the brook trout and they are extremely vulnerable to climate change effects. “It doesn’t take a big jump in the temperature of a stream to wipe out a population of brookies,” said Steve Moyer, Trout Unlimited. “And it happens so fast – seems like they disappear while you’re switching your fly from a nymph to a dry” (Bipartisan Policy Center 2008).

The brook trout is New York’s state fish and they are already stressed by non-native fish introductions, acid rain, habitat destruction and hydrological disruption. Not only do brook trout require cool water temperatures, they also need upwelling groundwater for reproduction and thermal refuge during hot summers (NYSERDA 2011). Obstructions along waterways, such as roads, can leave the trout’s habitat fragmented, making thermal refuge spots inaccessible to some populations. “As climate change reduces the availability of quality habitat, cold-water fish will concentrate in small, fragmented headwater streams. Native trout will increasingly retreat to shrinking coldwater refuges to avoid warming conditions” (Bipartisan Policy Center 2009). This is a health risk to the trout population as diseases can transfer easily in a high trout concentration area. With diminishing suitable trout habitats, fishermen are competing with each other in fairly small areas. This discourages people to engage in the sport since the quality of the experience has declined due to lack of privacy/space, affecting the future of fishing and related revenues (Boyer 2013).

In a 2011 study by Pennsylvania Natural Heritage Program, *Identifying Species in Pennsylvania Potentially Vulnerable to Climate Change*, aquatic species were ranked by vulnerability to climate change by 2050. The study “suggests that the abundance and/or range of these [*extremely or highly vulnerable*] species within Pennsylvania will likely decrease significantly or disappear entirely from the state by 2050.” The Eastern pearlshell mussel is considered to be extremely vulnerable to climate change while the Dwarf wedgemussel is listed as highly vulnerable. Mussels are adversely affected by climate change due to their inability to disperse far beyond their current habitats. Man-made structures, such as dams, degrade habitats and pose barriers in some species’ migratory flow. Other contributing factors to the susceptibility of mussels to climate change include increasing water temperature, increasing frequency and severity of floods, and water quality degradation (Furedi, et al 2011).

Additional Population Growth from Climate Refugees

Given the steady levels of population increases in most counties in the region, and the close proximity of the region to major metropolitan areas threatened by sea level rise, it is likely that the Upper Delaware region will see further increases in population as climate refugees move from more vulnerable coastal areas. While this in itself is not necessarily a negative impact, such population growth would result in more development pressure and, absent efforts to implement strategies to address them, added forest loss and impervious surfaces increase, both of which affect water quality. Population increases also amplify demand for water and other ecosystem services which adds further to non-climate and climate-related stressors.

Potential Water Solutions - Strategies for Climate Resilience

DRBC Executive Director Carol Collier highlighted potential climate change impacts on water supply and infrastructure and outlined proposed actions needed to protect the water resources of the Delaware River Basin (Collier 2010). Several broad categories of adaptation strategies were suggested to mitigate existing stressors and reduce the impacts of climate change:

- Reduce Demand Through Conservation
- Improve Stormwater Management
- Evaluate need for Increased Upstream Storage
- Focus on Flood Mitigation

These strategies set a framework for addressing basin-wide climate impacts. Some solutions for the Upper Delaware region are offered below.

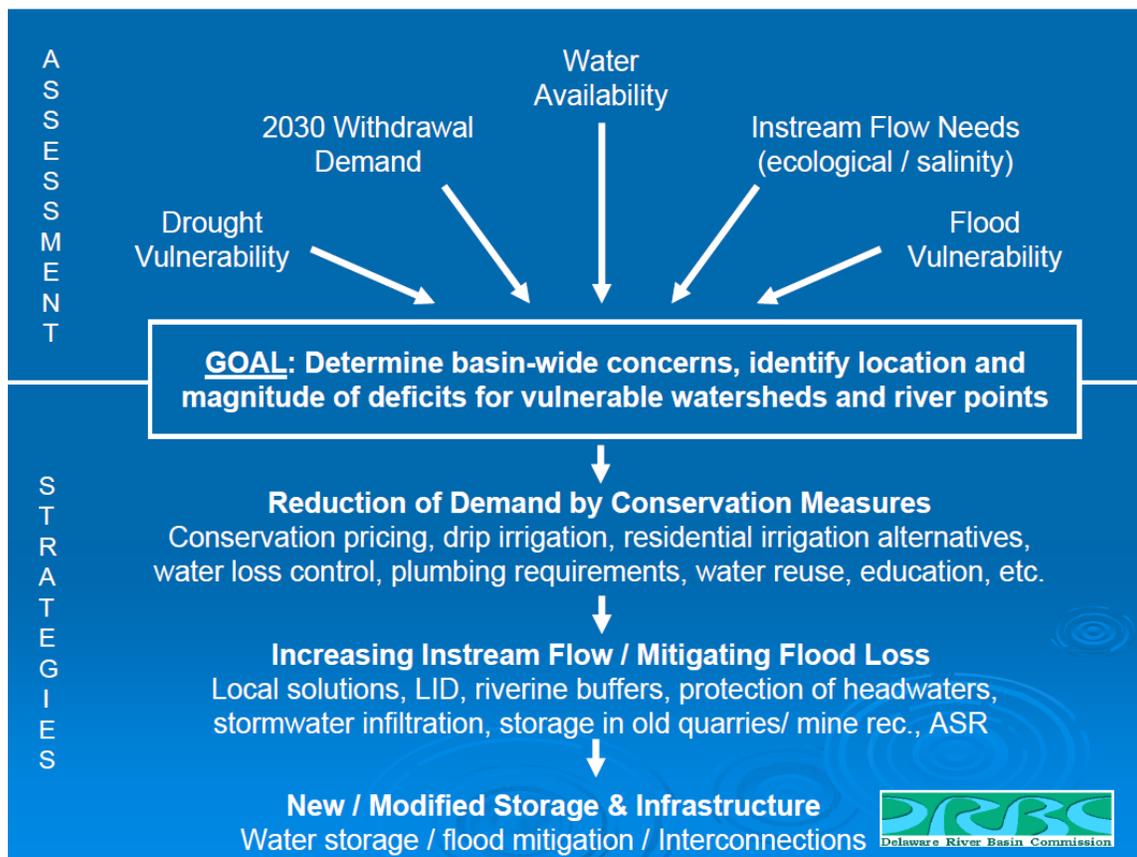


Figure W-36: Climate vulnerabilities and strategies for protecting water resources of the Delaware Basin. *Source: Collier 2010.*

Maintain Forest Cover

In his 1903 *Primer on Forestry*, Gifford Pinchot, the first Chief of the U.S. Forest Service, recognized the critical connections between forests and water (sidebar). Maintaining the ecosystem services provided by forests continues today to be an essential strategy for reducing the impacts of climate change on water resources and communities of the Upper Delaware region.

A forest, large or small, may render its service in many ways. It may reach its highest usefulness by standing as a safeguard against floods, winds, snow slides, or especially against the need of water in the streams.

– Gifford Pinchot, 1903

Research has indicated that land development that eliminates mature forest cover and undisturbed soil degrades aquatic systems as much as or more than associated increases in impervious area. Both forest loss and imperviousness can result in significant changes to stream flow regimes and, in turn, to the physical stability of stream channels (see Figure W-37). Structural stormwater best management practices (such as detention ponds) can never completely mitigate these hydrologic changes, suggesting that retention of forest cover is the more pressing need in rural areas (Booth, et al. 2002).

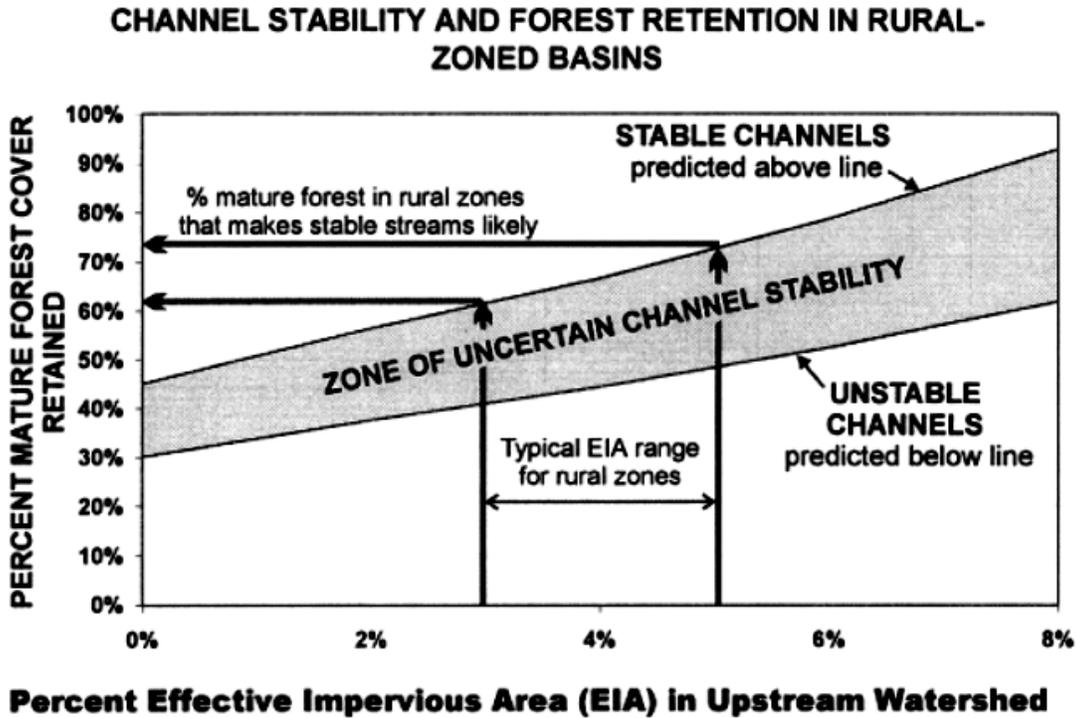


Figure W-37: Small forest losses and low levels of imperviousness impact stream channel stability. Source: Booth, et al 2002.

Conservation of aquatic resources in developing areas will require integrated strategies, including impervious-surface limits, forest-retention policies, stormwater detention, riparian-buffer maintenance, and protection of wetlands and unstable slopes. In the Upper Delaware region, a multitude of local governments are responsible for these types of land use standards and development decisions. Working

collaboratively with local governments is key to establishing or improve existing policies to foster forest, water and economic resilience.

Engage Downstream Water Users in Investing in the Upper Basin

The City of Philadelphia, which depends on the Delaware River for its drinking water supply, describes the main threat to the water quality and quantity of the Delaware River as coming from population growth and subsequent land cover changes and stresses the importance of “regional efforts to preserve as much forested land as possible” and the need to understand the relationship between land cover and water quality and quantity, and population growth and development within the Delaware River watershed. Philadelphia also expresses concerns about climate change related alterations in the hydrology of the Delaware River: increases in evaporation, loss in soil moisture, increased winter precipitation, more severe rain storms, season length changes and resulting alterations in streamflow. In prioritizing its source water protection strategies, the Philadelphia Water Department recommends that DRBC enhance its Special Protection Waters regulations to incorporate forest and canopy protection requirements into existing non-point source pollution regulations (Philadelphia Water Dept. 2007).

In addition, the Philadelphia Water Department has articulated several additional strategies to preserve forested lands and open space:

- Support ongoing forest protection initiatives by providing information to counties, municipalities, land trusts, the Smart Growth Alliance, and other environmental conservation groups.
- Meet with the Pennsylvania Department of Conservation and Natural Resources (DCNR) about purchasing, or means to conserve, forested lands for source water protection.
- Explore funding options for purchasing land or easements in the name of source water protection.

Forest protection in the Upper Basin is described as “the single most important action needed to minimize degradation of drinking water supply quality” in the Delaware River Basin (Kreeger, et al. 2012).

Recognizing this, Common Waters Partnership and the Pinchot Institute have started conversations with major water users in the Lower Basin to identify additional information needed to justify investments in source protection upstream and find key partners and funding to undertake research and modeling efforts to meet these needs. This is an important ongoing effort.

Improve Floodplain & Stormwater Management Standards

A number of flood events, extreme precipitation events and the associated property losses and infrastructure damages point to the need for a more concerted and coordinated approach to floodplain and stormwater management that crosses state and municipal boundaries. Government officials should also factor the potential for climate-induced extreme weather patterns into the design standards for public infrastructure, prioritize maintenance and repair of existing high risk infrastructure and revise policies that encourage development in areas at risk of flooding.

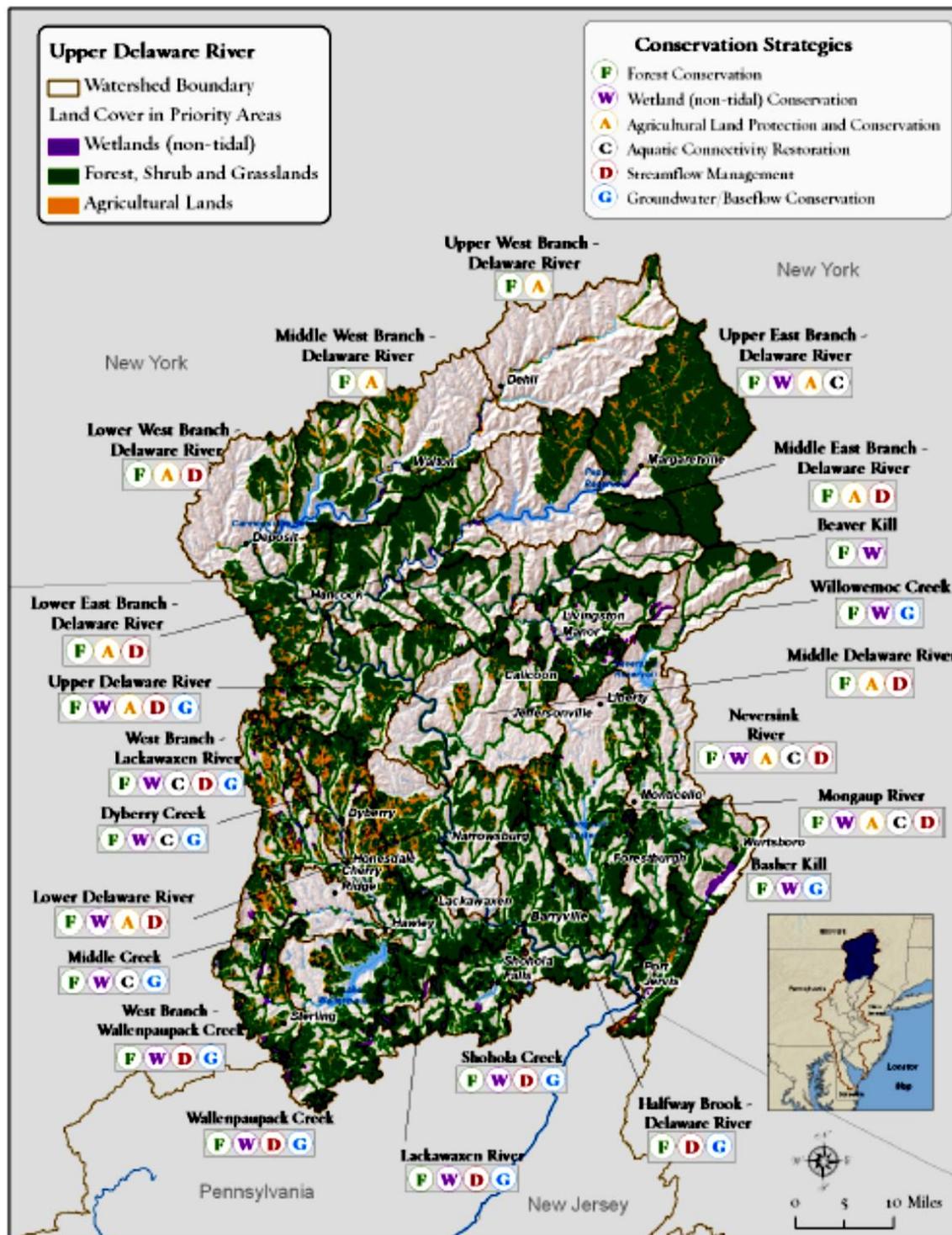


Figure W-38: Priority conservation areas & recommended conservation strategies for the Upper Delaware. Source: The Nature Conservancy 2011.

Among the recommendations of the DRBC Interstate Flood Mitigation Task Force were the following:

- **Stormwater management:** implementation of watershed stormwater management plans; long-term maintenance of stormwater infrastructure; use of non-structural stormwater management options; stronger enforcement of stormwater management regulations; and the development of stream restoration and debris removal guidelines.
- **Floodplain mapping:** development of a seamless floodplain map that is consistent throughout the basin; coordination of flood study and mapping updates; incorporation of existing and planned development and residual risk zones into new maps; re-define and re-map the floodway along the main stem and tributaries.
- **Floodplain regulation:** Regulations applicable to floodplain areas in the Delaware Basin vary widely; existing floodplain regulations should be catalogued, evaluated and updated and uniform regulation of floodplains within the basin established; a flood hazard disclosure requirement should be imposed, a repetitive loss reduction strategy adopted and riparian zones defined in accordance with uniform standards basin wide.

Twelve consensus recommendations (see Appendix 2) were put forward by the Task Force to provide more consistent, comprehensive and watershed-based application of floodplain regulations and promote a new minimum standard for the Delaware River Basin that is more stringent than the FEMA national minimum standards. The flood-related costs already experienced by communities in the Upper Delaware region should be a strong incentive for local governments to adopt uniform floodplain regulations, and efforts should be made to share the task force's recommendations with all municipalities in the region.

Use Available Funding Strategically to Conserve Priority Landscapes

The Nature Conservancy's *Delaware River Basin Conservation Initiative* created a biodiversity-driven conservation blueprint for the Basin, mapping priority areas and identifying a number of conservation strategies focused on the long-term health of the basin's ecosystems. For the Upper Delaware region, priority areas mapped include floodplain complexes, headwater stream networks and non-tidal wetlands. Conservation strategies recommended for the priority areas include forest conservation, wetland conservation, agricultural land preservation, aquatic connectivity restoration, streamflow management and groundwater baseflow conservation (The Nature Conservancy 2011).

Utilizing several existing data sets, the Common Waters Partnership created the *Common Waters Land Conservation Prioritization Model* to assess the value of landscapes in the Upper Delaware watershed for the conservation of both ecological and drinking water resources. The underlying data sources include: Natural Lands Trust Source Water Protection Model, Natural Lands Trust Smart Conservation Aquatic Assessment, The Nature Conservancy Priority Forest Areas, USFS Forests, Water, & People Assessment (Ability to Produce Clean Water) and The Nature Conservancy's Basin-wide Freshwater Assessment.

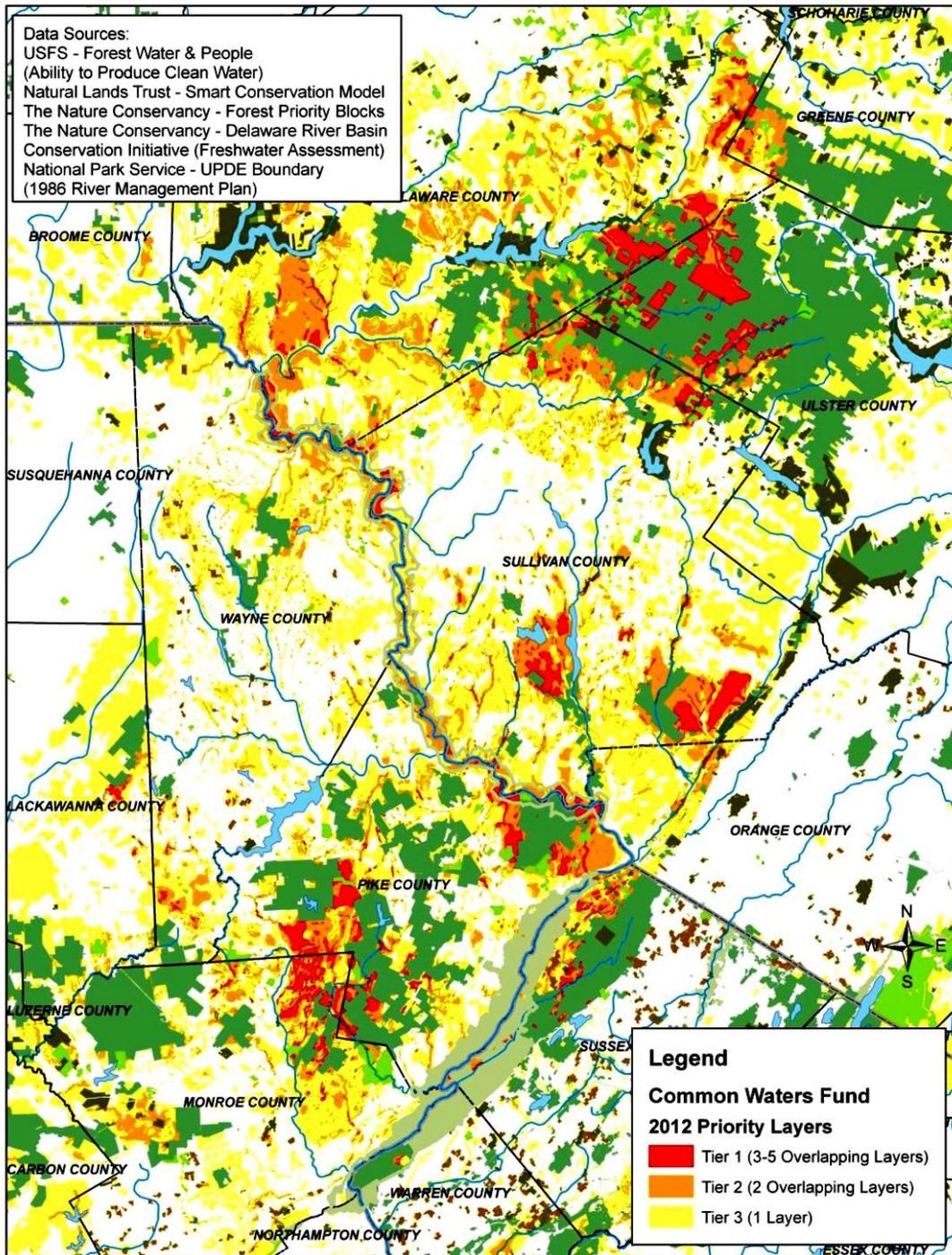


Figure W-39: Common Waters Fund Priority Areas in the Upper Delaware region.
Source: Common Waters Partnership 2012.

The Common Waters Partnership has utilized the Prioritization Model and the Common Waters Fund (www.commonwatersfund.org) to direct a limited amount of grant funding towards conservation of Upper Delaware forested lands critical to water quality and quantity in both the upper and lower basin. Basin water users who depend on clean, plentiful water supplies, particularly the sizable consumptive users in lower basin metropolitan areas, have in the Common Waters Fund a proven vehicle for investment in protecting their source water in the Upper Basin.

The William Penn Foundation (WPF) in Philadelphia recently announced that it will use its environmental grant-making to support land conservation and water quality protection in the Delaware River watershed. A portion of the Upper Delaware Region, the *Pocono Kittatinny Cluster*, designated as a Conservation Cluster by WPF, has been identified by the Academy of Natural Sciences (ANS) as a critical place to protect - a place high existing water quality and one that contributes significantly to the maintenance of clean water within and beyond its borders. A group of stakeholders, many of them Common Waters Partnership members, are working with WPF to develop a conservation plan for this Cluster aimed at targeting those ecologically significant lands most important to the maintenance of water quality and prioritizing efforts to protect them. This effort will likely produce cross-cutting strategies and collaboration opportunities for climate resiliency implementation.

Analysis and Recommendations to Address Assessment Findings

To assess the impacts of climate change on the Upper Delaware Region and identify strategies by which communities might adapt and prepare, the core planning group conducted a risk analysis for each sector – forests, water resources and economics. A master list of current and potential climate risks or stressors was developed for the region using the forest, water and economics assessment findings. Consequences associated with those risks were ranked with a score of high, medium, or low. The probability of each risk occurring was also ranked using the same scale, as well as the ability of communities in the region to respond to the risks (a relative measure of vulnerability).

The overall Risk Value was assigned using the following formula (Crosset and Griffith 2013):

$$\text{Risk Value} = (\text{Consequence} + \text{Probability}) - \text{Ability to Respond}$$

High Risk = Likely Priority
Medium Risk = Possible Priority
Low Risk = Less Likely Priority

The tables in Appendix 3 summarize the risk analysis, the results of which were ultimately used in the development of goals, objectives and strategies for this Plan. Notes associated with the rankings provide insight as to the group’s thought processes associated with various rankings.

Once the risk values were determined, the core group then identified and ranked potential solutions for each risk identified. A community level SWOT analysis (Strengths, Weaknesses, Opportunities and



Figure A-1: Pike County Planning Director Michael Mrozinski and planner Jennifer Boysen during a goal development session.

Source: Nalat Phanit 2013.

Threats) as well as additional factors such as the likelihood of success for various solutions, the potential timing of success, and potential opportunities for synergy, helped to further inform the prioritization process.

In working towards development of plan goals, the core group, using the risks/stressors master list, started by grouping priorities into clusters based on similarity, overlap, cross-cutting issues, or synergy. The group continued this exercise until several overarching goals emerged that incorporated all of the risks/stressors from the master list. These were “big picture” goals that the group felt were consistent with the priorities that emerged from the risk analysis.

Additional valuable input on risks, potential solutions and their overall importance to natural resources and communities in the Upper Delaware region was provided during an interactive session with the Upper Delaware Roundtable, a networking initiative to foster communication and collaboration among stakeholders in the region. In ranking risks to water resources, increased competition for water, water quality and habitat degradation, and thermal stress/loss of cold water fish topped the Upper Delaware Roundtable’s list. For forest risks, loss of ecosystem services had high priority as did deer population increases and loss of bird and wildlife habitat.

Economic risks associated with agricultural losses and extreme weather events were high priorities with this group. This feedback, which was different in some respects from the core group's initial analysis, was used to further refine the plan goals, objectives and strategies and to help in development of the action plan.



Figure A-2: Upper Delaware Roundtable participants ranking climate risks important to their communities. *Source: Heron's Eye Communications 2013.*

The broad goals identified to address key risks are summarized below. Achieving these goals represents a significant challenge, particularly given the size and diversity of the Upper Delaware region. In addition, it is expected that there will be additional capacity needed – both human and financial - to coordinate the broad actions necessary to achieve these goals and bring climate resiliency to the Upper Delaware region.

Education – Generating dialogue and information exchange about specific risks associated with climate change was repeatedly identified as a top priority for the Upper Delaware region – both to reduce risks and build support for implementing solutions. While most people have a general understanding of climate change as a future global problem, many might not make the connection with impacts happening in our communities now or, if they do, don't know what they can do about it. Raising the awareness level about the hazards of climate change here in our region will have the added benefit of building understanding about what it will take to reduce greenhouse gas emissions (mitigation). This is important since our ability to adapt will likely be limited if the pace of climate change continues to increase.

Local Government Policy and Planning - In considering the findings of the forest, water and economic assessments – evaluating current stressors, climate related risks and potential strategies for reducing those risks – and in conducting the risk analysis and prioritization, it is clear that the risks to Upper Delaware region forests, waters and economies could be reduced significantly by implementing land use policies that focus on maintaining existing forest cover, reducing forest fragmentation, keeping impervious cover at reasonable levels, and taking full advantage of the ecosystem services provided by floodplains and

riparian corridors. Local governments in the region have primary responsibility for the land use decisions that can ultimately make communities less vulnerable and more economically resilient to environmental changes. Although it is a daunting challenge to coordinate land use policy in a region that includes three states, seven counties and hundreds of municipalities, it has great potential for far-reaching climate resiliency benefits. A region-wide survey and evaluation of existing land use statutes or other tools associated with forest and water resources protection (i.e. canopy cover, riparian buffers, impervious area coverage, open space provisions, floodplain management, etc.) would be a good starting point to identify gaps and flesh out successful models.

Choices about land-use and land-cover patterns have affected and will continue to affect how vulnerable or resilient human communities and ecosystems are to the effects of climate change.

NCADAC Draft National Climate Assessment, Ch. 13 (v.11 Jan. 2013)

Local governments also have responsibility for the health, safety and welfare of the people in their communities and for managing the impacts associated with more flooding and extreme weather events, extreme heat and drought, and the municipal budgets that fund responses to these events. To prepare for the environmental changes we know are inevitable, and in some cases are already experiencing, local governments can develop floodplain management policies that take advantage of the natural assets the region possesses to reduce the risks and the substantial costs of emergency response, infrastructure damages and property losses. Local governments can also incorporate what they know about climate impacts into updates of emergency plans, hazard mitigation plans, transportation plans, stormwater management plans, comprehensive plans, and other local planning efforts. Culvert sizing and bridge design standards should be examined and updated to incorporate changes associated with extreme precipitation events. Funding options and mechanisms should be identified to address the backlog of high hazard dam maintenance and repairs as these structures are vulnerable to increases in precipitation intensity and present a safety threat to downstream people and properties.

Forest Landowner Support- Management practices that improve the health and diversity of forests in the region are important to reducing forest and water stressors. With so many of the forests in the Upper Delaware region under private ownership, landowners and the professional foresters that work with them will be essential to enhancing forest resilience during an expected long period of climate change. Land trusts and a large network of hunting and fishing clubs are also key partners in forest health initiatives, such as managing insects and invasive plants or supporting science-based deer population management that balances populations with sustainable forests and quality timber management. Collaborating with these groups and identifying funding mechanisms to support management practice implementation are key strategies. Tax assessment policies that incorporate the value of ecosystem services provided by forest lands are another important mechanism that helps landowners keep forests as forests.

Financial Investment – Forests in the Upper Delaware River watershed are essential to maintaining the extraordinary water quality of the Delaware River. The forests that keep water clean for the residents of the New York City metropolitan area, who draw their water directly from reservoirs in the headwaters, are maintained by the NYC Department of Environmental Protection, a public, tax-dollar funded authority. But the millions of people who live downstream and also depend on Delaware River water (Philadelphia, Easton and Trenton) have no such centralized oversight of the forests on which their water quality depends. The Common Waters Fund aims to fill this gap, by funding stewardship and

conservation by the private forest landowners in the Upper Delaware region on whose forests the water quality of all downstream users depends. A permanent funding stream would include contributions from downstream users who enjoy the extraordinary water quality of the Delaware River and are willing to invest in its continuation.

Support and Mitigate Impacts to Businesses – Strategies that address climate change by conserving forest and water resources are also key to maintaining (and enhancing) the region’s economic vitality, quality of life, and natural and cultural heritage. Sustainable development does not represent a trade-off between business and the environment but rather an opportunity to strengthen the synergies between them. This plan recognizes the significant economic importance to the region of entrepreneurship, agriculture, tourism and outdoor recreation and the risks to these sectors, and to small businesses in general, of climate-driven extreme weather, hydrologic changes and seasonal disruptions. Strategies that help manage impacts while identifying and capitalizing on new economic opportunities presented by a changing climate will be important to those businesses here now and those locating here in the future.

Flow Management – There are many entities vying for Upper Delaware region water resources and few Upper Delaware region stakeholders directly involved in decisions about how that water gets allocated and managed. Given the hydrologic changes associated with increasing temperatures and the finite storage capacity in Upper Basin reservoirs, it is essential that flow management policies factor in climate change to ensure sufficient water quantity for both human and ecological needs.

The priority adaptation goals identified in the planning process are summarized here and outlined in detail below in the adaptation action plan.

- Goal 1: Build the capacity – both human and financial - necessary to implement the Climate Adaptation Plan for the Upper Delaware Region.
- Goal 2: Generate active dialogue and information exchange about climate change by educating and engaging the public, media and local officials on region-specific climate change risks and opportunities.
- Goal 3: Conserve the current 75% forest land cover to protect water quality and quantity and enhance climate resiliency.
- Goal 4: Maintain and improve ecological health and sustainability of forests
- Goal 5: Enhance financial investment in Upper Basin forest management and land conservation through engagement with key stakeholder groups.
- Goal 6: Reduce the impacts of flooding and stormwater runoff from extreme storm events on people, property and infrastructure.
- Goal 7: Support, mitigate impacts to, and enhance the region’s agriculture, tourism, and recreation industries while identifying and capitalizing on new economic opportunities presented by a changing climate.
- Goal 8: Promote basin-wide flow management policies that will ensure sufficient water quantity for both human and ecological needs.

Climate Adaptation Action Plan

This Climate Adaptation Action Plan maps out an ambitious set of goals, objectives, strategies and actions to be accomplished over the short-, medium-, and long- term with clear benefits, not just for climate resiliency but for addressing existing non-climate forest and water stressors. This should not be considered a static prescription for implementation, but should instead be a flexible guide that will be adapted and added to over time as implementation proceeds and as new partners and opportunities are recognized. The identification of specific actions for some goals and objectives is ongoing.

For the first year of implementation, the focus will be on Goal 1 (capacity building) and Goal 2 (generating dialogue and information exchange about climate change). A number of actions (defined as short-term) from Goals 3 through 8, driven in part by synergistic efforts such as the Pocono-Kittatinny Conservation Plan and Sullivan County’s Climate Action Planning will also begin during year one as resources allow.

GOAL 1: Build the capacity – both human and financial - necessary to implement the Climate Adaptation Plan for the Upper Delaware Region.

Objective 1-1: Hire a paid coordinator to shepherd plan implementation.

Strategy 1-1-1: Incorporate funding for coordinator in applicable Pinchot Institute for Conservation (PIC) or other Partner grant applications.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Include Climate Adaptation staff coordination in budget for PIC 2014 USFS proposal	Short		PIC	Application to USFS	Application Funded
Identify & hire individual (s)	Short	Funding	PIC/CWP		Coordinator on board

Objective 1-2: Find synergy with and integrate climate resiliency strategies into governmental and nongovernmental planning processes, academic projects or activities.

Strategy 1-2-1: Leverage and build on existing partnerships and stay connected regionally with Common Waters Partners and other collaborative efforts.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Have regular communication with and meeting attendance at CWP, UPDE Roundtable, UDC and other key stakeholder groups	Short-Med	Funding for coordinator	Coordinator	Communication & meeting attendance	Regional communication and awareness of stakeholder activities
Review Sullivan Co. UPDE Waterfront Revitalization Plan and insert climate-related language where appropriate	Short Early 2014	Time	S. Beecher	Comments to H. Jacksy	Final plan incorporates comments
Review draft Pocono Kittatinny Conservation Plan for strategies synergistic w/ climate strategies	Short	Time	S. Beecher	Comments to plan devp. team	Collaborative implementation of synergistic strategies

Strategy 1-2-2: Cultivate university contacts to broaden academic interest in the region and create opportunity for research collaboration.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify existing Common Waters Partner or other stakeholder academic contacts	Short	Partner time	CWP	List of potential academic partners	Broad academic interest in regional climate issues
Partners make contacts/engage academic representatives in CWP meetings and activities	Short	Partner time	CWP	Academic representatives engaged	Academic partners participating in CWP and directing research activities to support climate resiliency
Meet with Lacawac Sanctuary Foundation Board Chair Steve Lawrence to get details about Lacawac's Environmental Consortium and opportunities around climate research being conducted there	Short	Time	S. Beecher	Meeting	Opportunities for education/collaboration
Strategy 1-2-3: Explore grants and other non-traditional sources to fund climate adaptation initiatives. Look for local grant opportunities, state and federal funding and opportunities to provide matching funds or in-kind services for Partner grant applications that include climate resiliency components.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify a short-list of projects that would kick-start implementation activities	Short	Time	Coordinator/CWP	Project list	List ready for grant search
Include funding for key educational strategies in in budget for PIC 2014 USFS proposal	Short		PIC	Application to USFS	Application funded
Review Wm. Penn Found. guidelines and make contacts outside of Pocono Kittatinny Cluster context	Short	Time	Coordinator	Grant application completed	

GOAL 2: Generate active dialogue and information exchange about climate change by educating and engaging the public, media and local officials on region-specific climate change risks and opportunities.

Objective 2-1: Cultivate an informed public that actively calls for climate preparedness from its elected officials and considers climate interests in its consumer choices.

Strategy 2-1-1: Form an education team to take the lead in organizing/implementing educational initiatives.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Identify expertise that would be helpful in planning/carrying out educational strategies	Short	Time	Coordinator/CWP	List of team member expertise	Broad expertise level for education activities
Draw on Common Waters Partners, Upper Delaware Roundtable, Upper Delaware Council, Conservation Districts, educators groups to identify persons that fit the types of expertise needed	Short	CWP meeting	Coordinator/CWP	List of prospective team members	Diverse group for education activities
Connect with identified persons and, with those who agree to participate, build a framework for moving forward.	Short	Time	Coordinator/CWP members/other partners	Identified team	Engaged, energetic, diverse group to plan education activities
Strategy 2-1-2: Engage a marketing professional to assist in identifying target audience and developing messages and materials to which target audiences can relate.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify and meet with prospective candidates	Short	Time	Coordinator, ed. team	Recommendation to CWP	CWP agreement
Engage marketing professional	Short	Funds to pay professional fees	Coordinator, ed. team		Marketing professional on board
Develop a primer with key points from the full Climate Adaptation Plan	Short	Time, printing costs	S. Beecher, Coordinator, ed. team, marketing professional	Primer	Resource for varied audiences
Develop a presentation template that can be utilized by volunteers for public outreach (utilize template from MFPP/NOAA)	Short	Time	Coordinator, ed. team, marketing professional	Presentation template	Resource for varied audiences

Strategy 2-1-3: Collaborate with NACL Weather Project and Sullivan Alliance for Sustainable Development (SASD) to complement their efforts in Sullivan County.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Join NACL retreat in January 2014 to plan Weather Project activities for the year	Short	Time	S. Beecher	Attendance at retreat	Activities synergistic w/ UPDE Climate Plan
Look for schools on PA side of river who will host classroom visit by Elaine Matthews (NASA scientist working with NACL)	Short	Time	Coordinator/ Education team	Contacts with schools, teachers	Classroom visits scheduled and visits completed
Participate in February 2014 SASD Climate Symposium	Short	Time	S. Beecher Coordinator Peter Pinchot (PIC)	CWP rep. on Symposium Agenda	Activities synergistic w/ UPDE Climate Plan
Strategy 2-1-4: Engage the two National Park Service units and State Parks to provide to visitors information about potential climate impacts to local natural resource.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Contact interpretive staff at both NPS units to discuss creating handouts/display customized for NPS visitors	Short	Time	CW Partners Leslie Morlock (DWGNRA), Carla Haan (UDSRR)	Report back to Coordinator	Interpretive activities synergistic w/ UPDE Climate Plan
Strategy 2-1-5: Work with Chambers of Commerce and/or Business Councils to bring climate preparedness information to small businesses.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify information appropriate for this audience	Short	Time to research info needs	Coordinator/ Education team rep.	Toolkit of materials	Materials in sync w/ UPDE Climate Plan
Identify and contact key individuals from Chambers or business groups	Short	Time	Coordinator/ Education team rep./CWP	List of contacts from across the region	Contacts made
Insert climate preparedness info into chamber newsletters/e-news	Short	Identified materials	Coordinator/ Education team rep.	Concise package of info for publication	Article(s) appear in a variety of publications
Develop a climate preparedness workshop template for use in engaging this audience	Short-med	Time/materials	Coordinator/ Education team	Workshop template	
Using key contact list, engage groups to sponsor workshops	Short-Med	Time/materials venue(s)	Coordinator/ Education team/key business leaders	Workshop held	Positive feedback

Strategy 2-1-6: Work with local news media to promote educational materials, activities and projects.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Collate a list of all regional media sources	Short	Time	Coordinator, River Reporter	Regional media contact list	List available
Publicize all climate plan implementation activities through new releases, social media, CWP website announcements	Short-Med	Time and comprehensive media list/ CWP web-master time	Coordinator, CWP	Publicity materials	Activities well attended
Develop a schedule and contributor's list for regular news articles, op-eds, local TV spots on climate issues of local significance	Short-Med	Time, contributors,	Coordinator, ed. team, CWP	Outreach materials	News media publishing regular climate info
Strategy 2-1-7: Collaborate with the US Forest Service and Pinchot Institute for Conservation to use Grey Towers National Historic Site as a setting for climate conversations, programs and demonstration projects.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Contact Lori McKean and Peter Pinchot to plan at least 2 events for 2014	Short	Time	Coordinator/P IC/ed. team	calendar of events	Events on GT calendar for 2014
Plan and hold programs at Grey Towers	Short - Med	Time/registration fees to cover costs/speakers	Coordinator/education team	Events	Positive feedback
Strategy 2-1-8: Develop a toolkit of stories to help people to relate to climate change personally and to address potential opposition.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Tap NACL's oral history component of the Weather Project to include climate stories	Short	Time/people to participate	Coordinator, NACL	Recordings of people's local experiences with climate change	Good cross section of stories supporting risk findings
Investigate PA Humanities grant program as a potential source of funding	Short	Time	Coordinator	Info on application, timing/	Grant application developed

Objective 2-2: Engage local officials to build support for implementing strategies that will make their communities more resilient to climate change.

Strategy 2-2-1: Identify key local and state government leaders who can help craft and bring the climate resiliency message to their colleagues.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Develop a list of key leader contacts	Short	Time	Coordinator, CWP	List	Key leaders from across the region included
Conduct a “legislative breakfast” or other gathering with key leaders to review elements of Climate Adaptation Plan	Short	Planning time, venue, funding for food	Coordinator, CWP (could combine this with news about other CWP initiatives, asks)	Event	Relationships built with key leaders
Strategy 2-2-2: Use local elections as an opportunity for educating local officials about climate issues.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Make contacts with candidates for office and provide Primer from Climate Plan	Med	People/Time Primer	Coordinator, CWP, ed. team	Contacts made and Primer in the hands of candidates	Candidates elected who are informed about local climate risks/strategies
Strategy 2-2-3: Invite local officials to all educational events, demonstration projects, public programs.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Develop a contact list of officials from the region	Short-Med	Addresses, e-mail lists	Coordinator, CWP (esp. County Planners)	Contact lists by municipality	List provides good contact coverage region wide
Use list to publicize all climate-related events, news	Short-Med	Up-to-date lists	Coordinator, ed. Team, key CW partners	Publicity about specific events	Local official participation at educational events & programs

GOAL 3: Conserve the current 75% forest land cover to protect water quality and quantity and enhance climate resiliency.

Objective 3-1: Establish collaborative land use policies or improve existing policies to foster forest, water and economic resilience.

Strategy 3-1-1: Conduct a region-wide survey/evaluation of existing land use statutes or other tools associated with forest and water resources protection (i.e. canopy cover, riparian buffers, impervious area restrictions, open space requirements, floodplain management, etc.) to identify gaps and flesh out successful models.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Contact Ann Hutchinson to work within the context of The Pocono Kittatinny Conservation Plan, which includes goals associated with municipal land use regulations	Short	Time	S. Beecher or Coordinator	Framework for survey	Framework for survey
Recruit college interns to work in collaboration with PKC and county planners	Short	Time, possibly small stipend for intern	Coordinator & county planners	Summary document w/ ordinance matrix	Summary document w/ ordinance matrix
Strategy 3-1-2: Using information from the region wide survey of land use statutes, work with the Upper Delaware Council (and/or other regional stakeholders) to develop recommendations for standards, compatible with the River Management Plan, to be incorporated in municipal land use ordinances.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Talk to UDC staff and Chair re: approach/ committee structure for developing recommendations	Short-med	Time, UDC participation	Coordinator and UDC staff	Land use tools	Utilization by UPDE municipalities
Keep current with Sullivan County Climate Action Plan effort, including opportunities for implementing climate resilient land use standards	Short-med	Time	Coordinator, SC Planner Heather Jacksey	Comments developed	Climate resilient land use tools included in SC Plan
Review NYC watershed program standards and talk to DEC staff about program's approach to watershed protection	Short	Time	Coordinator,	Summary of applicable tools	Additional tools for incorporation in recommendations
Develop draft recommendations and present to UDC and/or other stakeholders	Med	Time	Coordinator, UDC, county planner reps.	draft recommendations	Recommendations supported by UDC

Objective 3-2: Utilize education and voluntary incentive programs to facilitate maintenance of existing riparian buffers, restoration of degraded riparian buffers and reconnection of streams to floodplains.

Strategy 3-2-1: Look for examples of beneficial stream restoration projects/activities to hold up as examples/alternatives to post-flooding dredging and channelization					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Work with Sullivan County Conservation District, FUDR and Trout Unlimited to hold a stream restoration workshop/field trip for municipal officials and landowners	Med	Small amount of funding to support low/no fees	Coordinator, CWP Conservation Districts	Workshop	Broad representation of UPDE municipalities attending wkshp
Strategy 3-2-2: Work through Common Waters partners and forest landowner associations to identify opportunities for riparian buffer planting or riparian invasive species management demonstration projects					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify funding sources available for demonstration projects, including potential local sponsors	Med	Time	Coordinator,	Funding source(s) identified	Application submitted
Identify and contact prospective landowners/identify locations and partners	Med	Time	Conservation Districts, DHC	Contacts made/sites identified	Contacts made/sites identified
Secure funding and carry out demonstration project(s)	Med	Funding for plant materials, equip/supplies	Coordinator with identified partners	Project(s) completed	Successful demonstration of riparian vegetation importance

GOAL 4: Maintain and improve the ecological health and sustainability of the region’s forests.

Objective 4-1: Partner with forest management professionals and forest landowner groups to identify and implement management practices to improve forest health and sustainability while supporting climate resiliency.

Strategy 4-1-1: Using the Maryland DNR example, develop a landowner outreach piece about forest climate risks & strategies.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicators</i>
Look for small grant source for funding publication and distribution	Short	Time	Coordinator, CWP	Funding source identified	Application submitted
Convene a meeting of forestry professionals to help refine the piece for local conditions	Short	Time/lunch for foresters	Coordinator, Catskill Forest Assoc., Service Foresters	Meeting	Positive feedback on the outreach piece
Print document and, using Common Waters Fund mailing lists, send the piece to regional forest landowners	Short	Funding for printing and postage	Coordinator	Outreach piece distributed	Positive feedback from landowners
Strategy 4-1-2: Engage professional foresters and forest landowner groups in the region to present information from the Climate Plan, hear feedback and highlight forest risks and best practices for resiliency.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Contact Catskill Forest Association to inquire about partnering on this effort and to schedule time on CFA’s radio show	Short	Time	Coordinator, CFA	Contact made Radio spot scheduled	CFA agreement to participate
Using the CWF forester contact list, invite foresters to a discussion session (combine w/ forester mtg. in 4-1-1 above)	Short	Time/lunch for foresters	Coordinator	Meeting	Positive feedback from foresters
Get on the meeting agendas of Pike-Monroe and Wayne-Susquehanna Associations	Short-Med	Time	Coordinator	Attendance at meetings scheduled	
Using Primer and outreach piece from 4-1-1, meet with associations	Short-Med	Time/Primer/landowner outreach piece	Coordinator	Meetings held/outreach materials disseminated	Positive feedback from landowners
Strategy 4-1-3: Explore establishment of a Cooperative Weed Management Area for the Upper Delaware region to bring together landowners and land managers to coordinate actions and share expertise and resources to manage invasive plant species.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Contact CRISP coordinator to discuss group’s efforts and explore feasibility of expanding geographic area covered	Med	Time	Coordinator	Contact made	CRISP open to expansion of service area
Contact Donna Murphy, USFS for additional resources	Med	Time	Coordinator	Contact made	
Recruit CWP for a workgroup to move this effort forward	Med	Time	Coordinator/CWP	Volunteers	Work group formed

Objective 4-2: Partner with hunting and fishing clubs to support science-based deer population management that balances deer populations with sustainable forests and quality timber management.

Strategy 4-2-1: Work through CHAT (Pike/Wayne counties) and Catskill Forest Association in NY to bring Climate Plan findings to clubs and get feedback about this objective.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Schedule time on CHAT meeting agenda	Med	Time/Primer	Coordinator, Ken Ersbak or Scott Savini	Meeting	Feedback from group
Contact CFA to determine if there is a comparable club group to meet with in NY	Med	Time	Coordinator	Meeting	Feedback from group

Objective 4-3: Promote expansion of urban forests in the region’s cities and town centers.

Strategy 4-3-1: Work to incorporate this objective into cities’ and towns’ planning efforts.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Develop a contact list for all shade tree commissions or other such groups by county	Med	Time	Coordinator	List	List provides good contact coverage region wide
Contact USFS (Donna Murphy for resources) and Cooperative Extension offices to inquire about climate-related information for urban forests	Med	Time	Coordinator	Additional resources	
Look for CW Partner(s) or other champion to carry this objective forward	Med	Volunteer	Coordinator and TBD partner(s)		

GOAL 5: Enhance financial investment in Upper Basin forest management and land conservation through engagement with key stakeholder groups.

Objective 5-1: Establish a steady and long-term funding stream to the Common Waters Fund.

Strategy 5-1-1: Leverage the momentum gained through Common Waters Fund projects/activities to date.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Include landowner testimonials and key project details on Common Waters Fund website	Short	Time, landowner testimonials	Coordinator, CWF local partners, CWP Webmaster	Info on website	Visits to website
Look for continued outreach opportunities to downstream as well as Upper Basin water users	Short-med	Time, travel expenses	Coordinator, PIC, DHC	Meetings scheduled with water users	Buy-in from water users
Strategy 5-1-2: Leverage funding from various sources (NRCS, State forestry agencies, etc.) for implementation of climate resilient forest management practices.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Devote coordinator time to meet with NRCS and state agencies to identify climate resilient management practices that can be funded through existing programs	Short	Time	Coordinator, CWP NRCS contacts	Meeting(s)	Mgmt. practices and program funding identified
Meet with NRCS to explore a potential Cooperative Conservation Partnership Initiative agreement to administer funds for Common Waters Fund forest stewardship planning and implementation activities	Med	Time	Coordinator, CWP NRCS contacts, PIC	Meeting	Partnership agreement established
Strategy 5-1-3: Building on existing materials, studies, research reports, etc. develop a comprehensive toolkit of information that highlights the economic value of natural resources in the Upper Delaware region.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Conduct a comprehensive review of available information starting with Kauffman, Costanza	Med	Time	Coordinator, PIC, DHC, TNC	Toolkit	
Tap CWP academic contacts for assistance	Med	Time	Coordinator, PIC, DHC, TNC		

Strategy 5-1-4: Identify additional information that water users need to justify making investments in source protection upstream.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Debrief PIC staff on their work to date in reviewing existing studies and models to identify data gaps	Short	Time	Coordinator, PIC		
Identify key partners and funding to undertake research and modeling efforts to meet these needs	Med	Time, funding options, academic partners	PIC, CWP		
Look for successful examples of how water users contribute financially to source protection	Med		Coordinator, PIC		

Objective 5-2: Work with partners towards additional open space bond ballot initiative(s) to fund land acquisition/easement purchases.

Strategy 5-2-1: Engage with William Penn Foundation’s Pocono-Kittatinny Cluster (PKC) as they work to frame messages, recruit business leaders and conduct attitudinal polls in targeted counties to gauge public support for open space land protection.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Participate in PKC’s proposed Action Network of Volunteers for potential open space initiatives in targeted counties and possibly some municipalities.	Med	Time	Coordinator, CWP	Action Network of Volunteers members	Bond initiative(s) on ballot

Objective 5-3: Promote tax assessment policies that incorporate the value of ecosystem services provided by forest lands and help keep forests as forests.

Strategy 5-3-1: Utilize a subcommittee of the Common Waters Partnership in collaboration with state representatives, forest landowner groups and consulting foresters to explore systems in use by other states, examine options and develop recommendations for improving each state’s (NY, NJ, PA) policies.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Convene subcommittee of interested partners to move this objective forward	Med-Long	Time	Coordinator, PIC, DHC	Committee formed	

GOAL 6: Reduce the impacts of flooding and stormwater runoff from extreme storm events on people, property and infrastructure.

Objective 6-1: Direct development away from floodplains.

Strategy 6-1-1: Promote cross-border conversations of governmental and non-governmental agencies on basin-wide flood management.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Contact DRBC to make connections with Flood Advisory Task Force chair	Short	Coordinator time	Coordinator	Connection made	
Develop municipal outreach plan using DRBC Flood Advisory Task Force recommendations	Med	Coordinator time, travel expenses	DRBC, county planners, UDC, EMA directors, municipal PEMA reps	Plan of action for outreach	
Strategy 6-1-2: Develop region-specific data that quantifies the impacts and costs of extreme storm events and projects the potential savings associated with maintaining intact floodplains.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Participate with MFPP/NOAA project to <i>Develop and Pilot Strategies to Mitigate Climate-Related Disaster Risks and Secure Co-Benefits for People and Communities</i>	Med 2014-2016	NOAA grant to MFPP, coordinator time, stakeholder outreach	Coordinator, PIC	CWP as one of the pilot communities	Cost data and stakeholder buy-in
Contact FEMA for an update on the flood inundation models for the Milford/Matamoras area and inquire about extent of this work and possibility of expanding study area	Short		Pike Co. Comm. Planning		
Use flood inundation maps for municipal outreach	Med		Coordinator, County Planners		
Strategy 6-1-3: Improve participation in buy-out programs for repetitive loss properties.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Work through county planners and emergency management personnel to develop a list of repetitive loss properties	Med		Coordinator, county planners, EMA staff	List	Comprehensive regional list by county
Collect and distribute outreach information about buy-back programs to property owners	Med	Funds for mailing	Coordinator, county planners, EMA staff	Outreach info distributed	Inquiries from property owners to county personnel

Objective 6-2: Enhance preparedness of local governments for extreme weather events and associated transportation and power disruptions.

Strategy 6-2-1: Incorporate climate change into updates of emergency plans/hazard mitigation plans, stormwater management plans, comprehensive plans, etc.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Bring findings of climate plan to county emergency management coordinators	Short	Time, Primer, contact info for EM coord.	Coordinator and County Planners	Meeting(s)	
Track planning efforts through regular updates at CWP meetings	Short-Med	Time	Coordinator, CWP	Ongoing list of planning efforts	
Provide input during planning processes through advisory committees, meeting attendance, written comments	Short-Med	Time	Coordinator, County Planners or other applicable CW Partners	Climate-related input provided	Climate resiliency measures incorporated
Strategy 6-2-2: Identify tools for municipalities for updating culvert sizing and bridge design standards to incorporate changes associated with extreme precipitation events.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify individuals in State dept of transportation design units who might assist in this effort	Med				
Strategy 6-2-3: Support efforts to finding funding and other mechanisms to begin to address backlog of high hazard dam maintenance and repairs.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
	Med				
Strategy 6-2-4: Engage with utility companies on how best to avoid situations that would lead to service disruptions.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Identify utility company community outreach individuals for all regional electric service providers	Med	Time	Coordinator	Contact info for company reps.	
Work with outreach reps. to identify landscaping or other strategies around utilities to limit damages during extreme weather	Med	Time, participation by utility companies	Coordinator	Concise info compiled	
Have utility companies incorporated this information on their websites	Med	participation by utility companies	Coordinator	Info posted on websites	

GOAL 7: Support, mitigate impacts to and enhance the region’s agriculture, tourism and recreation industries while identifying and capitalizing on new economic opportunities presented by a changing climate.

Objective 7-1: Create a story line (personal accounts) about impacts to and opportunities for the agriculture, recreation and tourism industry associated with climate change.

Strategy 7-1-1: Work initially with <i>Natural Economies</i> workshop participants to identify and engage local business owners.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Retrieve contact list from workshop organizers	Short	Time	Coordinator, Stewart Comm.	List	
Identify other key business owners	Short	Time	Coordinator, CWP	Additions to list	
Tap NACL’s oral history component of the Weather Project to include climate stories focused on businesses	Short	Time/people to participate	Coordinator, NACL	Recordings of people’s local experiences with climate change	Good cross section of stories supporting climate risk findings
Incorporate stories as a feature of Common Waters website and contact Mikki Uzupes about airing stories on her radio show	Med	Time, webmaster time	Coordinator, ed.team	Web posting/ radio airing	Feedback and offers of additional stories

Objective 7-2: Partner with Chambers of Commerce to inform business owners about current and potential economic impacts associated with a changing climate and how to prepare for extreme weather events to mitigate losses.

See cross-cutting Strategy 2-1-5 and associated actions to meet this objective.

Objective 7-3: Consolidate information that identifies and quantifies the economic value of the region’s natural resources.

See cross-cutting Strategy 5-1-3.

GOAL 8: Promote basin-wide flow management policies that will ensure sufficient water quantity for both human and ecological needs.

Objective 8-1: Build support among Supreme Court Decree Parties and DRBC for incorporating climate resiliency into flow management policies.

Strategy 8-1-1: Identify decision makers that need to be influenced, policies that need to be changed, messages that need to be heard and who can best deliver the messages.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Build a relationship with the new Director of DRBC – invite to CWP meeting focused on UPDE water issues	Short	Time, travel expenses	Coordinator, PIC	Contact(s) made	Continued DRBC support of CWP
Meet with Friends of the Upper Delaware Executive Director and Trout Unlimited to provide Plan information and get information on current issues/initiatives and how CWP can best support those initiatives	Short	Time, travel expenses	Coordinator	Contact(s) made	Additional partnerships formed
Strategy 8-1-2: Enhance local stakeholder representation in flow management discussion/policy-making.					
<i>Actions</i>	<i>Timing (S,M,L)</i>	<i>Resources Needed</i>	<i>Responsible Parties</i>	<i>Deliverable</i>	<i>Success Indicator/s</i>
Review, provide comment on draft TNC/DRBC Delaware River Basin Ecosystem Flow Study report when available	Short	Time	Coordinator	Comments	Study recommendations consistent with Plan
Call on Common Waters Partnership members to support, where appropriate, the efforts of conservation groups already engaged in this effort – invite reps to CWP meetings for updates	Med-Long	Time, consensus	Coordinator, CWP Steering Committee	Partner support where applicable	
Meet with state and federal legislators to advocate for local representation in flow management decision-making affecting the Upper Basin	Med-Long	Time	Coordinator, UDC, NPS	Face-to-face meetings	Legislators knowledgeable of issues

Plan Implementation

Common Waters is a regional partnership of 40 governmental and non-governmental organizations and agencies focused on cross-boundary collaboration to conserve clean water, natural places, and working lands in areas threatened by forest loss and fragmentation. The Partnership, which includes a broad spectrum of stakeholders with local ties to the people and governments of the Upper Delaware region, is a key mechanism for leveraging efforts and funds to conserve forests on a landscape scale. As such, members of the Partnership will be crucial to both the near and long-term success of this Climate Adaptation Plan. Preparing for climate change doesn't need to happen in a void. Common Waters Partners and the communities to which they are tied already administer a wide variety of programs that can be used as vehicles to implement this Plan.

The Pinchot Institute for Conservation, which serves as the fiscal agent and coordinator for Common Waters, is no less important for Plan implementation. Pinchot Institute provides an important framework for fundraising and grant administration. Pinchot's small but very dedicated staff is based in Washington, DC and works throughout the country. They have a strong history with Grey Towers National Historic Site in Pike County, PA, and they bring to the table significant expertise in forest conservation thought, policy, and action.

The challenge for these two entities in implementing this very ambitious regional scale climate adaptation plan will be raising the funds necessary to support added capacity to coordinate this work in synergy with all of the Partnership's other activities. While not an absolute necessity for all of the actions identified, added capacity would greatly enhance the ability to implement this plan on a landscape scale and within a timeframe in keeping with the rapid pace of climate change and the associated environmental changes being experienced locally.

In the short term, the Pinchot Institute for Conservation is leading the effort to identify and secure funding for a person or persons to coordinate Plan implementation moving forward and to continue the relationship with the Model Forest Policy Program through the Climate Solutions University Implementation Support Network. Pinchot is also incorporating certain implementation components into funding proposals for 2014. Current core group leader Susan Beecher will shepherd the early implementation efforts until a coordinator is identified for the longer term.

Given the many jurisdictions potentially involved in implementing a regional plan such as this one, a helpful early organizational task would be the creation of a policy and governance summary table for the region. This task could be accomplished by the current core planning team with the assistance of county planners.

It will also be important in the short term to distribute this Climate Adaptation Plan for the Upper Delaware region widely beyond the Common Waters Partnership - to local government decision makers, agency staff, organizational representatives and the general public. A distribution list can be brainstormed at the last Common Waters Partnership meeting of 2013. This will be beneficial in developing new partnerships with groups having overlapping interest and/or responsibility for climate change planning and adaptation, avoiding duplicative efforts, combining resources and identifying ways to translate the Plan's broad goals into specific local jurisdictional activities.

Members of the current planning team will start working immediately with Common Waters partners to build the education team that will focus on public engagement strategies and to identify Common Waters partners interested in and available to work on other plan components. Regular updates on Plan implementation will be provided at quarterly Common Waters Partnership meetings to assure synergy with other ongoing Partnership efforts. An end of the year review and progress report will be compiled by the coordinator, presented to the Common Waters Partnership, posted on the Common Waters website and shared with key stakeholders.

Measuring Progress

The end of the year review and progress report will provide a good starting point for tracking the success of Plan implementation. Additional suggestions for measuring progress are provided in Chapter 12 of *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments* (Snoover, et al, 2007), which outlines four recurring steps that can be pursued at regular intervals by the coordinator, the education team (or other groups formed to assist with specific elements of the Plan) and the Common Waters Partnership Steering Committee:

1. Measure progress in implementing the action plan and identify whether it is helping to meet the vision for climate resilient communities (examples of measurement tools and a set of simple guiding questions are included to assist in this task);
2. Periodically review the basic assumptions that guided the risk assessments, priority planning areas and goals development along with the information collected from measuring progress in #1 to ascertain whether assumptions have changed over time;
3. Update the Plan and actions based on information from #1 and #2;
4. Look beyond the Plan for opportunities to share what's been learned.

Anticipated Outcomes

This Climate Adaptation Plan for the Upper Delaware Region represents a real opportunity for the people and governing bodies of the region to prepare for a “new normal” set of environmental conditions; to take steps now to help our region adapt to warmer temperatures, changing hydrology and more unpredictable weather patterns; to factor in climate changes as an integral part of existing planning efforts; and to manage risks and reduce the social, economic and environmental costs associated with those risks. Climate adaptation can be likened to an insurance policy for the future. In much the same way that we protect our homes, our cars and our health against losses, we can prepare the Upper Delaware region for changing environmental conditions.

The Action Plan maps out an ambitious set of goals, objectives, strategies and actions to be accomplished over the short- and longer term. This Plan has clear benefits, not just for climate resiliency but for addressing existing non-climate forest and water stressors.

Generating active dialogue and information exchange about climate change risks in the region is one of the most important things we can do because knowledge opens the door to action. We are certain that if the people of this region understand what is at stake and the steps they can take individually and collectively to reduce risk, they will act decisively to influence the outcome.

Maintaining the 75% forest cover (even higher in some parts of the region) will support our exceptional water resources and benefit both the people and economy of the Upper Delaware region in three states, seven counties and hundreds of municipalities. These forest and water resources are also essential to some 16 million water users - people and businesses - in urban centers both in and outside of the watershed who depend on the Delaware River for their water supply. By utilizing smart growth policies that limit forest loss and impervious cover, local governments can promote growth of new businesses while supporting the keystone tourism and recreation industry and the quality of life that draws new visitors, entrepreneurs and residents to the region. Such policies can also provide a tactical advantage for the Upper Delaware region as the Supreme Court Decree parties and DRBC adjust flow management policies to a changing climate, changing hydrologic conditions, changing population and changing water demands in the basin in years to come.

Improving the health and sustainability of the approximately 1.8 million acres of privately-owned forests and the myriad of undervalued ecosystem services they provide both in the region and beyond is one of



Figure A-3: Mitigate, adapt or suffer - the choices seem intuitively simple. *Source: Adapted from Dahlman 2013.*

the most cost-effective hedges against climate change, but also perhaps the most complex. Landscape-scale forest protection and management on privately owned lands in important source water areas needs to be approached using a suite of strategies and collaborative efforts to meet diverse landowners needs while focusing on the bigger picture of forest conservation. We have already seen through the Common Waters Fund program that many landowners, given technical and financial assistance, have great interest in stewardship planning and forest management to meet a variety of goals that help keep forests as forests. Building upon the success of the Common Waters Fund to support landowners already engaged, to reach additional landowners and find additional funding to do so will provide landowners with key information about climate risks to forests and strategies to improve forest health and resiliency. This outcome, driven by private forest landowners, but supported by those who enjoy the multitude of benefits provided by private forestland would benefit some 16 million water users basin-wide and beyond.

By increasing their financial investments in forests of the Upper Basin, the Supreme Court Decree parties and other water users outside of the Upper Delaware region can be proactive, cost-effectively reducing threats to the water quality and quantity of the Delaware River. These investments can reduce the threats to water resources coming from population growth and land cover changes, as well as climate change related alterations in hydrology that could ultimately force the need for costly water treatment or additional storage capacity.

Directing development away from floodplains makes people, property and infrastructure less vulnerable to the increased runoff and changing precipitation patterns that we are already experiencing in the region. Taking advantage of intact floodplains is a cost-effective flood control strategy that saves money and lives and breaks the cycle of repetitive flood losses to properties in flood prone areas. Protecting the tree canopy along stream corridors or planting trees where there are none buffers stream banks and adjacent properties from the erosive forces of extreme precipitation events, provides cooling and refuge for fish during periods of high air and water temperatures, and helps filter pollutants from stormwater runoff. The outcomes from these efforts include a reduction in streamside property damages and costly stream restoration projects, maintenance of a world-class trout fishery and high quality eagle habitat and a healthy and growing tourism and recreation economy.

There is much at risk with climate change, but the Upper Delaware region also has the natural assets that can help reduce those risks: a relatively high percentage of forest cover; private landowners with a stewardship ethic; clean water and healthy ecosystems; and governmental and nongovernmental groups working to support sustainable communities and working landscapes. Translating this plan to action will support those efforts already underway while building a solid foundation for lasting prosperity, improving the lives of the people who live here and the experience of visitors, strengthening the economy, and maintaining the health of the natural systems that sustain us - both now and for future generations.

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Appendix 1: Members of the Common Waters Partnership



Building Consensus for Sustainability
Catskill Forest Association
Delaware Highlands Conservancy
Delaware River Basin Commission
Environmental Protection Agency
Lacawac Sanctuary
League of Women Voters, Pennsylvania
Monroe County Conservation District
National Fish and Wildlife Foundation
National Park Service, Delaware Water Gap National Recreation Area
National Park Service, Rivers and Trails Conservation Assistance
National Park Service, Upper Delaware Scenic and Recreational River
Natural Lands Trust
Natural Resources Conservation Service
New Jersey Forest Service
New York Department of Environmental Conservation
Orange County, NY Department of Planning
Pennsylvania Department of Conservation and Natural Resources
Pennsylvania Environmental Council
Pike County Conservation District
Pike County, PA Office of Community Planning
Pinchot Institute for Conservation
Pocono Environmental Education Center
Pocono Resource Conservation and Development Council
Sullivan County, NY Division of Planning and Environmental Management
Sullivan County Soil and Water Conservation District
Sussex County Soil Conservation District
Sussex County, NJ Department of GIS Management
Sussex County, NJ Planning Division
The Nature Conservancy, National Headquarters
The Nature Conservancy, New Jersey
The Nature Conservancy, Pennsylvania
Upper Delaware Council
Upper Delaware River Roundtable
US Forest Service, Grey Towers National Historic Site
US Forest Service, State and Private Forestry
Wayne Conservation District

Appendix 2: DRBC Flood Advisory Committee (FAC) Recommendations for more Effective Floodplain Regulations in the Delaware River Basin, October 2009

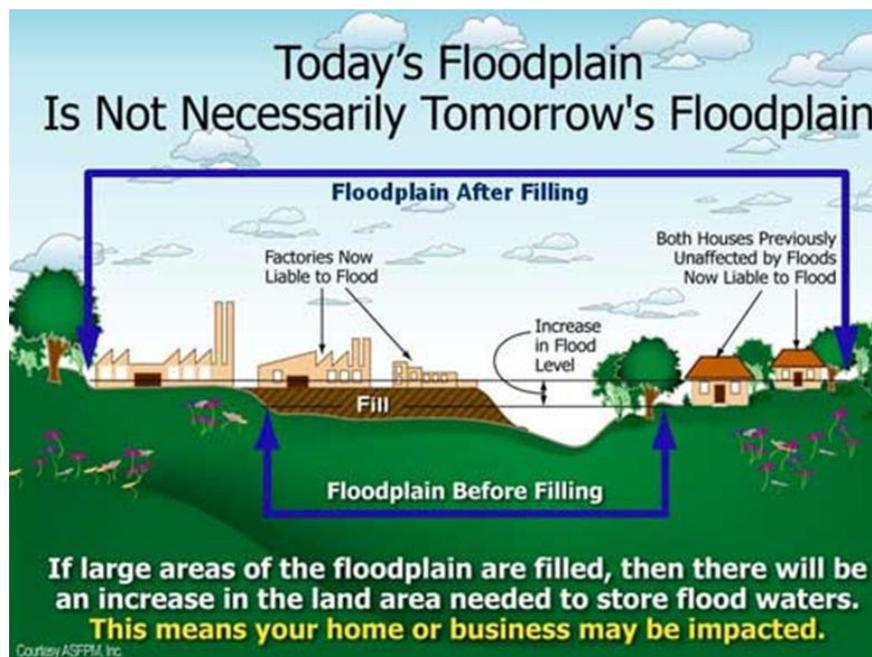
SUMMARY:

The Flood Advisory Committee (FAC) presented a report containing twelve (12) recommendations for more effective floodplain regulations to the Commission in October 2009.

Flood damage potential is a function of human development in floodplains. The regulations currently in place for addressing development in the floodplain have not successfully reduced flood damages. In fact, existing regulations have continued to allow new development and redevelopment of flood-prone lands in the Basin. This has resulted in an increased population at risk.

The Committee determined that minimum floodplain management regulations, administered by FEMA through the National Flood Insurance Program, do not adequately identify risk or prevent harm. Although some states and communities in the Basin have adopted more stringent floodplain regulations, the committee recognized that floodplain regulations are inconsistent from State to State and from community to community.

The FAC recommends that floodplain regulations need to be applied more consistently and comprehensively, on a watershed basis that reaches across jurisdictional boundaries. A new minimum standard that is more stringent than the FEMA national minimum standards needs to be applied in the Delaware River Basin.



Below is a brief summary of the twelve (12) FAC recommendations:

A. Regulatory Floodplain Definition:

1. The regulatory floodplain for waterways in the Delaware River Basin should be greater than the
1% annual chance (previously known as the 100-year) floodplain.
2. Unmapped waterways of the Basin need a mechanism for identifying the regulatory floodplain.

B. Floodway Definition:

The floodway in the Delaware River Basin should be defined by a 0.2 foot rise standard for main stem Delaware River and all other streams and rivers within the basin. The floodway is currently defined as a less restrictive 1.0 foot rise.

C. Development/Fill in the Flood Fringe:

Protect the flood fringe in a naturally vegetated state and limit development including, but not limited to, structures, infrastructure, impervious surfaces, fill, grading and removal of vegetation.

D. Development/Fill in the Floodway:

New development in floodways should be prohibited.

E. Stream/Riparian Corridors and Vegetation Disturbance:

Incorporate the buffer concept as part of a comprehensive floodplain management program to protect communities from flood damage.

F. Adopted Building Code:

Continue the adoption of International Codes issued by the International Code Council.

G. Standards for the Lowest Habitable Floor of Structures (Freeboard):

All new substantially improved residential, institutional and commercial structures within the Delaware River Basin should be constructed two (2) feet above 1% annual chance base flood elevation.

H. Enclosed Areas below Flood Elevation:

1. Deed restriction should be required for enclosures.
2. Structural requirement: If the enclosure below the flood elevation is greater than 6 feet in height measured from floor to floor, at least 25 percent of the surface area of the outer wall of enclosures should be left permanently open.

I. Substantial Damage/Improvement to Structures:

1. Cumulative Substantial Damage Declaration
2. Tracking of Cumulative Substantial Damage/Improvements

J. Dams and Flood Damage Risk:

1. Increase monitoring of dams. Dams with a clear and present danger of failure should be removed.
2. States should increase funding and assistance to small dam owners for evaluation and removal.
3. Hydraulic studies in the vicinity of high and medium hazard dams should be revisited to evaluate the change in flood hazard areas.
4. Completion of emergency action plans for high hazard and significant hazard dams must be prioritized. These plans contain inundation maps that identify flood hazard areas in cases of a dam failure.
5. Before a dam is removed, hydraulics must be revisited to evaluate the adequacy of downstream drainage structures, and the accuracy of upstream floodplain maps.
6. Require the evaluation of downstream flooding impacts as part of the permit application process for dam decommissioning or dam repair which increases spillway capacity.

K. Bridge/Culvert Construction or Reconstruction and Flood Damage Risk:

1. Design new bridges and culverts to ensure that flooding to existing buildings or facilities is not exacerbated upstream or downstream. Design should be based on the results of updated flood models using recent climate data that incorporates changing precipitation trends.
2. Maps should be updated for new crossings.

L. Stormwater Regulations - New and Redevelopment:

The goal of stormwater design within the Delaware River Basin should mimic pre-development hydrology at a minimum.

The full report and background on the Subcommittee that advised the FAC can be viewed online at: <http://www.nj.gov/drbc/programs/flood/floodplainregs.html>

Appendix 3: Climate Risk Analysis Tables

Risks to Forests				
Risk/Stressors	Consequence (L,M,H)	Probability (L,M,H)	Ability to Respond (L,M,H)	Risk Value (L,M,H)
Warmer temperatures/milder winters/longer growing season	High More insects and diseases harmful to forests	High Already occurring & widespread	Low High cost to address/ Chemical treatments have risks	High
Warmer temperatures/milder winters/less snow	High Reduced winter deer mortality, higher deer populations and impacts to tree regeneration	High Already occurring	Low Much coordination needed across state agencies; hunters want more deer	High
Overall reduction in forest health and forest cover from various climate stressors	High Loss of habitat, migratory corridors and breeding areas, affecting birds and wildlife	Med Some uncertainty assoc. with ability of species to adapt to changing conditions	Med Land use/smart growth policies & improving forest health could help	High
Overall reduction in forest health and forest cover from various climate stressors	High Loss of ecosystem services: flood control, stormwater mgmt., pollutant filtration, carbon sequestration	Med Some lack of specifics assoc. with extent of ecosystem services loss and valuation	Med Land use/smart growth policies & improving forest health could help	High
Additional population growth from climate refugees	High More development pressure/forest fragmentation & loss	High Esp. given current and projected population increases	Med Can't blow up bridges; land use/smart growth policies could help	High
Warmer temperatures/milder winters/longer growing season	High More invasive plants and less-than-desirable native species	High Already occurring	Medium Some management successes, although expensive	Med
Drier summers and longer fire season	High Increased wildfire risks and associated property damages	Med Extreme precip. events may be moderating drought risk in recent years	Med Some coordination already w/fed, state and local agencies; high cost is a factor	Med
Increase in extreme weather events	Med Tree mortality and forests more susceptible to pests and diseases	High Already occurring	Low Insects/diseases already a factor	Med
Future temperature increases, hydrologic changes and shifts in growing season	Med Changes in forest species composition and regeneration problems for some species	Med Some uncertainty about how this will play out and when	Med Overall focus on improving forest health and diversity could help	Med
Warmer temperatures/milder winters/less snow	Low Reduced winter season for harvesting and other management practice implementation	Med Already occurring; low prices/lack of markets for timber also affect harvesting	Med Could shift harvest time and use other BMPs to reduce disturbance and compaction	Low

Risks to Water Resources				
Risk/Stressors	Consequence (L,M,H)	Probability (L,M,H)	Ability to Respond (L,M,H)	Risk Value (L,M,H)
Extreme precipitation events accompanied by flooding and stormwater runoff	High Streambank erosion and channel changes	High Already occurring	Low Can't control mother nature, expensive to repair – repairs failing w/ new events	High
Extreme precipitation events accompanied by flooding and stormwater runoff	High Water quality and habitat degradation: erosion & sedimentation, turbidity, SW pollutants, sewage overflows	High Already occurring	Low Can't control mother nature, minimal SW mgmt., some STPs already in FP	High
Additional population growth from climate refugees	High More development pressure/forest loss/impervious surfaces increase	High Esp. given current and projected population increases	Med Can't blow up the bridges but could develop better land use/growth management policies	High
Higher air and water temperatures/extreme heat/periodic drought	High Thermal stress to trout during summer heat waves/eventual loss of cold water fisheries	High Problem already exists	Low Many groups in region w/ interest, but Supreme Court Decree limits options and temps increase under all emissions scenarios	High
Higher temperatures/increased evapotranspiration/ prolonged periods of drought	High Reduced water storage in reservoirs/increasing competition for less available water – esp. high risk for downstream water users and ecological flows	High Already many competing demands for UPDE water and population continues to rise	Low High cost and environmental constraints of developing additional storage, Supreme Court Decree limits responses	High
Rising sea levels in coastal areas of the lower basin	High Rising sea levels downriver will increase demands on Upper Basin water to mitigate salt water intrusion	High Sea level rise already occurring	Low Can't stop sea level rise/Upper Basin will be the loser in this as legal entitlements are satisfied first	High
Higher air and water temperatures	Med Enhanced algae growth and lake thermocline disruptions	Med Already occurring in some lakes	Med	Med
Higher temperatures/increased evapotranspiration/ prolonged periods of drought	Med Depending on frequency and length of droughts, groundwater dependent water supplies see seasonal impacts	Med Extreme precip could temper this impact somewhat	Low High percentage of region depends on GW for drinking water supply	Med

Risks to People and Economies				
Risk/Stressors	Consequence (L,M,H)	Probability (L,M,H)	Ability to Respond (L,M,H)	Risk Value (L,M,H)
Warmer winters/less snow/more rain on snow events/higher spring flows & flooding	High More structural damage in flood plain; injury, loss of life	High Precipitation and floods already occurring	Low Historic floodplain development Cannot affect rainfall	High
Extreme precipitation events accompanied by flooding and stormwater runoff	High Both river and tributary flooding, property damages and infrastructure damage – roads, culverts, bridges, drainage facilities	High Precipitation, flooding and SW runoff already occurring	Low Can't control mother nature, minimal FP and SW mgmt., expensive to upgrade drainage structures and repair roads	High
Extreme precipitation events accompanied by flooding and stormwater runoff	High Impacts to high numbers of high hazard and significant hazard dams/potential for catastrophic failures	High Risks already existing, even without added precip. from extreme events	Low High costs, private ownership of many dams and lack of funding makes repairs difficult	High
Overall reduction in forest health and forest cover from various climate stressors	High Loss of ecosystem services flood control, stormwater mgmt., pollutant filtration. carbon sequestration	Med Some uncertainty about extent of ecosystem services loss and valuation	Med More emphasis on green infrastructure could reduce costs	High
Warmer temperatures/milder winters/longer growing season	High Increased costs to landowners and land management agencies of forest pest management/eradication	High Already occurring	Low	High
Increased turbidity, nutrient and other pollutant discharge during extreme precip. events	High Rising costs for water treatment (mostly a risk for downstream surface water users)	High Turbidity already a problem during heavy precip	Med Can't control mother nature, but improved SW mgmt. would help	High
Higher temperatures/increased evapotranspiration/ prolonged periods of drought	High Increased competition for available water/need to develop additional storage to meet demand	High Already competing demands. Pop. growth a factor also.	Low High costs and many environmental constraints assoc. with developing new storage	High
Rising water temps. Loss of cold water fisheries	High Decreased fishing opportunities for anglers and revenue losses for businesses	High Already a seasonal problem	Med Still have warm water fishing opportunities for anglers	High
Extreme precipitation	High Direct agricultural crop damages	High	Low	High
Higher temperatures/more precipitation	High Human health care costs related to higher incidence of Lyme disease, West Nile Virus, waterborne pathogens	High	Med Some regional variability in access to health care	High

Higher temps. increase algae blooms	Med Increased costs of treatment	Med Impact varies w/ lake and watershed conditions Many lakes already eutrophic	Low Many lakes privately owned by community associations	Med
Extreme heat	High Health impacts- to vulnerable populations – heat stress, respiratory problems	Med	Med	Med
Warmer temperatures/milder winters/longer growing season	Med Higher pollen-levels and associated allergy & other respiratory problems	High	Med	Med
Warmer temperatures/milder winters/longer growing season	High Increased agricultural weed and insect pressure	Med	Med Increased use of pesticides could lead to other problems	Med
Higher temperatures/increased evapotranspiration/ prolonged periods of drought	Med Increased crop water demand	Med	Med Could transition to less water dependent crops	Med
Extreme heat	Med Reduced milk production and/or crop yields	Med	Med-Low Dairy farmers already struggling w/ low milk prices. Could transition to different crops	Med