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# REGIONAL REPORT: NORTHEAST

## EXECUTIVE SUMMARY

*The Northeast Region consists of Maine, New Hampshire, Vermont, Massachusetts, New York, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Delaware, Maryland, and West Virginia.*

The most populous region in the US, the Northeast coastal corridor from Washington, D.C. to Boston, MA contains 17% of the nation's population on 2% of the land.<sup>1</sup> Inland, the region is known for its ecological diversity and small-town farming. The hills and valleys of the Appalachian Mountains, as well as their numerous sub-ranges, create havens of biodiversity isolated from human populations in the region.<sup>3</sup>

Because so much of the Northeast's infrastructure is centered on coastlines, it is highly vulnerable to hurricanes, flooding, and sea-level rise. The 2012 Hurricane Sandy caused an estimated \$60-80 billion in damages across New York, New Jersey, and Connecticut. Transportation systems were crippled as subway stations filled with water and highways flooded. The impact of hurricanes illustrates the region's vulnerability to rising seas due to melting ice and to increasingly frequent and more severe storms.

Although the Northeast has an extensive history of land use and high population densities, biodiversity is found in rural areas and state parks as well as directly within urban centers. Ecological experiments abound in the towns and cities of the New England, with residents frequently encountering coyotes, raccoons, and bears as suburbs sprawl into forested areas. Thousands of shorebirds roost in the islands of New York City's harbor, millions of migrating birds visit the city's parks, and cameras recording hawks nesting on skyscrapers surge in online popularity.

Links between biodiversity and humans are unfortunately also exemplified by diseases that are shared or catalyzed to spread between people and animals. Native bat populations have been decimated by a fungal disease known as White Nose Syndrome, which can be spread by humans moving the fungus between caves. The loss of millions of bats has diminished their natural ecological service of consuming insects, resulting in larger insect populations that pose risks to crops in the region. On the other hand, deer populations continue to grow in the absence of their natural predators (wolves), providing more and more opportunities for the transfer of Lyme-disease-carrying ticks from deer to humans.

## Regional Overview

### GEOGRAPHY & GEOLOGY

This region can be divided geographically and geologically into three major regions. The first region, the inland basin region, contains the Appalachian plateau. This Appalachian plateau was once a shallow inland sea that gradually built up layers of sand, silt and clay, resulting in the formation of oil, coal and natural gas reserves. Notably, the Bradford oil field, which historically was a major source of revenue during the Pennsylvania oil rush, extends from northwestern Pennsylvania to southwestern New York and is a product of this geologic history (Paleontological Research Institution, n.d.). The Marcellus shale formation, located in West Virginia, Pennsylvania, and New York, is yet another important geological feature of this region due to its natural gas content. USGS scientists estimate that the rock region contains 500 million cubic feet of natural gas, enough to meet U.S. demand for the next 25 years (Paleontological Research Institution, n.d.).

The second region, the Appalachian region, is characterized by valleys and ridges that are made from Precambrian rocks. The Appalachian Mountains, running from Maine down to Georgia, form the backbone of this region. Additional, smaller mountain ranges include the White Mountains in New Hampshire, which contain the tallest point in the eastern United States, Mt. Washington at 6,288 ft. The region also includes the Berkshires in Massachusetts, the Catskill Mountains in New York, the Poconos in Pennsylvania, and the Great Smoky Mountains, all of which contribute to the hills-and-valleys topography of the region. Although not geologically related, the Adirondacks Mountains, found in New York, are also found in this region. The Adirondacks are an unconnected series of mountain ranges that are a remnant of the Laurentian/Canadian Shield (New World Encyclopedia, 2013). The Adirondacks are important because they contain 85 percent of the the entire wilderness in the Eastern United States. Adirondack Park attracts nearly 9 million visitors each year, making it the most popular wilderness area in the Northeast (Thorndike, 1999).

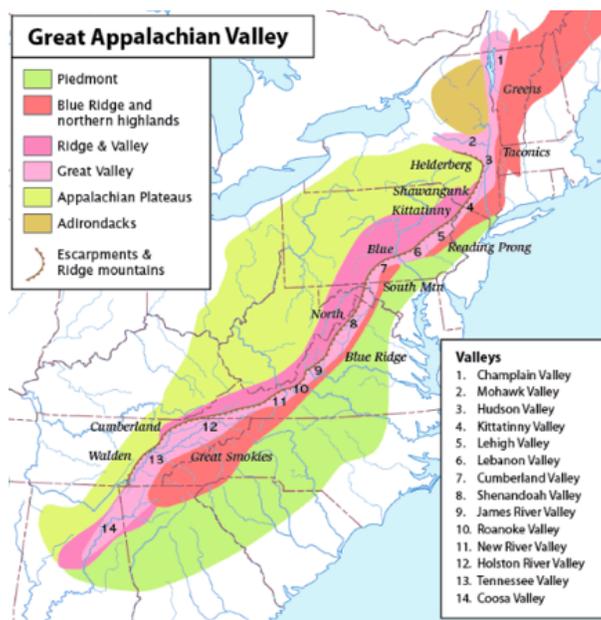


Fig. 1. A Map of the Great Appalachian Valley. "Great Appalachian Valley." *Wikipedia*. 2010. Web. 02 June 2015.

The third and final region, the coastal plain, begins with the Fall Line, a series of rapids and waterfalls that runs from Maryland to Long Island Sound, and it consists of young and soft sedimentary rocks from the erosion of the Appalachian mountains (Grymes, n.d.). Figure 2 shows the distinct separation between the Piedmont region and the Coastal plain. Marine shells and fossilized remains of whales indicate that this region is formed mostly on eroded sediments from the Appalachian mountain range (National Park Service, n.d.).

Various physical features such as river valleys, bays, and islands also characterize the geography of the coastal plain region. River valleys such as the Hudson, James River, and Champlain Valley contain key population centers because of the ease of river transportation. Notable rivers in this region

include the Delaware, Hudson, Connecticut, Kennebec, and Susquehanna rivers. Important bays include the Chesapeake (stretching from Maryland to Virginia), Long Island Sound (off the coast of New York), and Cape Cod in Massachusetts. Lastly, large islands have been heavily developed within the Northeast. These include Nantucket and Martha's Vineyard in Massachusetts, Block Island in Rhode Island, as well as Long Island, Manhattan Island, and Staten Island in New York.

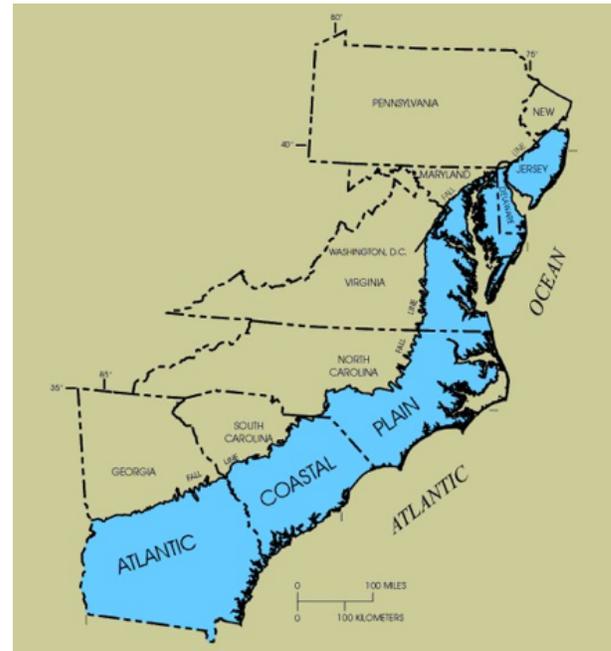


Fig. 2. Location of the Fall line. "Geology of the Fall Line". nd. Web. 03 June 2015.

## CLIMATE

The Northeast has a humid continental climate. While all areas in the Northeast experience four distinct seasons, the intensity of seasonal changes varies according to latitude (NOAA, 2013). The northernmost climatological zone is generally defined as above the 43rd parallel, including the states of Maine, New Hampshire, and Vermont, as well as upstate New York (NWS, 2010). This climatological zone is characterized by heavy snowfall in the winters: valleys and coastal regions average 35 inches of snow annually, while the Appalachian, White, and Green Mountains can average up to 100 inches of snow. In upstate New York, lake effect snowfall from the Great Lakes causes the the Tug Hill Plateau region

to experience extreme winter weather each year (NOAA, 2013). The region averages around 200 inches of snowfall per year, but some years receive up to 500 inches of snow. Summers in this climatological region are characterized by cool, but humid, conditions. This zone also experiences extended fall and summer transition seasons with moderate temperatures and moderate precipitation. The long duration of fall in the northern Northeast draws tourists from September to November each year to see the bright colors of the deciduous forests in these states.

The more moderate climatological zone in the Northeast extends from the 43rd parallel to the 39th parallel, plus mountainous West Virginia. Thus, it includes the states of Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, and West Virginia (NWS, 2010). This zone is characterized by moderate or variable snowfall in the winters. Coastal regions receive on average 30 inches of snow per winter, while inland regions receive up to 50 inches. This zone also includes much of the Appalachian mountains and the valley microclimate region (NOAA, 2013).

In this area, higher elevations may experience weather and snow conditions more similar to the northernmost climatological zone in the Northeast. Valleys, on the other hand, experience more moderate winters and more variable precipitation. The Northeast has a humid continental climate. While all areas in the Northeast experience four distinct seasons, the intensity of seasonal changes varies according to latitude (NOAA, 2013). The northernmost climatological zone is generally defined as above the 43rd parallel, including the states of Maine, New Hampshire, and Vermont, as well as upstate New York (NWS, 2010). This climatological zone is characterized by heavy snowfall in the winters: valleys and coastal regions average 35 inches of snow annually, while the Appalachian, White, and Green Mountains can average up to 100 inches of snow. In upstate New York, lake effect snowfall from the Great Lakes causes the the Tug Hill Plateau region to experience extreme winter weather each year (NOAA, 2013). The region averages around 200 inches of snowfall per year, but some years receive up to 500 inches of snow. Summers in this climatological region

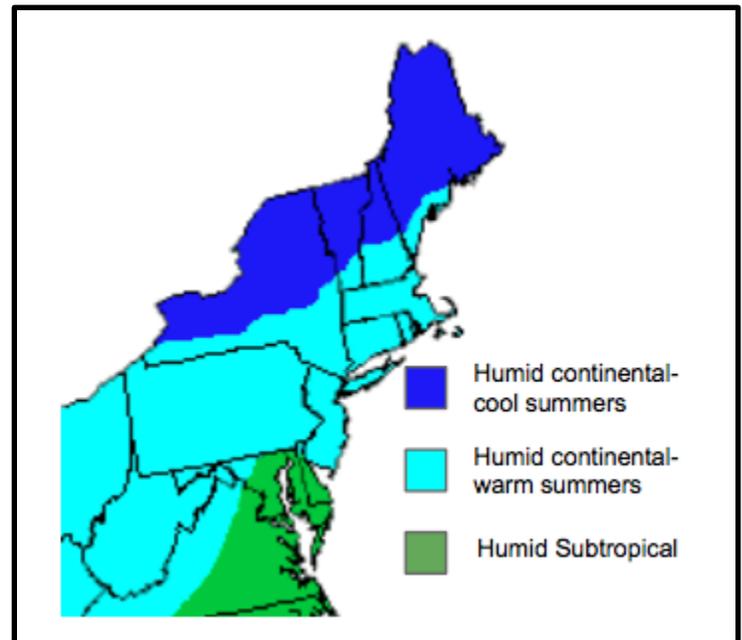


Fig. 3. Climate zones of the Northeast. "Climate Zones of USA" National Weather Service. 2010. Web. 03 June

are characterized by cool, but humid, conditions. This zone also experiences extended fall and summer transition seasons with moderate temperatures and moderate precipitation. The long duration of fall in the northern Northeast draws tourists from September to November each year to see the bright colors of the deciduous forests in these states. In the summer, temperatures in this zone reach into the 70s and 80s, with temperatures reaching into the 90s, and even sometimes the 100s, for around fourteen days on average. Summer brings intense thunderstorms as well as the threat of hurricanes to this region (NOAA, 2013). This zone also experiences the transition seasons of fall and spring, although these seasons begin later and start earlier, respectively, than in the north.

Lastly, the coastal southern northeast, consisting of the states of Delaware and Maryland, experiences a humid subtropical climate. Average seasonal snowfall in this region is only 20 inches, with the lower eastern shore of Maryland receiving only 10 inches on average (Maryland DNR, 2010). Despite the lack of snowfall, a considerable amount of precipitation still occurs in the winter months in the form of rain and sleet. Accordingly, this climatological zone is the only one in the Northeast with a winter average temperature above freezing. The summers in this zone are moderate along the coast, with average high temperatures peaking around 80 degrees most days. Inland, summer temperatures in this region range from 80 to 90 during the summer, with even mountainous regions experiencing an average temperatures of around 70 degrees (Maryland DNR, 2010). This coastal area is routinely hit by late season hurricanes or tropical storms in August or September, bringing heavy precipitation to the states in those months. Fall and spring in this region are more moderate than in the northernmost regions (NOAA, 2013).

## BIOMES

Biome regions within the Northeast change with proximity to the shoreline in addition to changes in latitude and climatological region. The inland Northeast is characterized by a temperate deciduous forest biome: in northern mountainous regions this is specifically an Acadian forest, while in the mid-latitude regions this is known as an Appalachian mixed forest. Coastal regions ranging from southern Maine to Delaware host the aptly named Northeastern coastal forest.

The Acadian forest of the northern Northeast occurs in Maine, New Hampshire, Vermont, and upstate New York (Baskauf, 2004). The flora and fauna found in this forest change dramatically with altitude. At high altitudes in the White Mountains, for example, the flora community is similar to that found in the Arctic tundra. These communities are dominated by heaths such as alpine bilberry and mountain cranberry, as well as grasses and

sedges (Gratton, n.d.). These areas are typically devoid of permanent fauna, as food is far more abundant below the tree line. Mid and low altitude communities in the Acadian forests have a far greater abundance of animal and plant life and diversity. The dominant tree species in this area include red and white pine, paper birch, hemlock, sugar maple, and yellow birch. Some of these trees, such as the hemlock, grow in isolated patches within a forest and create their own microclimates. Prominent fauna in this community include the American black bear, moose, white-tailed deer, red fox, North American river otter, fisher, and raccoon (Baskauf, 2004). The Acadian forest also holds many important microclimates, including bogs and swamps. These areas provide a home for many rare and threatened fauna, such as the critically endangered bog turtle (Glaser, 1992).

The mid-latitude Appalachian mixed forest is a temperate broadleaf and mixed forest located in the Appalachian inland regions of New York, Pennsylvania, and West Virginia. In this ecoregion, red spruce, and black spruce dominate higher elevations, as well as frasier fir and balsam fir in the highest parts of the Appalachian mountains (NatureServe, 2012). Hardwood trees, including maple and oak, also thrive in these forests. This region is also characterized by a diversity of plants in the understory: laurel, blueberry, and azalea all thrive in this niche. Whitetail deer, beaver, black bear, skunk, woodchuck, bobcat, grey fox, red fox, turkey, owls, salamanders, wood frogs, and copperhead snakes are dominant fauna in this ecoregion, in addition to five species of tree squirrel that are extremely abundant (Davis, n.d.).

Finally, the coastal regions of the Northeast are home to the Northeastern coastal forest, which extends from high-latitude coastal areas in southern Maine down through Massachusetts, Rhode Island, Connecticut, coastal New York, New Jersey, Maryland, and Delaware (Baskauf, 2004). These forests are dominated by a variety of oak species, most prominently red, white, and black oaks (Davis, n.d.). Other prominent tree species include white pine, American elm, and flowering dogwood. Common undergrowth species are mapleleaf viburnum, spicebush, and witch hazel in drier portions of the forest, while marsh areas are dominated by *spartina* grasses and shrubs. White-tailed deer, eastern gray squirrels, chipmunks, red foxes,

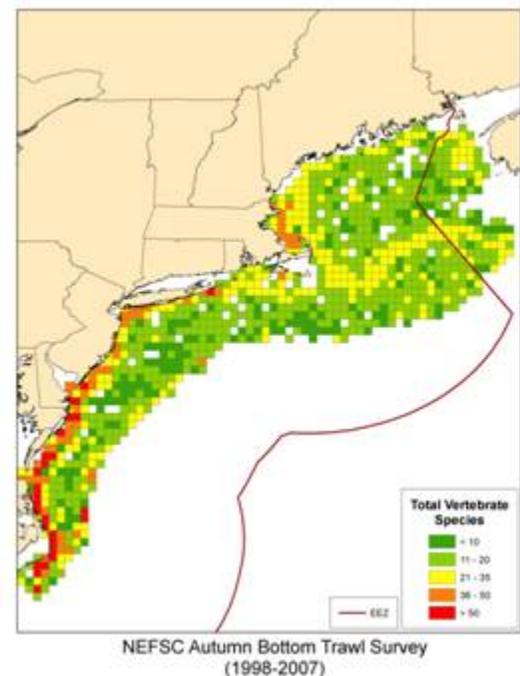


Fig. 4. NEFSC US Bottom Trawl Survey. "Ecology of the Northeast US Continental Shelf." NOAA, n.d. Web. 20 May 2015.

sparrows, chickadees, garter snakes, snails, coyotes, black bears, and raccoons are all common fauna in this biome (Baskauf, 2004).

The marine ecosystems directly abutting the coastline of New England are also havens for biodiversity (NOAA, n.d.). Important fish species include cod, herring, mackerel, and hake, in addition to shellfish such as lobsters, clams, oysters, and shrimp. Gray and harbor seal populations live in colonies of up to 5,000 seals on the coasts of Maine and Massachusetts, while blue, humpback, North Atlantic right, fin, sei, and sperm whales live further offshore (NOAA, n.d.). These marine animals are particularly important to local tourist economies. Sea turtles, including green, hawksbill, Kemp's ridley, leatherback, and loggerhead species, also live in the waters off of New England (NEFSC, 2007).

## DEMOGRAPHICS

The Northeast is the most densely populated region in the country, and is nearly 2.5 times more densely populated than the next most population-dense area, the South. The region is home to nearly 56 million people, with 50 million of those individuals living in one of five coastal cities that form the heavily-populated Northeast Megalopolis (Census Bureau, 2013). The Megalopolis' five major cities are Boston, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington, DC. North of these five cities, the population becomes more dispersed as the scenery switches from urban and suburban to rural farmland. Population centers north of the Megalopolis corridor include Pittsburgh, Pennsylvania; Albany, New York; Buffalo, New York; Hartford, Connecticut; and Springfield, Massachusetts.

Population demographics also change as one moves inland from coastal cities. In total, Caucasians make up 84.9% of the Northeast's population, of which 81.2% are non-Hispanic. Only 5.7% of the region's population is black, of which 5.3% were blacks of non-Hispanic origin. Asian Americans make up 3.5% of the region's population, while Native Americans made up 0.3% of the population (Census Bureau, 2013).



Fig. 5. Megalopolises in the Northeast. "Northeast." America 2050. n.d. Web. 21

However, the region's cities tend to be much more racially diverse than rural states. New York City, for example, is only 44% white; the state of Maine, on the other hand, is 97% white according to the 2010 census (Census Bureau, 2013). Poverty in the Northeast is equally severe in rural and urban areas: poverty rates in New York City, Boston, and Philadelphia hover around 20%, while rural counties in Maine and West Virginia experience a poverty rate of 30% or higher (Farrigan, 2015). One in four children in the entire state of West Virginia live in poverty. The Northeast also has some of the worst income inequality in the United States, with New York, Connecticut, and Massachusetts among the four states with the highest inequality in the nation (Census Bureau, 2013).

## ECONOMY

As of 2012, the Northeast accounts for 23% of the nation's gross domestic product (BEA, 2014). Much of the economic activity within the Northeast takes place in the Northeast Megalopolis region. New York City, located in the Megalopolis, is known as the financial capital of the world and is home to the New York Stock Exchange. In addition to finance, the major industries driving the New York City economy are health care, publishing, and real estate. Other prominent industries within the Northeast include technology (Boston, MA), education (Boston, MA), bio-science (Baltimore, MD), and tourism (Sassen, 2001).

Historically, the Northeast was also home to heavy industries and manufacturing, leading parts of the region to adapt the nickname of "the Rust Belt." However, industry has been declining in the region since the mid-20th century because of automation and globalization (McClelland, 2013). Despite this fact, the per capita income in many coastal Rust Belt areas has remained the same as new technology companies move into the region. The more rural former Rust Belt cities, including areas of Northwestern Pennsylvania and Northeastern New York, have not recovered from this economic downturn (Census Bureau, 2013).

Further south, the economies of rural sections of Pennsylvania and West Virginia are highly dependent on fossil fuel extraction. Hydraulic fracturing, also known as fracking, has taken off in Pennsylvania since the early 2000s. There are currently more than 7,775 active fracking wells within the state, with the majority located in northwestern Pennsylvania (Amico, 2011). West Virginia, on the other hand, is the site of massive coal mining operations. The state produces more than 15% of the nation's fossil fuel energy (West Virginia Dept of Commerce, 2014). The states in the Northeast dependent on fossil fuel extraction are facing significant political and economic pressure on those industries. West Virginia's coal sector shrank 39% in the past year, while Pennsylvania's fracking industry has

racked up over 4,000 penalties from the Environmental Protection Agency (NPR, 2015). Other states in the region have also attempted to block these industries from expanding across borders; notably, New York and Maryland have both banned hydraulic fracturing within the past year (Amico, 2011).

## AGRICULTURE

Although New England does not have as large of an agricultural economy as other parts of the United States, it still has a sizable one that is characterized by diversity. The types of agriculture within the Northeast include fruits, vegetables, vineyard work, timber harvesting, nursery, and greenhouse farming, in addition to dairy farming and commercial fishing off the coast (Laughton, C., Farm Credit East, 2012). Major crops include apples, grapes, sweet corn, snap beans, cabbage, and onion, along with flowers (USDA Climate Hub, n.d.). A number of crops are culturally prominent within the region, including cranberries, potatoes, dairy, and maple syrup (EPA, n.d.).

The region has approximately 180,000 farms, which bring in a total of \$17 billion to the region per year (USDA, 2009). The top three contributors to the Northern agricultural sector are dairy, which brings in \$4 billion and generates 32,000 jobs; nursery and greenhouse farming, which brings in approximately \$2.6 billion and generates 26,500 jobs; and commercial fishing, which brings in \$2 billion and creates 19,500 jobs (Laughton, C., Farm Credit East, 2012). As of 2007, the total number of farmer workers/operators added up to 510,548, with 45.3% of those workers employed in crop farming, 41% in animal production, and the other 13.7% distributed within the forestry, greenhouse, and the fishing industry (New York Center for Agricultural Medicine and Health, 2015).

Forests are a major part of land use in the northern part of the region, especially within the states of Maine and New Hampshire (Frumhoff, P. C. et al, 2007). Pasture land is also a component of the agricultural sector, with the Northeast containing 107,000 farms with 3.6 million acres of grazing land in 2012 (EPA Climate Hub, n.d.). Dairy is particularly prominent within Pennsylvania and New York, where it is the biggest sector of the agriculture economy in those states (Dairy Farming Today, n.d.).

# Impacts of Global Change: The Science

## CLIMATE DISRUPTION

One of the first major aspects of climate disruption to hit the Northeast is extreme temperatures. Since the 1970s, temperatures have increased throughout the Northeast: the average annual temperature rose by 2° F and the average winter temperature increased by 4° (EPA, n.d.). Increasing temperatures and extreme temperature events, such as heatwaves, are projected to continue to increase over the coming century (Union of Concerned Scientists, 2006). In the next 50 years, summer temperatures could increase by 4° up to 8°, depending on GHG emissions (EPA, n.d.). Winter temperatures are expected to increase between 4° to 7°, leading to more winter precipitation in the form of rain rather than snow (Union of Concerned Scientists, 2006).

A number of large cities throughout the northeast region, such as New York, Boston, and Philadelphia, are expected to have triple the number of summer days where the temperature reaches over 90° F (Union of Concerned Scientists, 2006). Hot summer days, where the temperature reaches above 90° F, pose a significant threat to human health: extreme heat increases the problem of air pollution, particularly in urban areas (EPA, n.d.). The “urban heat island effect,” where hot temperatures are magnified in urban areas, is especially stressful for vulnerable populations, such as young children, the elderly, or people of lower socioeconomic status (Union of Concerned Scientists, 2006).

Hotter temperatures would not just affect people but also industry within the Northeast. In relation to agriculture, higher annual temperatures could lead to an unsuitable climate for growing crops, and by the end of the century, much of the Northeast may be too hot for maple syrup production, a staple agricultural product of the region (EPA, n.d.). Although winter may be trending towards warmer temperatures, the risk from frost and freeze damage continues to be a problem: freezing events may actually become more common during the winter season (Horton et al, 2014). Hotter temperatures could change the growth of forests within the region and make forests more susceptible to invasive species, such as the hemlock wooly adelgid (EPA, n.d.).

A second major aspect of climate disruption is flooding, from two major sources: excess precipitation and sea level rise. Significant amounts of people live along the coast of the Northeast, making these two problems especially dangerous in this region (Union of Concerned Scientists, 2006). Precipitation has increased by a total of 5 inches over the past century, or 0.4 inches per decade, and the Northeast has experienced the largest increase in precipitation during storms and extreme weather events of any region within the United

States (Horton et al, 2014). Heavy rain in the spring time is expected to increase in the region. Together with coastal storms, this combination may result in increased flooding (EPA, n.d.).

Since 1900, the sea level along the coast of the Northeast has risen by 1 foot, which is greater than the national average for sea level rise by 8 inches (Horton et al, 2014). By the end of the century, the sea level along the coast of the Northeast is predicted to rise eight inches to three feet (Union of Concerned Scientists, 2006). Consequences of rising sea levels and increased flooding events may include water disrupting airports, subway tunnels, cropland, and sewage treatment plants (Union of Concerned Scientists, 2006).

## POPULATION CHANGE

The northeast is a highly dense population. The populations in each state are continually growing as a result of increased immigration into the big cities in this region. This influx of people has resulted in competition for space and resources in historically population dense areas. Unexpectedly, increasing population and sprawl has also led to more encounters with wildlife (Kretser, 2007).

As populations in large cities like New York City continue to grow, more and more people are moving into other, less dense and less expensive areas of New York, especially northern New York. In the Northern region of the state, development is extending into previously wild areas (Kretser, 2007). This has led to increased human-wildlife interactions that have been recorded in both colloquial stories and in scientific research in those areas. These reports have found that low-density developments in particular, such as suburbs, lead to greater human-wildlife interactions (Kretser, 2007). These interactions will most likely lead to more conflict between humans and wildlife, as people now inhabit areas formerly occupied by wild animals. Potential effects of this interaction included more wildlife-related injuries, species population declines, and increased development of wild areas.

In addition, the continued urbanization of the Northeast may threaten populations in the area in the coming years (Alig, 2004). The urbanization observed in the Northeast is similar to that found all over the United States. Populations in the Northeastern states relative to other regions of the US are expected to decline, but the amount of urban area is still expected to rise in the future (Alig, 2004). By 2025, developed land in the Northeast is also expected to increase by 73% (Alig, 2004). This trend in the increased development and urbanization of Northeastern states makes sustainable development implementations all the

more important to incorporate. Development in this area needs to be created with future urban sprawl in mind.

Increasingly dense populations in the area have also revealed things about the health of the population in the Northeast. A study by Kulldorf *et al.* (1997) found breast cancer clusters in the New York City-Philadelphia metropolitan area. These clusters of breast cancer diagnoses are significantly higher than the rest of the country and researchers found that this area has a 7.4% higher breast cancer mortality rate than the rest of the Northeast (Kulldorf *et al.*, 1997). This may be the result of a local phenomenon or it may be linked to genetic mutations, environmental factors, breastfeeding, or age at first birth among other potential factors (Kulldorf *et al.*, 1997). More research still needs to be done, especially looking into the potential relationship between the number of breast cancer cases and the residential proximity of patients to industrial locations in the tri-state area.

## BIODIVERSITY LOSS

In coastal New England, salt marshes are among the most vulnerable ecosystems experiencing biodiversity loss (Silliman, 2003). Historically, salt marshes have served as an important biodiversity hotspot in the shoreline community, providing protected breeding ground and ample prey for keystone species. However, human development and habitat alteration has caused plant diversity to decrease dramatically in this ecosystem. Silliman *et al.* (2003) found a three-fold decrease in plant species richness in the 22 New England salt marshes they sampled. Biodiversity loss in coastal marshes is also partially driven by climate change (Gedan, 2009). Fauna of the salt marsh are also struggling. Horseshoe crabs are threatened by commercial catching, with one study finding that only 3 per every 100,000 juvenile horseshoe crabs escapes capture in the Delaware Bay (Botton, 2003). Experts worry that a decrease in the horseshoe crab population will lead to a trophic cascade in the coastal ecosystem, as horseshoe crab eggs very important as food source for many larger predators.

In terrestrial ecosystems, biodiversity loss occurs in areas where human impact on the land has been the most severe. In the Appalachian mountains, significant biodiversity loss has been attributed to sulphuric runoff from mountain top removal coal mines. This runoff has particularly impacted river bank communities (Pond, 2004). Liminal invertebrates such as the headwater stonefly and caddisfly have experienced a sharp decrease in population numbers. Because these invertebrates serve as the foundation for many stream ecosystems, overall diversity has decreased in these communities as well. Further north in the Appalachian mountains, marten and lynx populations have decreased due to the dual impact

of climate change and human development (Carroll, 2007). Decreased snowfall, and thus decreased prey vulnerability, has driven this decline in big cats. Finally, terrestrial fauna are also experiencing biodiversity loss due to human impact. Biodiversity within traditional northeastern hemlock forests has continued to decline as the hemlock is driven to extinction by the woolly adelgid pest (Mahan, 2004). In fact, the decline in hemlock trees has also negatively impacted the diversity of the surrounding oak, pine, and birch stands.

## POLLUTION

Since the Northeast is a major industrial region, the surrounding environment and human population are exposed to many industrial pollutants and byproducts. Pollution in the area is primarily fueled by the burning of fossil fuels to operate these industries. Cities are in particular danger from the effects of pollution due to the high population density and socioeconomic factors of these areas. Pollution in cities has been linked to premature mortality in locals as well as increased instances of asthma. Hotter days have also been found to increase the impact of pollution and worsen its effects (EPA, n.d.). This is of particular concern because the Northeast region has been experiencing greater average temperatures every summer.

In addition to harming the local land and marine environments, pollution in the Northeast is also linked to many adverse health effects that affect the people living in these industrial areas. Recent research has linked lung cancer to proximity to industry and poverty, shedding light on the growth in socioeconomic health disparities of the area (Pless-Mulloli *et al.*, 1998).

In recent years, fracking has become a major source of debate as a new source of domestic energy and as a particularly prolific polluter. The main pollutants released during fracking processes include carbon dioxide, methane, nitrogen oxides, and volatile organic compounds that form ground-level ozone when exposed to sunlight (McDermott-Levy *et al.*, 2013). These pollutants have been linked to respiratory problems and cardiovascular problems, such as cardiac arrhythmia, increased risk of heart disease, heart attacks, and stroke, in people exposed to them for extended periods of time, namely residents of areas near fracking sites (Lauver, L.S., 2012). Additional pollutants include diesel particulate matter, hydrogen sulfide, and volatile hydrocarbons (McDermott-Levy *et al.*, 2013). These pollutants are linked to a plethora of other diseases that include brain and nervous system problems, such as headaches, lightheadedness, and disorientation; anemia and immunological problems; damage to the reproductive system; effects on fetal and child

development; cancer; and premature mortality (Lauver, L.S., 2012). In addition to contributing to air pollutants, fracking processes also releases toxic compounds into waterways and groundwater reservoirs. Inadequate safeguards have led to the contamination of groundwater drinking supplies (Lauver, L.S., 2012; McDermott-Levy *et al.*, 2013).

Because of the high density of population and industry, communities will continue to face the impacts of pollution in the Northeast if legislatures do not address ways to clean up contaminants (Rodrigues *et al.*, 2009). Proactive legislation can make a difference as New Jersey has recently shown in a case study. Through legislative pressure on manufacturing companies, New Jersey was able to reduce its pollutants down to standard set in the 1990s and there is now a push to cut back on even more pollutants (Johnson *et al.*, 2009). If the Northeast as a whole implemented similar strict protective standards of particulate matter concentration regulations like those set by California and Canada, 84-100% of the Northeast see increased protection from diseases such as allergies, lifetime asthma, and cardiopulmonary health problems (Johnson *et al.*, 2009)

## INVASIVES & DISEASES

The Northeast continues to struggle with both aquatic and terrestrial invasive species. Invasives are of huge concern because they alter existing community structure and disrupt ecosystem function and biodiversity. In particular, aquatic invasive species are a key concern because they threaten the health of marine resources that provide large economic profit. Roseovarius oyster disease (ROD), which affects oyster populations off the northern New England coast, is a large concern for oyster farmers, although research has recently identified the genes and metabolic processes that allow for American oysters to resist the bacterial pathogen (McDowell *et al.*, 2014). Similarly, the invasive Asian Shore Crab is the leading cause of the decline of blue mussels in Connecticut's Western Long Island Sound. A study found that Asian shore crabs accounted "for up to 25% of the blue mussel mortality in the intertidal zone at Black Rock Harbor," thus putting strain on the shellfish industry (Brousseau *et al.*, 2014).

Terrestrial invasive species are also of concern to conservationists. Invasives can threaten the health of forest ecosystems by selective removal of a species and disruption of natural forest functions. The invasive hemlock woolly adelgid is causing the decline of eastern hemlock, which has disrupted the decomposition rates in the forest (Cobb, 2010). Invasives also has potential threats to the a forest's native biodiversity by disrupting the

behaviors of the users of that forests. Research showed how invasive shrub honeysuckles acted as “ecological traps” in the forests of central Pennsylvania as its presence caused preferential nesting of the native birds to these areas (Gleditsch and Carlo, 2014).

One major terrestrial invasive that poses a large concern are earthworms introduced through human activities, such as fishing and timber harvesting. These earthworms are considered an invasive species to the forests of New England because earthworms are not originally present in these forests. Recent research found that earthworms in the forests of Vermont and New Hampshire help drive the accumulation of mercury, lead, and other toxic metals in the soil. While some of these metals occur naturally, others have been deposited by human activity; thus, the worms play a synergistic effect in worsening human contamination. Earthworms has been proposed as the reason for the increased toxic metal levels in the birds and mammals who feed on these forests (Richardson *et al.*, 2015).

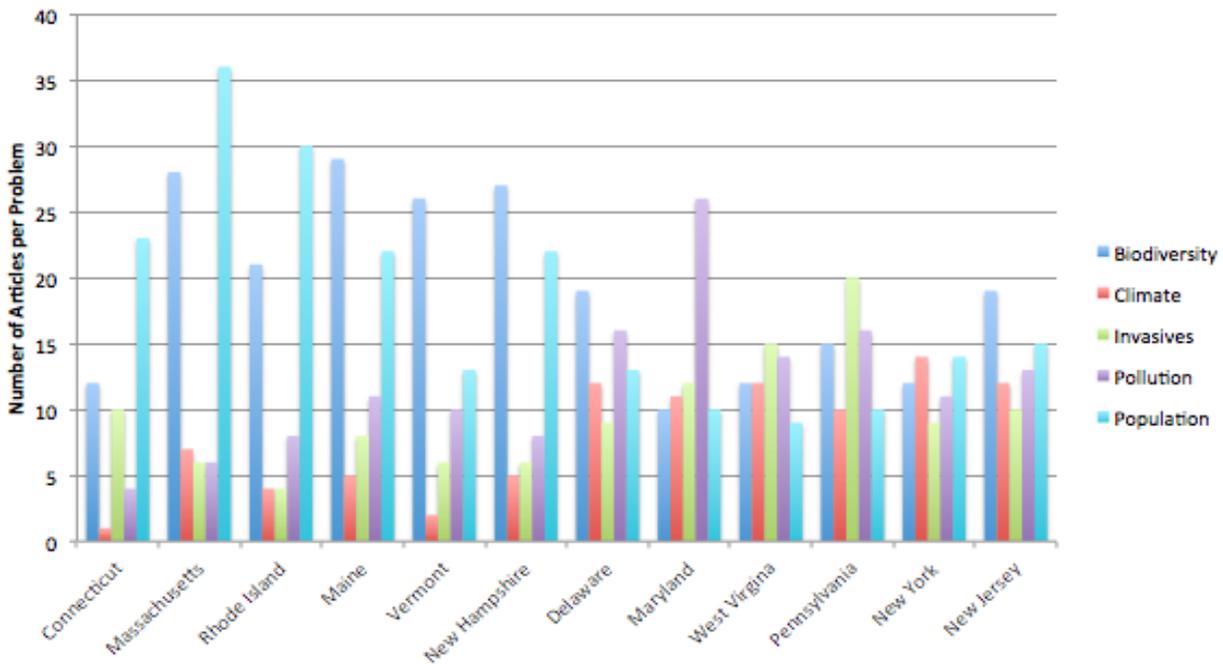
Due to the impacts that invasive species have on the Northeast population and ecosystem, much effort is placed into controlling and eliminating invasives. Local conservation groups typically use a cut-and-remove approach, yet the efficiency of this model is debated by researchers. A landmark study in Pennsylvania found that controlling the invasive shrub morrow honeysuckle through the methods of “cut, mechanical removal, stump application of glyphosate, and foliar application of glyphosate” was not sufficient, thus contradicting the common removal strategy. The researchers recommended repeated treatments of biocides in addition to active planting of native seedlings (Love and Anderson, 2009). In yet another invasive species case, controlling the spread of the invasive mosquito, *Aedes albopictus* (Skuse) involved mitigating a direct danger to human health. Researchers found the mosquito has developed resistance to commonly used insecticides like dichlorodiphenyltrichloroethane (DDT) in New Jersey (Marcombe *et al.*, 2014). The invasive emerald ash borer has also displayed immunity to many pesticides, leading researchers to develop and run simulations with a systemic insecticide that would help slow ash mortality. The simulation found that the insecticide treatment would be effective and is more cost-saving than removing dead or severely declining ash trees (McCullough and Mercader, 2012).

# Impacts of Global Change: Popular Media

## OVERVIEW

For this section, we analyzed popular media sources from the Northeast region to learn more about how the region is experiencing global change. Overall, we sourced 800 articles from the region, with state and problem distributions highlighted above.

**Number of Articles by Problem, by State**



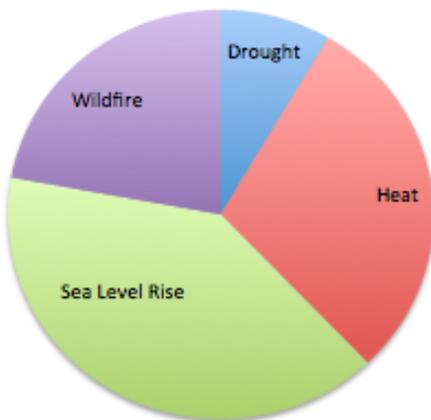
## CLIMATE DISRUPTION

Sea level rise is a key concern within popular news media along the coastal states of the Northeast region. This issue is of particular concern since the whole region is important as an economic resource for the whole nation. Many of the largest and densest cities are located along the coasts and waterways of the Northeast. States in the Northeast now have to take new precautions on how to effectively combat sea level rise as this problem poses a serious concern for the safety and livelihood of the region. Many media outlets in the region are speaking about the struggles facing coastal residents about sea level rise today (“New York’s Forecast: Rising Seas, Continual Heat Waves, and a Little Hope,” “New Jersey Future

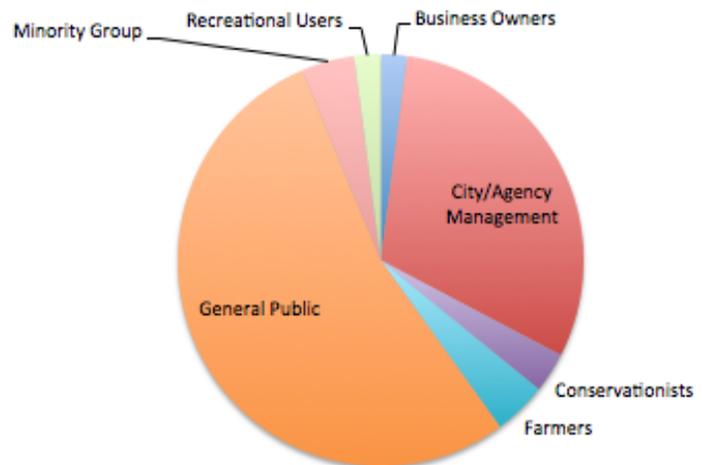
Warns Tuckerton and Little Egg Residents of Future Flooding”) (Bellafante, 2015; Johnson, 2015). In addition to threatening urban coastal populations, sea-level rise will also harm farmers in low-lying regions where sea level rise causes saltwater intrusion into previously freshwater aquifers (“Sea level rise spells salty future for coastal farms”) (Beeler, 2014).

The Northeast is also experiencing climate disruption in the form of more extreme temperatures, with hotter summers and colder winters. Extreme cold has become a problem in recent winter months (“Western Pennsylvania shivers toward record for coldest February,” “Ice Age Watch: New York Had Its Coldest Late Winter In Over 100 Years”) (Raap, 2015; Bastasch, 2015). Heat waves have also become more frequent and deadly (“Baltimore Co. man added to heat death toll”) (Dance 2012). Average temperatures in the region are increasing every year and this poses a serious concern for the safety of local populations and wildlife. Articles about wildfires ran across a number of different Northeastern states (“Wildfire risk spreads in New Jersey,” “Warnings Issued for Wildfire Conditions in PA,” “Wildfire season underway in Maine,” “Officials Warn Of High Fire Danger Across Region”) (Bates, 2015; Boyle, 2015; Karkos, 2015; Bradley, 2015).

**Climate Disruption by Topic**



**Climate Disruption by Impacted Stakeholder**



## POPULATION CHANGE

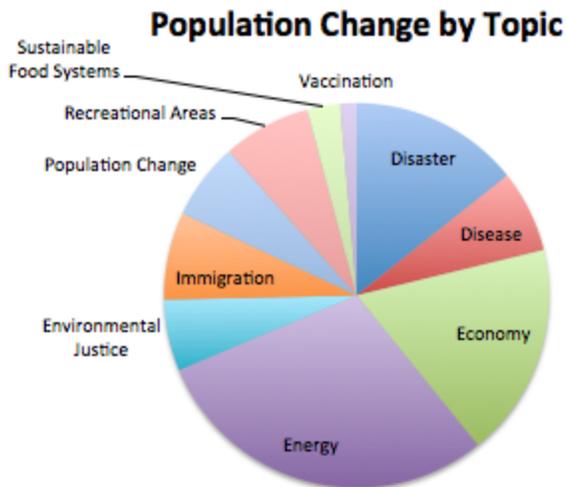
In the Northeast, many states are taking precautions against climate change. Many of these states are developing methods to adapt energy systems to deal with this growing environmental problem (“NY State Expects All Utilities to Prep for Climate Change”, “New York’s ‘smart grid’ research could influence other areas”) (Magill, 2015; Associated Press, 2015). For instance, Rhode Island has developed a tool called Sea Level Affecting Marshes

Model (SLAMM) to identify marshes vulnerable to sea level rise (“Battle With The Sea: Rhode Island Develops State-of-the-Art Planning Tools”) (Espinoza, 2015).

In other areas of the Northeast, private businesses and local governments are looking into expanding and exploring different energy sources in response to the growing populations in these areas. In particular, renewable energy technology is being pursued in various states, especially those in the far northeast. Vermont and Rhode Island are currently developing more methods of efficient wind energy capture (“Vermont taking breather from wind power, but more to come,” “Construction begins on wind farm off Block Island”) (Ring, 2015; Young, 2015). In Maine, solar energy is becoming a more prevalent source of energy (“Maine’s largest solar project proposed for former Navy radar site”) (Turkel, 2015). This is in contrast to the fossil fuel extraction powering New York, Pennsylvania, and West Virginia, the latter of which is experiencing a related economic downturn (“W.Va. Coal Production Down”) (Junkins, 2015). There is also recognition of the need for a trained workforce to construct proposed green buildings in the future is also seen with the establishment of specialized technical schools (“Middletown’s Vinal Tech students learn how to go green”) (Schassler, 2015). Interestingly, this push for expanded utilization of renewable technology through a renewable energy credit systems, such as those in place in Connecticut and Massachusetts, has raised attention to the Commerce Clause of the U.S. Constitution (“Lawsuit Challenges A Bedrock Of Connecticut’s Energy Policy”) (Dowling, 2015).

Changes in agricultural practices in these states have also been observed. In Vermont, farmers are developing more sustainable practices for their own farms, as well as sharing their developments internationally (“Vermonters bring organic insights to farmers in Cuba”) (Conn, 2015). In Delaware, produce farmers are innovating by reutilizing waste from nearby poultry farms in order to fertilize fields (“Farmers Help Drive Responsibility in Delaware”) (Williams, 2015).

Growing populations has also increased the risk of exposure to different illnesses and diseases in addition to problems with resources. The whole country has experienced a resurgence in semi-eradicated diseases, such as tuberculosis and measles, as more people are acting upon their distrust of vaccinations. States in the Northeast, such as Vermont and Maine, have seen a particularly high number of cases of these diseases, potentially because of the high population density of the Northeast in comparison to the rest of the United States (“Vermont Health Department says 3 more test positive for TB”, “Maine CDC: Infected student exposed Kittery shoppers to measles”) (Ring, 2015; Farwell, 2015).



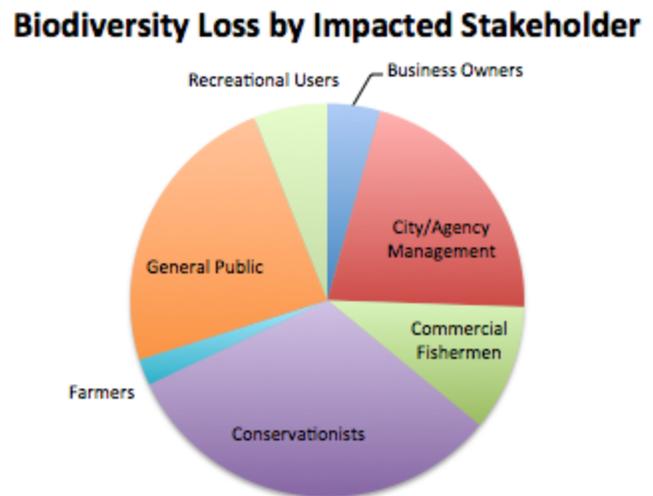
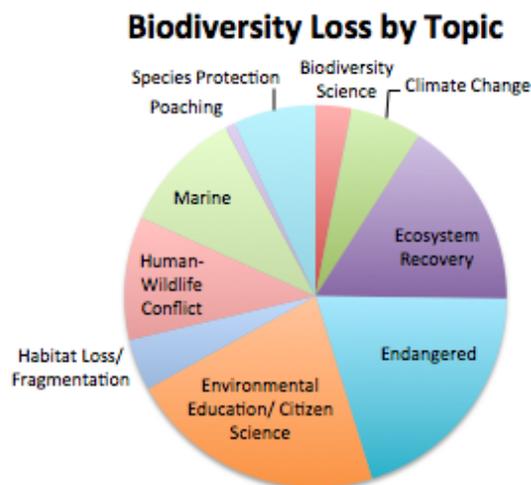
## BIODIVERSITY LOSS

As the population in the Northeast continues to grow, cities continually expand to urbanize previously undeveloped or wilderness areas. Intense human development is driving biodiversity loss in the region, particularly for endangered species and species synergistically impacted by biodiversity loss and the warming climate.

While harm to some endangered species appear outside of direct human control (“Bat Bacteria Helps Battle White-Nose Syndrome”), many others are harmed by more direct human-wildlife conflict (“Is it a bird? Is it a bat? No, it’s a rare flying squirrel near New Haven!”) (Stallard, 2015; Learns-Andes, 2015). Overall, many different species in Northeastern states are in decline, such as honey bees, the northern long-eared bat, and white ash trees (“Some common NJ species in serious decline: Nature column,” “Several plant species of New Hampshire face risk of extinction,” “Keeping the bees in Rehoboth Beach”) (Byers, 2014; Grace, 2015; Pacella 2015). However, efforts are being made to help endangered species throughout the Northeast region from both human activity and invasive species (“Feds act to save tiny bats from extinction,” “Invasive Bug Prompts Quarantine In Pennsylvania Townships,” “Value of endangered bumblebees weighed in VT”) (Nearing, 2015; Chappell, 2014; Baird, 2015). Some species have even seen a successful recovery (“Bald eagles starting a family in New York City”) (Berman, 2015).

The warming climate is also having drastic negative effects on the fish populations and fishing industries of the Northeast, particularly in the Gulf of Maine. Commercial fish

populations are moving northwards towards colder Arctic waters and warmer waters have led to near collapse of Rhode Island lobster fisheries (“Warming climate spells disaster for Gulf of Maine fisheries, unless we act”) (Reiner, 2015). There has also been conflicts between recreationalists, business owners, conservationists, and legislators in the region over fishing rights and regulations (“Sportsmen hoping to reel back alewives’ access to St. Croix River,” “Waterman ‘seen’ by radar cited for poaching oysters”) (Miller, 2015; Wheeler 2015). Changing migration patterns of marine species are observed along the coasts such the unusual sightings of beluga whale in Rhode Island’s Narragansett Bay, the decline in numbers of migratory shad in Connecticut river, and the late arrival of right whales in Cape Cod (“Rhode Island’s Beluga Whale Mystery Continues”, “Berlin Fishway Opens, But Cold Water Slows Migration,” “Right whales throng Cape Cod Bay, with babies in tow”) (Skahill, 2015; Leukhardt, 2015; Lum, 2015).



## POLLUTION

One of the most contentious sources of pollution in the Northeast is hydraulic fracturing. Fracking has been found to be harmful to health, pollute the air and water supply, and damage local infrastructure and environment. Many current articles in the region address the concerns surrounding fracking and its impact on both people and the environment (“Rise of deadly radon gas in Pennsylvania buildings linked to fracking industry,” “After nearly 7 years, NY releases final fracking review”) (Cha, 2014; Campbell, 2015). Others focus on the harmful effects of fracking and link the industry to issues with

the water supply (“Fracking chemicals found in Pennsylvania drinking water supply”) (Frazier, 2015).

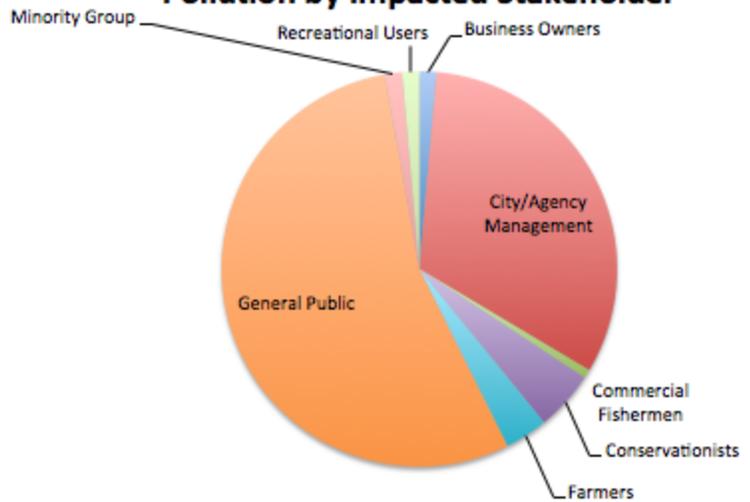
Industrial air pollution is a significant issue across the Northeast region and is harmful for human health (“S. Phila. refinery creates toxic air as well as jobs,” “Study: Breathing New York air can increase risk of stroke”) (Bunch, 2015; Engel, 2015). Water pollution is also a notable issue due to the large human population living in coastal areas. The harbors of Boston, New York City, and Baltimore have all been tarnished with severe water pollution. While community clean-up efforts are underway in many of these localities, others are struggling with the long-term removal of toxic waste (“The Wheels Are Turning In Baltimore Harbor,” “Radioactive tritium found in ice outside Hope Creek”) (Mathur, 2015; Montgomery 2015).

Despite high levels of waste and pollutants, the Northeast is attempting to minimize its impact on the environment through thorough recycling and litter reduction programs (“Vermont landfill ban on recyclables goes into effect July 1,” “New York City Aims to Cut Waste 90 Percent by 2030,” “Construction underway on Crofton rubble landfill”) (Rathke, 2015; Associated Press, 2015; Hainsworth, 2015). There are also a number of successful citizen initiatives to pick up trash along river and stream banks (“Volunteers Clean up New Castle’s Battery Park”) (McMichael, 2015). The one benefit of a large Northeast population, in environmental terms, is the success of volunteer-led trash and litter removal efforts in densely populated coastal metropolises.

**Pollution by Topic**



**Pollution by Impacted Stakeholder**



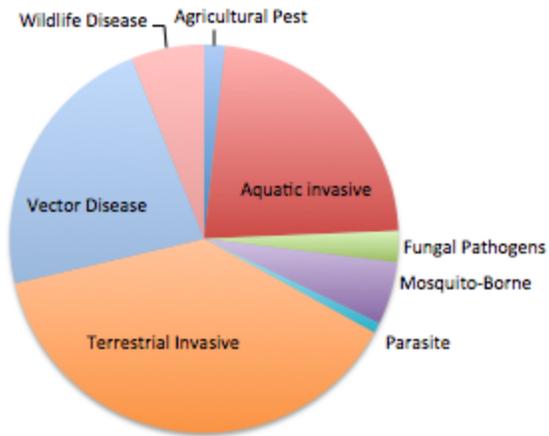
## INVASIVES & DISEASES

Invasive species are a big issue in the Northeast, particularly in regards to the plants and forests of the region. Northeastern trees, such as hemlock and ash, are reported to be at a particular risk within the popular media. A number of articles in the region address efforts to eliminate invasive species attacking forests (“Foresters scrambling to save state's hemlock trees from insect invaders,” “Montgomery Township OKs further plans to battle Emerald Ash Borer,” “Maine seeks volunteers for invasive beetle event”) (Hopey, 2014; Sokil, 2015; Associated Press, 2015). Terrestrial invasives like the Asian longhorned beetle is currently threatening the pine trees in Connecticut (“Tiny, invasive beetles threaten state's pines”) (Puffer, 2015). In addition, the number of invasive aquatic species has been increasing, especially as the coastal waters of the region are warming up (“Invasive snails pose threat to Great Lakes waterfowl,” “Trying to Save Bog Brook Unique Area from Invasive Reeds”) (Associated Press, 2015; Taliaferro, 2015).

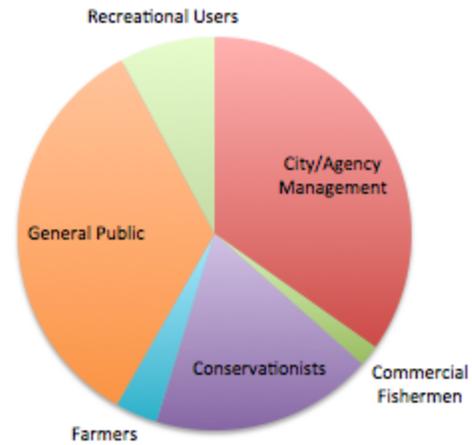
Aquatic invasives such as invasive green crabs, Eurasian watermilfoil and zebra mussels are also a concern in the Northeast. In the coasts of Massachusetts, restaurants are experimenting with the consumption of invasive green crabs (“Green crabs are multiplying. Should we eat the enemy?”) (Warner, 2015). A community in Connecticut introduced voluntary workshops for boat inspections and decontamination procedures to prevent invasive species introduction in lakes (“Brookfield launches boat inspection program on Candlewood Lake”) (Koerting and Oliveira, 2015).

Vector borne diseases, particularly either tick or mosquito-borne, are often reported on throughout the Northeast region. The region has a large deer population, who often carry ticks, and the summer climate is perfect for breeding mosquitoes. These characteristics contribute to the prevalence of these these vector diseases and highlight the need for effective preventative measures to protect local populations. News articles commented on the overall expansion of ticks (“Deer ticks found in all Pennsylvania counties”) as well as specific tick diseases, including ones such as Lyme disease (“Pa. ramping up fight against Lyme disease,” “The number of Lyme disease cases is on the rise”) (Savana, 2014; Wenner, 2015; Vannetter 2015). Many states also observed newer tick-borne diseases appearing, such as the Powassan virus (“Powassan virus: A newer, nastier tick-borne disease”) (Brown, 2015). Several vector borne diseases that had not been seen in the Northeast until recently were also reported on (“State authorities keeping eye on Chikungunya disease spread by mosquitoes”) (WGAL News, 2014). In addition, there have been cases of other vector borne diseases increasing, but it is unknown how the region will react to these changing conditions (“Evolution of Disease Vectors Makes It Difficult to Predict Impact on Human Health”) (Quintin, 2015).

### Invasives & Disease by Topic



### Invasives & Disease by Impacted Stakeholder



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