"We are working on far more complex environmental problems than we did 20 or 30 years ago. Today, the definitions of environmental problems are often far less certain, possible solutions are more difficult to identify, and the costs of dealing with them are likely to be much greater."
– Christine Whitman, Administrator, US Environmental Protection Agency

STRESSORS AFFECTING ENVIRONMENTAL CONDITIONS

Stressors are the byproduct of human activities and natural processes that cause undesirable impacts. Some of these stressors and their effects have been scientifically studied and documented, and their effects can be solved through sound management. Other stressors and their effects are not as well understood and require additional research. Research from EPA's MAIA program has given us estimates of the extent of some Mid-Atlantic Highlands stressors. Other stressors have been identified through research and CVI's work with stakeholders, but estimates of the extent of these problems are not yet available (Table 5).

Riparian and Aquatic Habitat Loss

Habitat is the place where a plant or animal lives and grows. Aquatic organisms need both good riparian and instream habitats to survive, live, and reproduce. Riparian or streamside habitat includes the grasses, ground cover, vines, shrubs, and trees growing along the stream. Riparian vegetation shades streams, particularly small streams, maintaining cool water temperatures required by many organisms, like trout and smallmouth bass, for growth and reproduction. It also stabilizes streambanks and helps prevent silt and associated contaminants from entering the stream. EPA and US Forest Service studies have shown that poor riparian and aquatic habitat is a major problem in many Highland streams. Almost 25% of Mid-Atlantic Highlands streams (over 17,000 stream miles) have poor riparian habitat (Figure 5). In addition, about 28% of Mid-Atlantic Highlands streams, or over 18,000 stream miles, are only in fair condition. Poor riparian habitat contributes to stream sedimentation, lack of cover, limited filtering of sediment and pollutant inputs

Table 5. Highlands Stressors

EPA Estimates Available	Estimates Not Available
• Riparian and aquatic habitat loss	• Flooding
• Sedimentation	• Ozone damage
• Acidic deposition (acid rain)	• Waterborne pathogens
• Acid mine drainage	• Invasive species
• Forest fragmentation	• Persistent pollutants
	• Climate change

from the watershed, and loss of good fishing areas. Healthy streams can not be sustained without good riparian habitat.

Sedimentation

In addition to riparian habitat, instream habitat is also important. Woody debris from riparian trees that fall or wash into the stream creates complex habitat structure and pools for fish and aquatic insects. Habitat created by boulders, cobble stones, and gravel in streams provides areas where fish and aquatic organisms can reproduce, feed, and hide from predators. Good instream habitat is as important as good riparian habitat for healthy streams, but it can be covered over or smothered by soil and sediments washing into the stream from the upstream watershed or from streambank erosion. Poor instream habitat affects fish and other aquatic organisms by eliminating areas in which organisms can live, feed, and lay their eggs. It also results in the loss of good fishing areas. Healthy streams need both good riparian and instream habitat.

Unfortunately, excess sedimentation is a major problem for Mid-Atlantic Highlands streams. Research has shown that about 25% of Mid-Atlantic Highlands streams, or over 18,000 stream miles, have poor habitat because of stream sedimentation and 40%, or almost 29,000 miles, have only fair habitat (Figure 5).

Healthy streams require good riparian habitat. Stream bank erosion creates bad riparian habitat.

Acid Rain

Acid rain has been a regional problem for over four decades. During the 1980s, the Mid-Atlantic Highlands was extensively studied by the EPA, US Geological Survey, and US Forest Service through the National Acid Precipitation Assessment Program. Acid rain forms when emissions of nitrogen and sulfur compounds from combustion of fossil fuels combine with water vapor in the atmosphere and become acidic. These acids can be transported long distances before they fall to the earth and acidify the watersheds and streams into which they fall. In most instances, the acid rain falling on watersheds in the region comes from the Ohio Valley. Many aquatic organisms are sensitive to acidic waters and cannot survive or reproduce under these conditions. Acid rain is a particular problem for smaller streams that provide nursery and spawning areas for aquatic organisms. Even though larger streams might not become acidic,

Not all problems in the Highlands are understood. Applied research is needed to develop science-based, cost-effective solutions.

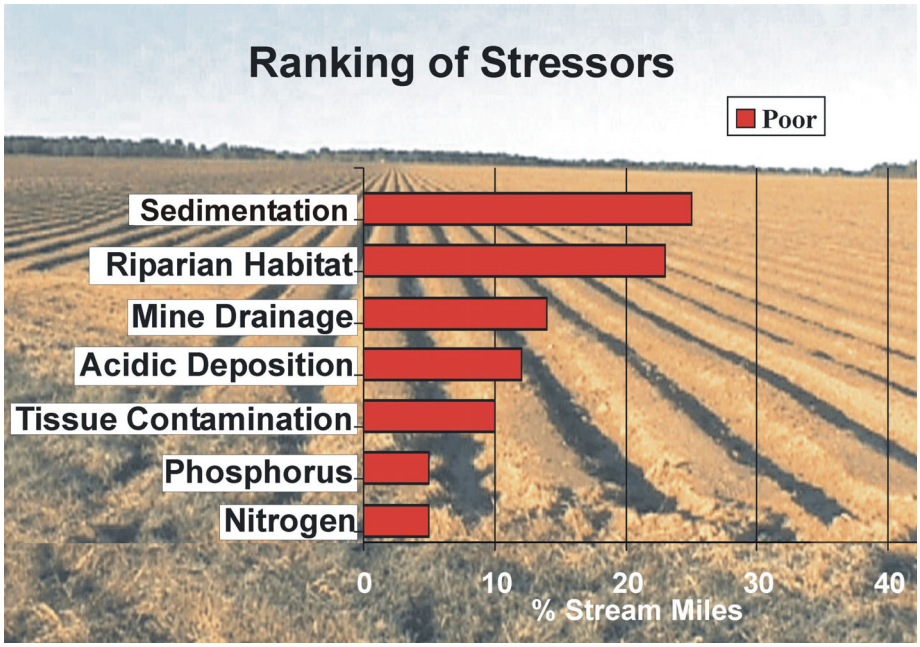

Figure 5. The greatest stressors on streams in the Highlands are sedimentation of instream habitat and destruction of riparian habitat.

these larger streams depend on their smaller tributaries for a continual supply of fish and other aquatic organisms. While the 1990 Clean Air Act Amendments helped reduce emissions that contribute to acid rain, there is still a "bull's eye" of low pH or acid rain over parts of the Mid-Atlantic Highlands region (Figure 6). The EPA initiative found over 7,500 miles of Mid-Atlantic Highlands streams are susceptible or in poor condition due to acid rain.

Acid Mine Drainage

During mining, overburden and spoil are discarded, piled around the mine, or pushed into a valley. This overburden and spoil contain sulfur compounds that are converted into sulfuric acid just by exposure to the air. Many people think the effects of acid mine drainage (AMD) are primarily due to this sulfuric acid leaching or running into a stream. When it rains, however, not only is this sulfuric acid washed into the streams, but so are toxic concentrations of heavy metals and high loads of sediment. Sulfuric acid makes the stream acidic and unsuitable for life. Metals can poison the aquatic organisms living in the streams, and sediment can smother the bottom and ruin habitat for fish and other living organisms. The effects of acid mine drainage, then, are greater than just the acid load to the streams. Over 10,000 stream miles in the Mid-Atlantic Highlands have been degraded by AMD (Figure 5) and, as a result, many affected streams contain no fish. Pennsylvania has estimated it loses over $65 million a year due to the elimination of sport fishing in these AMD-affected streams.

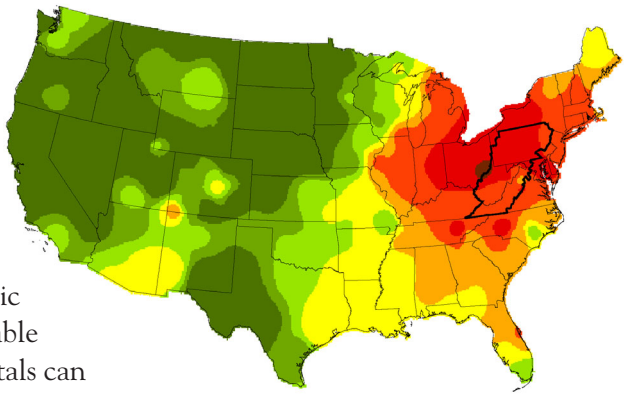

Figure 6. The dark red colors show the bull's eye of acid rain over parts of the Highlands. The darkest red areas have a pH of less than 4.25, the orange areas have a pH of 4.6 to 4.7, and the green areas have a pH of 4.9 or higher. Natural rain has a pH of 5.0 to 5.5.

The effects of mining are not just limited to surface waters. There are many abandoned deep mines throughout the Mid-Atlantic Highlands, a legacy of coal production that fueled the US economy. Many of these mines are filling, or are already filled, with water that is acidic because sulfur in the coal and overburden has been converted to sulfuric acid. Scientists and regulators don't understand the full extent of the problem yet, but the potential seepage of acidic underground water is a looming problem in the Mid-Atlantic Highlands. For example, there is a 42 square mile area of underground abandoned mine shafts and tunnels in and around Fairmont, WV that is full of acidic water. This water is currently being pumped and treated to keep the underground pool from overflowing. However, if this pumping and treating ever stops, the acid water will contaminate nearby streams like Buffalo and Paw Paw Creeks and the Monongahela River. If this water eventually blows out of several "seeps," the fish in these streams will be killed for long stretches downstream. Better scientific information about this problem is needed to determine how extensive it is, and what the potential risks are to Mid-Atlantic Highlands streams.

Forest Fragmentation

As stated earlier, the forests in the Mid-Atlantic region are a globally important resource. No other place in the world has as much temperate, contiguous hardwood forest as the Mid-Atlantic. But it is rapidly being reduced from large, contiguous stands to smaller pieces. This is known as fragmentation. Many human activities and land uses, such as unconstrained development or sprawl, urbanization, building utility lines and roads, timber harvesting, and mountaintop mining all contribute to habitat loss and degradation. Almost half (47%) of the Mid-Atlantic Highlands landscape is considered to be in poor or fair condition because of forest fragmentation (Figure7). Many living organisms, from migratory birds to black bears, require large blocks of contiguous forest to sustain their populations.

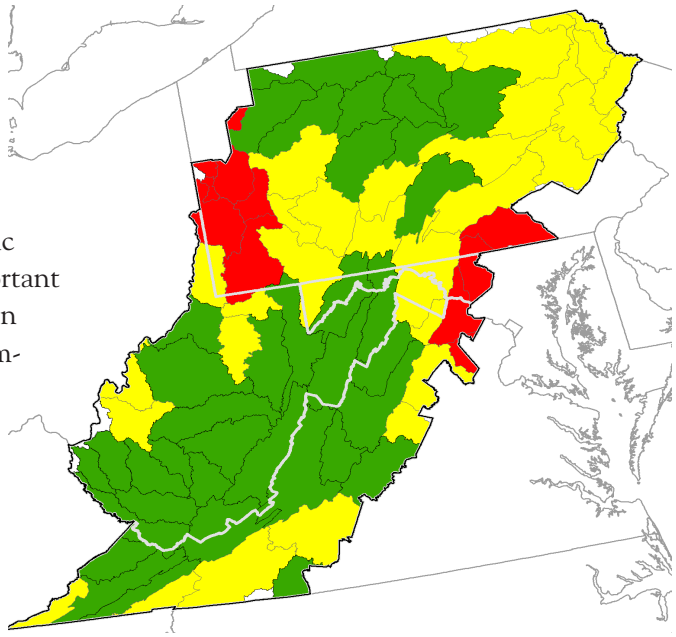

Figure 7. Based on landscape fragmentation indicators, like population density and amount of steamlength with adjacent forest, the areas in dark green (53%) on this map are in good condition, the areas in yellow are in fair condition (39%), and the red areas are in poor(8%) condition.

Over the past 20 years, people have learned a lot about how the arrangement of the landscape affects living organisms. The US Forest Service and EPA Office of Research and Development have been actively studying how landscape patterns affect the quality of the habitat for living organisms. By looking at these patterns throughout the world, they were able to determine how unique the Mid-Atlantic Highlands forests are, and how susceptible they are to fragmentation and habitat destruction and loss. Forests are an integral part of the environment, economy, culture, and lore of the Mid-Atlantic Highlands, and there is a continuing need for additional research into ways to protect and manage this valuable resource as residents in the Mid-Atlantic Highlands move toward sustainable development.

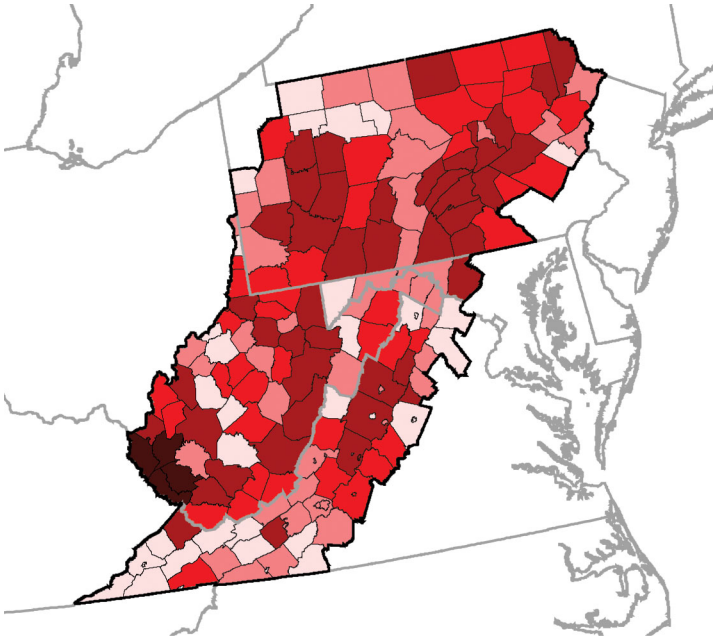

Figure 8. All Highlands counties have been affected by at least one federally declared flood disaster. Counties in the darkest color have been affected by 7 or 8 federal flood disasters from 1965 to 2000. Counties in the lightest color have been affected by 1 or 2 flood disasters, and the rest of the counties have experienced 3 to 6 flood disasters in the same period.

Flooding

People may experience increased flooding as upstream areas and the floodplain are developed. Increased development, floodplain development, and changes in land cover, like forest fragmentation and forest loss, contribute to flooding. Roads, parking lots, and cleared lots all contribute to increased runoff and downstream flooding. Streambank erosion from higher flows eats away land, putting homes in danger of being lost or damaged. While Mid-Atlantic Highlands residents recognize flooding as one of their major concerns, the extent to which land use changes have contributed to increased flooding is not known.

During the 35-year period from 1965 to 2000, 54 flooding events were declared federal disasters in the Mid-Atlantic Highlands. Unfortunately for some counties, flooding has become a recurring event. Over this 35-year period, 50 of the 174 Highland counties have had 5 to 8 federally declared flood disasters and 93 counties have had 4 or more federally declared flood disasters (Figure 8). While the Federal Emergency Management Agency provided over $600 million in flood assistance just since 1985, these dollars can't compensate for the loss of lives, family homes and heirlooms, or the constant fear of future floods.

Ozone Damage

Ozone is formed through a series of complex chemical reactions of nitrogen compounds, organic mixtures, and sunlight in the atmosphere. Ozone is highly reactive and is used in some water treatment plants to kill bacteria or other organisms that might be living in the water. Because it is so reactive, it can also cause damage to plants with which it comes into contact.

Ozone damage is often thought of as just a big city problem, but US Forest Service studies have found that Mid-Atlantic Highlands forests are being affected by ozone damage. Ozone damage creates a distinct mark on tree leaves (as seen in the photo at right), so it is easy to distinguish from the effects of disease or insect damage. Ozone not only damages leaves, it makes the trees more susceptible to disease and other pollutants. Overlapping regional problems such as acid rain and ozone can aggravate the severity and extent of local problems. Loss of forest productivity translates directly into lost dollars to the timber industry. The full extent of ozone damage is unknown, and more scientific studies need to be conducted to understand the effects of ozone on the environment, the economy, and local communities.

Pathogens

Pathogens are organisms such as bacteria and viruses that can cause diseases. Human waste can contain pathogens that make people sick if they drink water or come into contact with water in which sewage was discharged. The discharge of raw sewage into streams occurs throughout the region. This raw sewage is typically discharged by local residents directly from their house into the stream through pipes because many rural communities in the Mid-Atlantic Highlands aren't served by wastewater treatment plants. Unfortunately, the full extent of the problem is unknown. Studies are needed to determine the extent of raw sewage discharge and pathogens associated with these discharges.

Invasive Species

The Mid-Atlantic Highlands has rich species diversity because of its unique geological history. Several Mid-Atlantic Highlands species are considered rare, endangered or of special concern because they aren't found in other places. Forest fragmentation, acid rain, acid mine drainage, habitat loss and other problems create stresses on native species and make it easier for non-native species to outcompete them and move into the area. Researchers from the US Forest Service, The Nature Conservancy, and similar organizations point out that non-native species have invaded the Mid-Atlantic region and are a major problem. These non-native species range from pathogens (Nile virus) to plants (purple loosestrife) to insects (gypsy moth, Figure 9) to birds (starlings). These non-native species can outcompete native species because their natural enemies are not present in the Mid-Atlantic region. Combining habitat loss with invasive species introductions results in the loss—in many cases permanent loss—of native species. Eliminating pest species once they get a foothold in a region is almost impossible, and very expensive. Preventing these species from entering is much more cost effective.

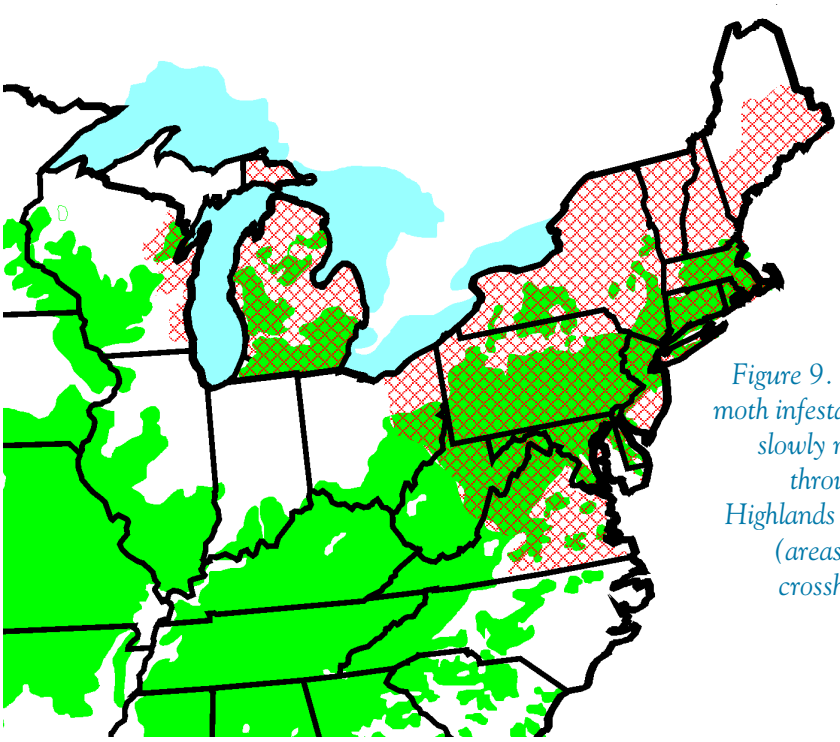

Figure 9. Gypsy moth infestation is slowly moving through the Highlands forests (areas in red crosshatch).

Persistent Bioaccumulative Toxins

Some pollutants, such as mercury, are persistent and do not go away. Even worse, mercury concentration increases at each step up the food chain, from the water to microscopic plants in the stream, to insects that feed on plants, to small fish that feed on insects, to largemouth bass that feed on the small fish. This is called bioaccumulation and biomagnification. Many streams in the Mid-Atlantic Highlands region are under fish consumption advisories because the mercury concentration in top predator fish, like largemouth bass, exceeds

safe levels for human consumption as determined by the Food and Drug Administration and EPA. Mercury enters the atmosphere naturally because it is a naturally occurring element, and also through human activities such as coal combustion, the burning of municipal or medical waste, and other uses like mercury switches for electric lights. The extent of mercury contamination, as well as other persistent, bioaccumulative toxins, such as lead and dioxin, is not well known in the Mid-Atlantic Highlands.

Climate Change

Although a hotly debated issue, most scientists agree that human-influenced climate change is occurring. Increased carbon dioxide, nitrogen oxide, methane, sulfur dioxide, water vapor and other "greenhouse" gases are contributing to heat retention within the atmosphere, which results in the warming of the earth. This warming may contribute to significant changes in the climate over much shorter periods of time than have occurred in the past. With climate change, floods and droughts could be more frequent and severe in the Mid-Atlantic Highlands. Increased runoff from heavy rains can carry more sediments, pesticides, fertilizers, and germs into the streams.

These pollutants can affect fish and other aquatic life living in these streams. Increased temperatures can change the composition of the forests, making some important hardwood species less abundant. Trout and other cold-water fish would become less abundant and warm-water fish more abundant. The rate, magnitude, and effects of climate change are not well-understood. Without more research and understanding, it will be impossible to develop effective management and mitigation practices to deal with both the causes and effects of climate change.

These are just some of the stressors affecting the Mid-Atlantic Highlands environment. In most cases, these stressors result from human activities. What activities are causing or contributing to these effects in the Mid-Atlantic Highlands?