Helping your woodland adapt to a changing climate

Learn more about your woodlands

For more information, please visit the following websites:

http://extension.umd.edu/woodland

http://dnr.maryland.gov/climatechange

http://dnr.maryland.gov/forests

http://landserver.org

Find a forester

http://extension.umd.edu/woodland/your-woodland/find-forester

http://dnr.maryland.gov/forests/county_map.asp

http://dnrweb.dnr.state.md.us/download/forests/consultingforesters.pdf

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On the cover

A hardwood forest with diverse tree species of various ages and a healthy understory. Photo by Mark Twery, US Forest Service.

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Helping woods adapt

Woodland stewardship and a changing climate

Your woods are always changing and adapting as they grow and mature, or regrow after agricultural abandonment, natural disturbances, or harvesting activities. Events like storms, droughts, insect and disease outbreaks, or other stressors can damage trees or slow their growth. A changing climate may make your woods more susceptible to the problems these events can cause.

What is woodland stewardship?

Taking care of your land for the long term while ensuring that it is available for future generations is known as woodland stewardship. To become a good woodland steward, the first step is to learn more about your woods through online educational resources: ***http://extension.umd.edu/woodland***

The next step is to contact a forester (see inside cover). Walking the woods with a forester will help you understand the options and opportunities to improve the health of your woods and plan for climate change.

The third step is to identify your goals and objectives. For example, do you want to use your property to generate income, or are you more interested in attracting wildlife, or protecting rare and endangered plants and animals?

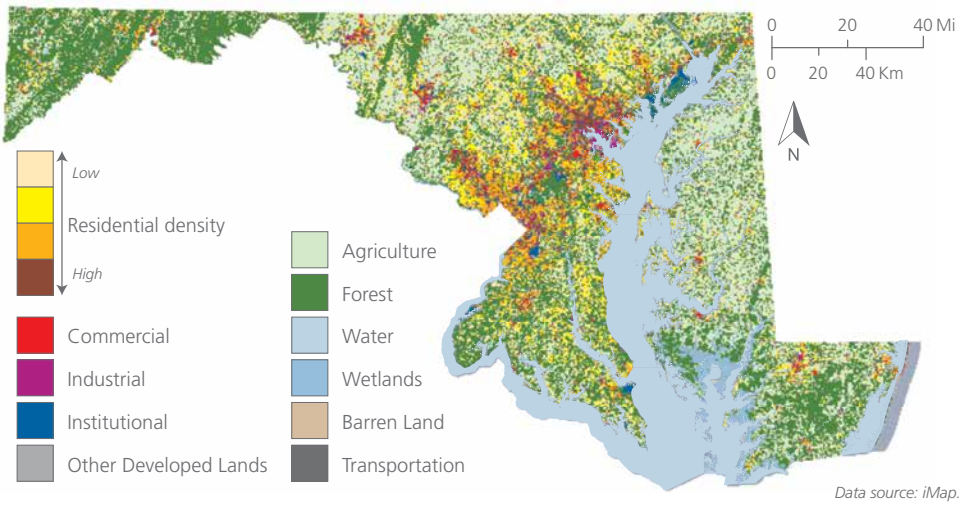
A forester can also assist you with the fourth step, which is to develop a forest stewardship plan to help you achieve your goals and objectives.

Your property can make a difference

Private landowners currently own 76% of all forestland in Maryland and are also the first to see any changes in their woods over the years. Keeping an eye out for changes and seeking assistance will help you make wise decisions. Have you noticed trees dying or strange insects? These are only two of many visual clues that may prompt you to learn more about your woods.

The average size of woodland ownership in Maryland is 9.6 acres. Whether small or large, every property counts, and the cumulative decisions taken by you and 150,000 other private landowners will determine the future productivity, health, and biodiversity of Maryland's forests.

Land use in Maryland (2010)



Data source: iMap.

Manage your woods

Step 1
Learn more about your woods

Step 2
Contact a forester

Step 3
Identify your goals & objectives

Step 4
Develop and implement a forest stewardship plan

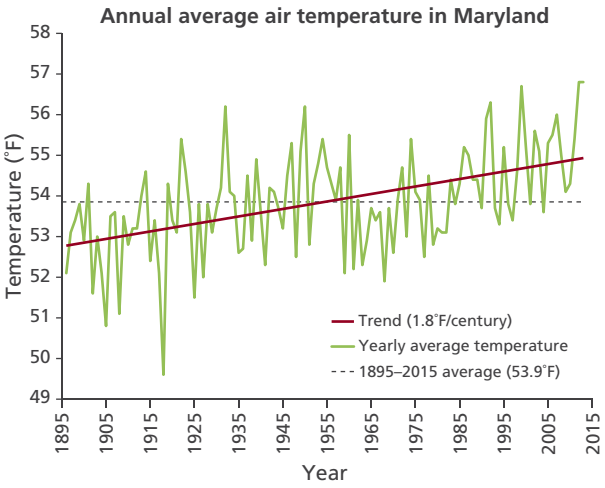
Jane Hawkey, IAN Image Library

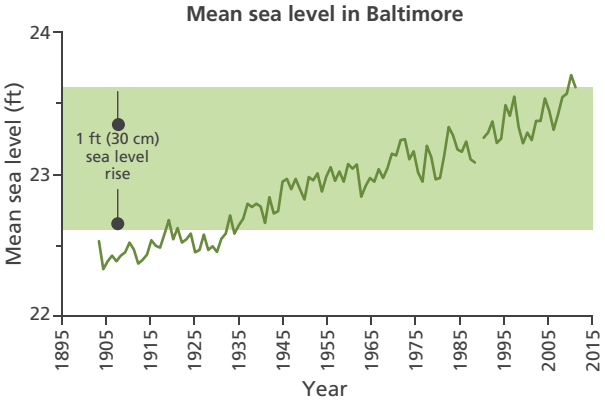
A forester can help you to identify opportunities to improve the health of your woods.

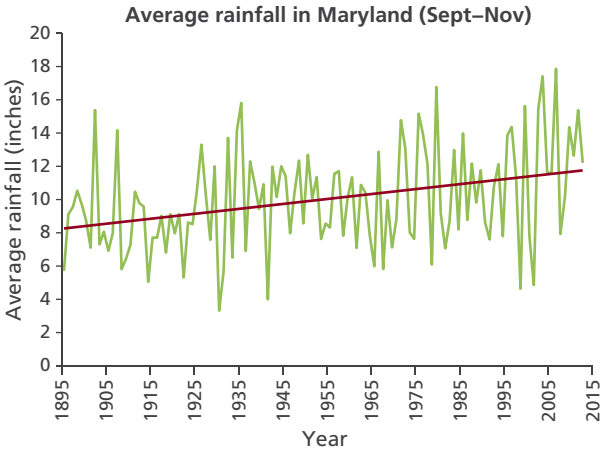
Private landowners currently own 76% of all forestland in Maryland. The remaining 24% is comprised of federal, state, and local government forests and parks.

Climate change facts

Maryland's climate is changing







*Top: Data from the National Climatic Data Center shows that average air temperatures in Maryland have increased ~1.8°F per century since 1895.**

Middle: The long-term tide gauge in Baltimore Harbor shows a steady rise in sea level since the early 1900s.†

*Bottom: Average fall rainfall (September–November) in Maryland has increased by 3 inches over the last century.**

Within the last 100 years, Maryland has experienced changes in temperature, coastal sea level rise, and rainfall patterns that can have future environmental and economic impacts on your woodland.

Temperatures are increasing

One hundred years of data show that Maryland is getting warmer. On average, temperatures have increased by 1.8°F but in November, December, and February, average temperatures have risen by as much as 3.6°F. This may mean less snow in some areas, but more ice, which may harm the health of your woodland.

Coastal sea levels are rising

Historical tide gauge records demonstrate that sea levels in Maryland have risen approximately one foot over the last 100 years due to a combination of global sea level rise and sinking land. According to a 2013 report,‡ scientists agree that sea level will continue to rise 1.6 feet by 2050 and as much as 4.6 feet by 2100, pushing waves and seawater further inland, flooding more land, eroding shorelines, and adding saltwater above and below ground. Trees that are not tolerant of salt and flooding in the groundwater will die off along coastal areas, and survival rates of young trees will decrease.

Rainfall patterns are changing

As the Earth warms, we have experienced changes in rainfall patterns. Over the last century, Maryland has become wetter in March and autumn, and drier in July and August. This means we have more water during seasons when we don't need it and less water when we do. Drier summers will continue to stress young and mature trees and increase the risk of wildfires; however, the extra autumn rains may help to establish fall tree plantings, and help mature trees become ready for their dormant season over winter.

Extreme weather events are more frequent

Maryland is experiencing more frequent extreme rain and storm events, and more flooding as a result of sea level rise and coastal storms. August and September of 2011 were the State's wettest in 117 years, while July of 2011 and 2012 were the second and third hottest on record. Woodlands affected by extreme events such as hurricanes and tornadoes, wind storms, ice storms, summer heatwaves, droughts, floods, and wildfires can take decades to recover after disturbance, and forest ecosystem structure and productivity may change as a result.

* National Oceanic and Atmospheric Administration (2013) NOAA's National Climatic Data Center. http://www.ncdc.noaa.gov/. Accessed March 11, 2013
† Permanent Service for Mean Sea Level (2013) Mean sea level for Baltimore. http://www.psmsl.org/data/obtaining/stations/148.php Accessed March 11, 2013
‡ Boesch et. al (2013) Updating Maryland's Sea-level Rise Projections. 22 pp. University of Maryland Center for Environmental Science, Cambridge, MD.

Projected changes

How will climate change affect your woodlands?

As our climate changes, the projected changes that are most likely to affect woodlands are:

- increasing temperatures
- changes in rainfall patterns
- longer growing seasons
- drier soil in summer and wetter soil in winter
- saltwater intrusion into groundwater
- increasing abundance of pests and diseases
- increasing invasive species
- more frequent extreme weather events

Combinations of some or all of these changes will affect the health of your woods and may change what tree species grow on your property.

Good management can save you time and money

Your management decisions affect how well your woodland can withstand damage or recover after damage. A good woodland steward takes steps to keep woodlands healthy even as conditions change. Preparing for these changes now will save you time and money in the long run, improve forest health, increase your enjoyment of your property, and reduce the risk of losses in the future.

There are several things you can do to enhance the ability of your woodland to adapt to climate change and its effects. In most cases, these actions are part of normal woodland management.

The following pages explain the potential impacts of climate change in Maryland and how they may affect your woodland. Management options are described for each of these climate change impacts to reduce or avoid loss of forest cover, declines in forest productivity, and reductions in the environmental benefits of woodlands.

In some cases, the best management option may be to take no action, and to allow species composition and structure to change naturally over time (natural succession).

Erik Meyers, The Conservation Fund

David Heise

Jerry Edmundson

Jack Perdue, Maryland Forest Service

Saltwater intrusion into groundwater kills salt-intolerant trees along the coast.

Winding vines can strangle trees and increase damage from ice, snow, and wind.

A wet late winter and early spring in 2011 caused heavy flooding along the Potomac River.

Ice storms can break branches and tree trunks.

Key actions

Keep your woodlands healthy

- **Manage for a healthy density.** Keep trees vigorous to better resist pests and survive in the face of disturbances. Practices like thinning or timber stand improvement reduce stress and keep forests at reasonable densities for a mix of species and age classes.
- **Diversify species.** If planting, consider species likely to be successful even if the range of species is expected to change over time with climate change. For example, loblolly pine is predicted to expand its range further north.
- **Choose drought-resistant species** when planting in areas prone to drought. Techniques like using root gels or watering newly planted seedlings during a dry summer can help improve survival.
- **Diversify stand ages and structure.** Stands of different ages and species will not all be susceptible to the same damage. Timber stand improvement, thinning, harvesting, and planting all provide opportunities to create diversity.
- **Build connectivity.** Connected woodland parcels allow tree species and wildlife to migrate more easily, which encourages greater diversity.
- **Learn how to control invasive species.** The species, season, and desired control method all matter if you want to avoid wasting time and money.
- **Control invasive vines.** All invasive plants compete for light, water, and nutrients, but vines bring special problems. Vines can completely overgrow trees and shade out their canopy—those with winding growth habits can strangle trunks, and the mass of vines in canopies increases risk of damage from ice, snow, and wind.
- **Manage deer.** Too many deer usually means too few young trees and the loss of the understory in the woods. If you don't hunt, consider a hunt club or hunting lease on your property to control deer populations.
- **Design for wind.** Reduce risk of wind-thrown trees by having gradual transitions from short to tall vegetation at the edges of woodland stands.
- **Plan fuel breaks.** Wildfire is always unexpected, but having fuel breaks like well-maintained roads or a thinned area can make it more difficult for fires to spread.
- **Assess conditions quickly** after a storm or fire, and act wisely; some actions are only possible or cost-effective soon after the damage. Contact a forester before you act.
- **Monitor for disease and insects.** A small problem is easier and less expensive to control.
- **Consider future flooding** when investing in management or land purchases on the coast or along rivers.
- **Consider storm surges and sea level rise.** Plan for species with higher flooding and salt tolerances in flood-prone tidal and non-tidal areas.
- **Ask your forester** about programs to help pay for needed management.

Jane Hawkey, IAN Image Library

Jack Perdue, Maryland Forest Service

Jane Hawkey, IAN Image Library

Dan Hedderick, Maryland Forest Service

An example of timber stand improvement is girdling sweetgums due to their low harvest and wildlife value, allowing more valuable trees to grow.

A healthy forest with diverse species and ages.

Damage to a young tree from deer.

Removing a hung-up tree to prevent further damage to other trees.

Climate change impact

Shifting species distributions

Suitable habitat for many species will move further north

The composition of woodland is largely controlled by past land use history, the impact of deer browsing, and what species are adapted to the climate in the area. Slow subtle changes in woodland composition and distribution are determined by a number of factors such as seasonal temperatures, when and how much it rains, soil moisture patterns, the severity of extreme storm events and other natural disturbances, deer browsing, and the abundance of pests and diseases. As these factors change, the habitat required for certain species may shift. Some landowners may choose to allow this shift to occur naturally.

It is estimated that the range of some woodland species in the U.S. is migrating at a rate of 1–3 miles per year. It is predicted that this trend will continue, as preferred habitat for many tree species moves northward due to changes in temperatures and rainfall. In some cases these changes may occur faster than some species can handle. As woodland composition changes, the types of wildlife supported will also change, and forest productivity may increase or decrease depending on the species.

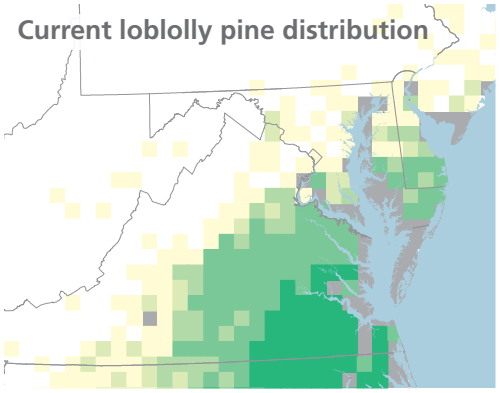
Populations of species at the northern limit of their range may become more abundant or colonize new habitat, whereas those species at the southern limit of their ranges may migrate away from intolerable conditions or die off locally. In Maryland, it is likely that the high elevation northern hardwood forests of sugar maple and birch trees, and the valuable black cherry tree, will decline as their suitable habitat decreases in quality and extent; meanwhile oak, hickory, and loblolly pine trees are likely to expand their range in Maryland.

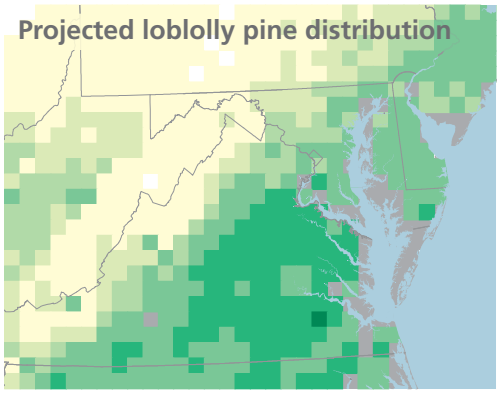
Current distribution of loblolly pine and black cherry in 2000 (left) and projected distributions in 2100 (right) based on the average of three climate change models at high carbon emissions rates. Loblolly pine distribution will expand to the north and west, while suitable habitat for black cherry will be reduced.*

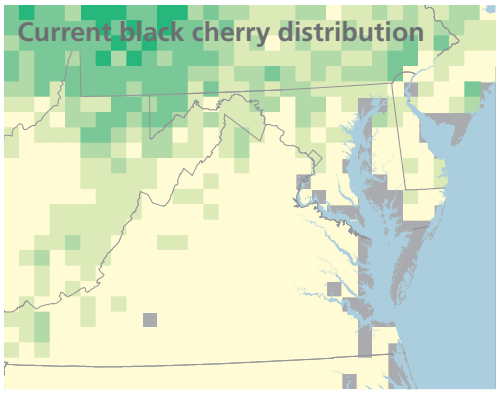
Importance value is defined as the most dominant species by size and abundance in a forest.

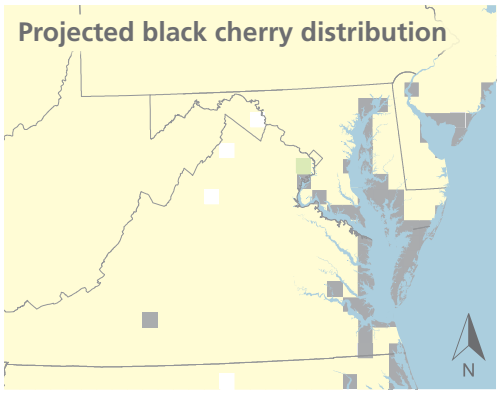
Edwin Remsberg, University of Maryland

Mark Twery, USDA Forest Service









Importance value (dominance)

- 0 (low)
- 1 - 3
- 4 - 6
- 7 - 10
- 11 - 20
- 21 - 30
- 31 - 50
- > 50 (high)
- no data

*Data source: Prasad, A. M., L. R. Iverson., S. Matthews., M. Peters. (2007-ongoing) A Climate Change Atlas for 134 Forest Tree Species of the Eastern United States [database]. http://www.nrs.fs.fed.us/atlas/tree, Northern Research Station, USDA Forest Service, Delaware, Ohio.

Management options

Shifting species distributions

1. Consider current conditions for regeneration and establishment of native species when harvesting, as well as conditions 50 years from now.

2. Diversify stand ages and structure through timber stand improvement, thinning, harvesting, and planting. Stands with diverse ages and species have more opportunities to adapt to changing habitat conditions.

3. Plant diverse tree species, choosing native species that are expected to be better adapted to future conditions.

4. Build connectivity to allow trees and wildlife to migrate more easily as their preferred habitat changes.

5. Identify and maintain species at the southern extent of their range in cooler and moister microhabitats. For example, areas on north-facing slopes, lake edges, and wetlands may be suitable.

6. Choose drought-resistant species such as eastern red cedar, Virginia pine, black locust, and loblolly pine when planting in areas prone to drought. Techniques like using root gels or providing watering for newly planted seedlings during a dry summer can help improve survival.

7. Increase monitoring and control of invasive species to allow native tree species to migrate naturally. Invasive species often gain a competitive advantage as habitat conditions change.

Mark Twery, USDA Forest Service

Anne Hairston-Strang, Maryland Forest Service

Maryland Forest Service

When planting, choose a variety of native species best adapted for projected future conditions.

Deferment cutting promotes a two-age stand structure, improving aesthetics and wildlife habitat.

Forests with diverse ages and structure have more opportunities to adapt to changing habitat conditions.

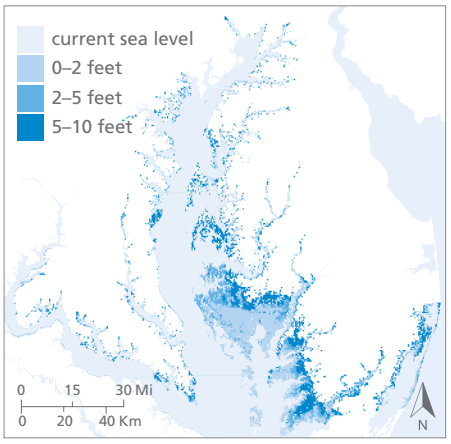
Climate change impact

Sea level rise and coastal flooding

Sea level will rise 2–5 feet by 2100

Historical rates of sea level rise along Maryland's coastline are nearly twice those of the global average. Sea level has risen approximately one foot in the last century and is expected to rise at least another 1.6–4.6 feet by the year 2100 due to a combination of rising sea level and lowering (subsidence) of the land. This will lead to increased coastal flooding, higher storm waves, more shoreline erosion, and saltwater intrusion, which is the movement of saline water into freshwater aquifers.

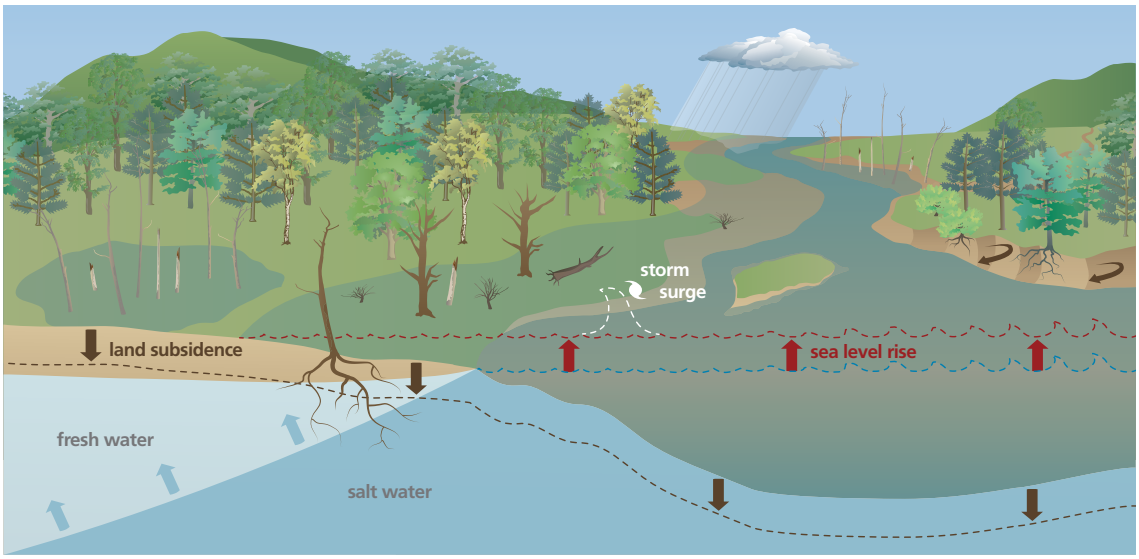
Already woodlands along some coastal areas of Maryland are failing to regrow because of increased flooding due to sea level rise. This is occurring even when there are abundant seedlings and an open canopy—conditions that would usually result in woodland growth. Species that are sensitive to increased salinity tend to die back and be replaced by fewer native and more non-native species that can tolerate saltwater. As land subsides along the coast, root networks collapse and trees drown in saturated soil, producing the 'ghost' forests already seen in some coastal areas of Maryland.



Vulnerability to sea level rise in the coastal areas of Maryland based on projected sea level rise calculations by 2100 of 1.6–4.6 feet. Vulnerable areas were calculated using elevation data.

Flooding along coastal areas will increase

More rainfall may mean more flooding along coastal areas. Trees, shrubs, and grasses that grow along rivers and streams are dependent on water flow and frequent flooding. Increased flooding may change species diversity and habitat, reduce shoreline stability, and result in the loss of edge species as the shoreline erodes following flood surges. However, more small floods may also have positive effects on regeneration by providing additional sediment for growth and creating better habitat for species adapted to these conditions.



Ghost forests
As land subsides along the coast, roots may collapse and trees drown in saturated soil, creating 'ghost' forests.

Saltwater intrusion
Saltwater intrusion into ground water will cause salt-intolerant trees to die off, to be replaced by salt-tolerant trees.

Sea level rise
1.6–4.6 feet sea level rise will lead to increased coastal flooding, storm surge inundation, and saltwater intrusion.

Coastal flooding
Increased rainfall may lead to more frequent coastal flooding.

Erosion
Coastal erosion, and erosion along river banks leaves tree roots exposed.

Erik Meyers, The Conservation Fund

Land subsidence and saltwater intrusion into the groundwater has created a 'ghost' forest of dead trees in Blackwater National Wildlife Refuge on the eastern shore of Maryland.

Management options

Sea level rise and coastal flooding

1. Monitor high-water line marks and salinity levels for your area, particularly near tidal waters. Where appropriate, replace dead trees with salt-tolerant shrubs and grasses.

2. Plant red cedar and honey locust where salty soils are a problem; plant black walnut for aerial salt spray. More detailed salt tolerance information for tree species can be found at: **http://pubs.ext.vt.edu/430/430-031/430-031.html**

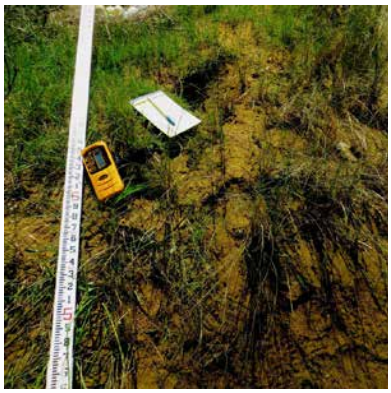
3. Plant a diversity of flood-tolerant vegetation where appropriate to help the forest ecosystem recover from disturbances. A list of flood-tolerant species can be found at: **http://nps.gov/plants/pubs/chesapeake/pdf/chesapeakenatives.pdf**

4. Plant flood-tolerant species at higher elevations to ensure species can recover after flooding. Physically move individuals of select species (e.g., bald cypress, tupelo) to suitable future habitat.

5. Create living shorelines and use natural stabilization techniques to protect shorelines and streambanks. This will allow swamp, shoreline, and floodplain forest species to naturally migrate as conditions change.

6. Increase the width of forest buffer lands along shorelines and streams on your property.

7. Control invasive species such as nutria that destroy marsh and swamp lands.



South River Federation

South River Federation

South River Federation

Surveying elevation along waterways.

Planting flood-tolerant vegetation at Beards Creek restoration site.

Living shoreline project on Church Creek will help to stabilize the shoreline and allow swamp, shoreline, and floodplain forest species to migrate to higher elevations.

Climate change impact

Increased temperatures, drought, and fire

Less water makes trees more susceptible to pests and disease

Forests generally adjust to natural disturbances such as drought and increased temperatures through built-in natural recovery systems. Trees pull water up through the soil when it is available, but a changing climate means less water in the hot summer and prolonged heat stress. Larger trees fare better because of their well-developed root systems; however, seedlings and saplings may not survive. Eventually, when droughts last long enough, all trees are affected, reducing productivity and reproduction. As trees and soils lose moisture, trees become stressed and more susceptible to pests and disease.

Pests and disease increase fuel sources for wildfires

When trees are already stressed from drought, pests and diseases can further increase the amount of dead leaves and branches on the forest floor. Invasive vines can also serve as ladder fuels, allowing wildfires to move from the ground to the canopy, where fire is very difficult to control.

Although wildfires are not a serious problem in Maryland, fires do occur when there is an absence of moist vegetation, and when dry vegetation and debris cover the ground. Increasing temperatures and more droughts, combined with less snowfall and snowmelt, could result in earlier and longer fire seasons in Maryland, which may affect your woodland.

Brian Kunkel

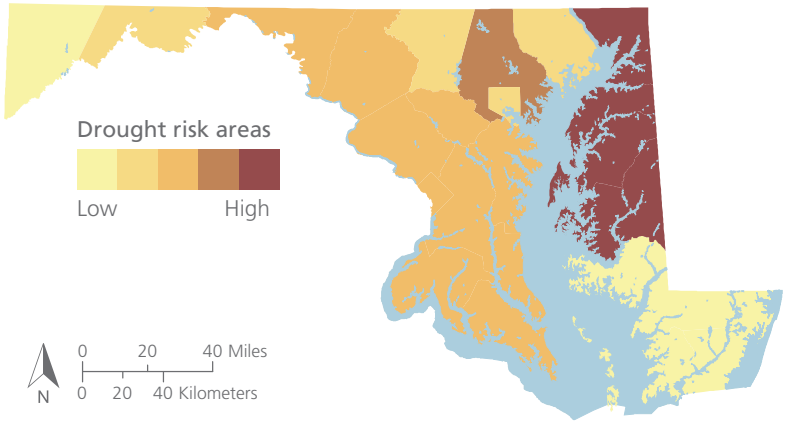


Photo: The leaves of a tulip tree turn yellow due to drought stress.

*Map: The eastern shore of Maryland is most at risk of drought according to historical drought frequency from the Palmer Drought Severity index.**

Maryland Forest Service

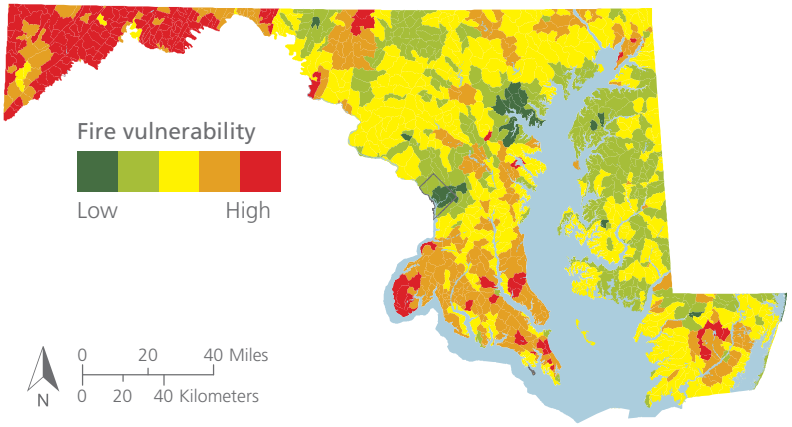


Photo: Forest wildfire at night.

Map: Vulnerability to fire is highest in western and southern Maryland.†

* Data source: Maryland Emergency Management Agency. 2011. State Hazard Mitigation Plan. Maryland Emergency Management Agency, Reisterstown, MD.
† Data source: Maryland Forest Service.

Management options

Increased temperatures, drought, and fire

1. Remove unhealthy trees and reduce overcrowding to protect remaining trees and to reduce wildfire risks.
2. Increase tree species diversity to protect against pest damage to a single-species stand.
3. Monitor woodlands for disease, insects, and invasive plant species.
4. Interplant species tolerant of drier, warmer conditions.
5. Avoid planting in a year that has severe drought predictions, or plant in the fall when precipitation is more frequent.
6. Reduce loss of soil moisture by: lengthening woodland harvesting cycles; planting cover crops; or using root dips, gels, and pellets before planting young seedlings.
7. Use vented planting tubes to minimize heat stress to newly planted seedlings.
8. Plan fuel breaks (e.g., roads, bulldozer lines, thinned areas, or bodies of water) to slow the spread of wildfire and protect areas of high concern or value.
9. Practice Firewise landscaping around your home to reduce the threat of damaging wildfires. **http://www.firewise.org**

Dan Hedderick, Maryland Forest Service

Donald Outen

Jane Hawkey, IAN Image Library

Reducing overcrowding improves the health of remaining trees, reducing wildfire risks.

Thinning the canopy at Oregon Ridge Park in Baltimore County using low impact harvesting techniques.

Dipping seedlings in a rooting gel helps to preserve moisture around the roots when it's planted.

Climate change impact

Invasive species, pests, and disease

Invasive species compete for light, nutrients, and water

Invasive plant species affect forest health and regrowth through competition for light, nutrients, and water. As many of these invasive plant species have been introduced from other regions, the absence of competitors or predators means that they are able to outgrow and replace many native plant species, especially understory species and young trees. This alters the structure of woodlands, changing what species grow there—often with a significant loss of biodiversity and reduced habitat for animals.

Unnaturally high deer populations intensify the problem as they prefer to eat native species, making it easier for invasive species to grow and expand. A changing climate may also intensify the problem in the following ways:

- A longer growing season resulting from a warming climate can give invasive species a bigger advantage in their competition with native species.
- Higher carbon dioxide levels have been linked to a faster spread of invasive plants and increased resistance to herbicide applications.
- Shifting species distributions as plant species gradually migrate north provides another opportunity for invasive species to outcompete natives.

Climbing vines make trees more likely to break in extreme weather

Invasive vine species like English ivy, kudzu, and multiflora rose climb up tree trunks, adding more weight and surface area to the crown of the trees. This stress makes branches and the whole tree more likely to break under the weight of snow, ice, or strong winds. Native grapevines and poison ivy can cause similar problems, but to a lesser extent.

Kudzu—usually found in southern Maryland—has recently been observed in western Maryland, which may be related to a warming climate. Kudzu is an example of a vine with the power to change the landscape. In states south of Maryland, kudzu has overgrown many acres of mature trees, creating vast wastelands of pure kudzu, covering the skeletons of formerly healthy trees.

Warmer temperatures help insect pests and disease to overwinter

Insect pests and disease can have a significant impact on woodlands, and a changing climate may affect what kind of pests are seen in Maryland, including insects, fungal pathogens, and diseases. Increasing temperatures may change the distribution and abundance of existing pests and diseases, and create new opportunities for invasions by pests and diseases that do not yet threaten Maryland's natural resources.

Many insects and diseases are controlled by winter temperatures, with colder temperatures reducing populations of insect pests and diseases. As winters get warmer with climate change, the number of these pests and diseases that survive the winter may increase, leading to infestations. However, at this time most woodland health problems are due to invasive pests that have been transported to Maryland from other areas by people, equipment, or through our globalized trade system, including emerald ash borer, gypsy moth, hemlock woolly adelgid, and thousand cankers disease.

John D. Byrd

Mark Twery, USDA Forest Service

Mark Twery, USDA Forest Service

Deer prefer to browse native plant species, making it easier for invasive species to take over.

Kudzu quickly overgrows mature trees, killing them by outcompeting for sunlight.

Hemlock woolly adelgid populations are controlled by how cold it is in winter.

Beech bark disease will ultimately kill the tree.

Management options

Invasive species, pests, and disease

1. Monitor and remove invasive plants in your woods, especially those at the forest edge. This will not only protect the health of your forests, but will also help your neighbors. Early detection and rapid response to new infestations will save you time and money.

2. Remove or kill unwanted, invasive vegetation before planting tree seedlings or harvesting.

3. Clean your equipment and clothing when leaving an area infested with invasives species, insect pests, or disease to avoid transporting them to a new location.

4. Reduce deer populations to healthy levels that allow native plant species to grow and compete with invasive species in your woodland.

5. Monitor for disease and insects. A small problem is easier and less expensive to control.

6. Diversify stand ages and structure through timber stand improvement, thinning, harvesting, and planting. Different tree species will not all be susceptible to the same causes of damage from pests and diseases.

7. Remove unhealthy trees and reduce overcrowding of trees to keep your forest healthy. Healthy woodlands are better at resisting the impacts of invasive species, pests, and diseases.

Jane Hawkey, IAN Image Library

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Dan Hedderick, Maryland Forest Service

It is best to cut English ivy at the base and let it die on the tree; pulling down the vine can tear off tree bark.

A forester inspects an insect-damaged tree.

Careful removal of some trees as recommended by a forester provides an opportunity to create diversity in stand ages, structure, and species types.

Forests capture carbon

Storing carbon in woodlands and wetlands

Healthy forests store carbon as biomass and in the soil

Scientists agree that our climate is changing and that these changes are caused by human activities, particularly the increase in carbon dioxide emissions (and other greenhouse gases) from burning fossil fuels such as coal, natural gas, and oil.

Forests naturally capture carbon dioxide from the atmosphere which is then stored as carbon in live trees, woody debris such as fallen branches and leaves on the forest floor, and the soil. This carbon can be stored for decades and centuries in living trees or in durable wood products like furniture or building frames until it is released when vegetation either decays or is burned. Maintaining or increasing the amount of carbon that can be stored by your woodland is crucial to help reduce our carbon emissions and the effects of climate change in the future.

When mature forests are harvested sustainably, the carbon that was removed by the forest over time is stored in lumber or other wood and paper products. After a timber harvest, carbon will be removed from the atmosphere at a slower rate at first, but once new forest becomes established the rate of carbon being removed from the atmosphere will increase because young trees have a higher tree density and faster growth rate than a mature forest.

If forested land is converted into housing developments, the total amount of carbon dioxide in the atmosphere increases due to the loss of carbon storage capacity on that land, while the construction of roads and buildings and an increased dependence on motor vehicles create new greenhouse gas emissions. Keeping forests as forests is the most important thing a landowner can do to help reduce and capture greenhouse gas emissions. These forests also provide other natural benefits such as producing clean air and water, creating wildlife habitat, and other aesthetic values.

Climate change itself will affect how much carbon can be stored in forests. For example, with increased temperatures and drought, trees may be less successful at reproducing and the rate of seedling survival may decline, reducing the amount of carbon that can be stored as trees typically store more carbon than grasses or other vegetation. An increase in wildfires will also release carbon back into the atmosphere as live and dead plant matter is burned. On the other hand, a longer growing season and rising carbon emissions may lead to increased tree growth, which will in turn absorb more carbon.

Forests can be managed to store and capture more carbon through sustainable forestry practices. Talk to your forester for more information about opportunities and incentives.

Salt marshes and wetlands can store carbon for millenia

Wetlands and salt marshes are even more productive at capturing and storing carbon in the soil, burying up to 57 tons of carbon per acre every year. This carbon can be stored in the soil for millenia, making these ecosystems very valuable for carbon storage; however, these ecosystems are also most at risk of development and are disappearing 5–10 times faster than rainforests, and this rate of loss is accelerating. Sea level rise is also eroding coastal salt marshes at a rapid rate.

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Maryland Wildland Fire Crew

Jane Hawkey, IAN Image Library

Carbon emissions from burning fossil fuels has been directly linked to climate change.

When forests are converted into housing developments, carbon emissions increase.

Carbon is stored until the tree decays or burns.

Salt marshes and wetlands are most at threat from development.

Management options

Storing carbon in woodlands and wetlands

1. Work with your forester to evaluate carbon storage potential and sustainable forestry practices on your own property. Identify opportunities to work with neighboring forest tracts through cooperatives or Limited Liability Corporations (LLC).

2. Keep forests as forests—minimizing conversion to other land uses such as housing developments that will increase carbon emissions.

3. Plan for longer intervals between harvesting trees to maximize carbon storage on your property.

4. Harvest wood and store carbon within wood products such as furniture rather than firewood to minimize carbon losses.

5. Identify locations for reforestation (on lands with little or no present forest cover) and afforestation (on lands that have not been forested in recent history, including agricultural lands). Increasing forest cover on these lands will help to capture more carbon, as well as other economic benefits.

6. Reduce overcrowding of trees through selective thinning to keep your woodland healthy.

7. Protect existing salt marsh and wetlands on your property, and restore degraded salt marsh and wetland habitat.

Jack Perdue , Maryland Forest Service

Anne Hairston-Strang, Maryland Forest Service

South River Federation

Work with a forester to evaluate carbon storage opportunities on your property, and work with your neighbors to create adjoining forest tracts.

Carbon can be stored in wood products such as furniture.

A wetland restoration project at Beards Creek that will help to capture carbon.

Climate change is real

Take action now to help your woodlands to adapt

Climate change is real and it is happening now. The impacts of climate change in Maryland are already evident as rising seas, summer heat waves, and more frequent extreme weather events. All of these changes will affect Maryland's citizens, their livelihoods, and the state's economy.

The impacts of climate change outlined in this document need to be considered as part of your forest stewardship plan. As a good woodland steward, you can make smart environmental and economic decisions, and implement the most effective strategies to help your woodlands adapt to climate change. Many of these management options are already part of good stewardship practices to enhance wildlife, timber values, recreation, and other objectives. You may also want to consider how your forests can play a role to help capture carbon emissions and minimize the impacts of climate change in the future.

Now is the time to get informed, make plans, and implement changes. Woodlands that are well adapted to new and changing conditions will be better able to meet your management goals as you build a more sustainable future for your woodlands.

Management choices revolve around three key options:

cut something

plant something

or do nothing

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