Chapter 2

Maryland's Land and Waterscape

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Introduction

Maryland is a state of great geographic diversity. Often called "America in Miniature," the state comprises 12,386 square miles of mountains, valleys, rolling hills, and coastal flatlands and beaches, and over 9,203 miles of freshwater streams (Versar, Inc. 2011). From the barrier islands, bald cypress swamps, and Delmarva bays of the Eastern Shore to the mountain bogs, caves, and eastern hemlock forests of the Appalachian Plateau, Maryland encompasses a wide range of habitats that support an impressive variety of species. Scientific names for Species of Greatest Conservation Need (SGCN) are included in Appendices 1a and 1b. Scientific names for other species are included in the text of the chapter.

Maryland's wildlife distribution and abundance are intricately connected to and ultimately dependent on the ecological integrity and diversity of its habitats. The state's varied physiographic features, geology and resulting soil types, topography, and climate support a range of plant communities and aquatic environments that provide diverse habitats for wildlife. These habitat characteristics directly influence the distribution of wildlife species in the state, especially for species at the northern or southern edges of their North American range and for endemic species with specific habitat requirements. This chapter presents an overview of this diversity, which lays the groundwork for identifying Maryland's wildlife and SGCN, discussed in Chapter 3 (**Element #1**), and wildlife habitats essential to their conservation, discussed in Chapter 4 (**Element #2**). Having an understanding of why certain species and habitats exist in Maryland also leads to understanding threats and developing conservation actions that are addressed in the State Wildlife Action Plan (SWAP). In particular, this chapter provides information on the physical layout and attributes of Maryland (Figure 2.1), providing a regional context for the elements of subsequent chapters.

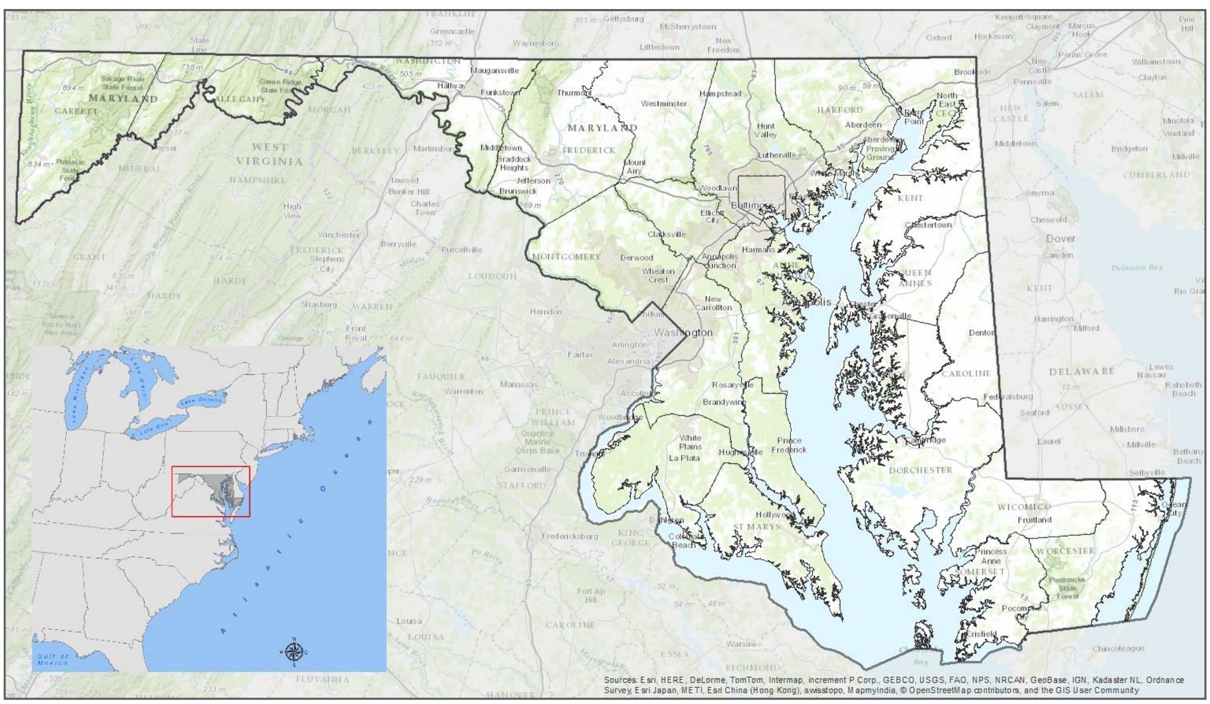


Figure 2.1 Maryland. Sources: U.S. Geological Survey (USGS) - The National Map (TNM), National Geographic.

Maryland's Physiography and Topography

Maryland's diverse landscape flows through a wide range of topographic features from the mountains to the sea. The state's landscape is divided into physiographic regions or provinces based primarily on soil types and the underlying regional geology. For the purposes of Maryland's SWAP (Plan), Maryland has been divided into six distinct physiographic provinces as follows: (1) Lower Coastal Plain, (2) Upper Coastal Plain, (3) Piedmont, (4) Blue Ridge, (5) Ridge and Valley, and (6) Appalachian Plateau (Figure 2.2). These provinces extend in belts of varying width generally parallel to the eastern edge of the North American continent. Many aquatic species found in the Atlantic Ocean can also be found in the Coastal Bays or the Chesapeake Bay. Therefore, for simplicity, the Atlantic Continental Shelf Province distinguished by the Maryland Geological Survey (MGS) has been merged with the Lower Coastal Plain.

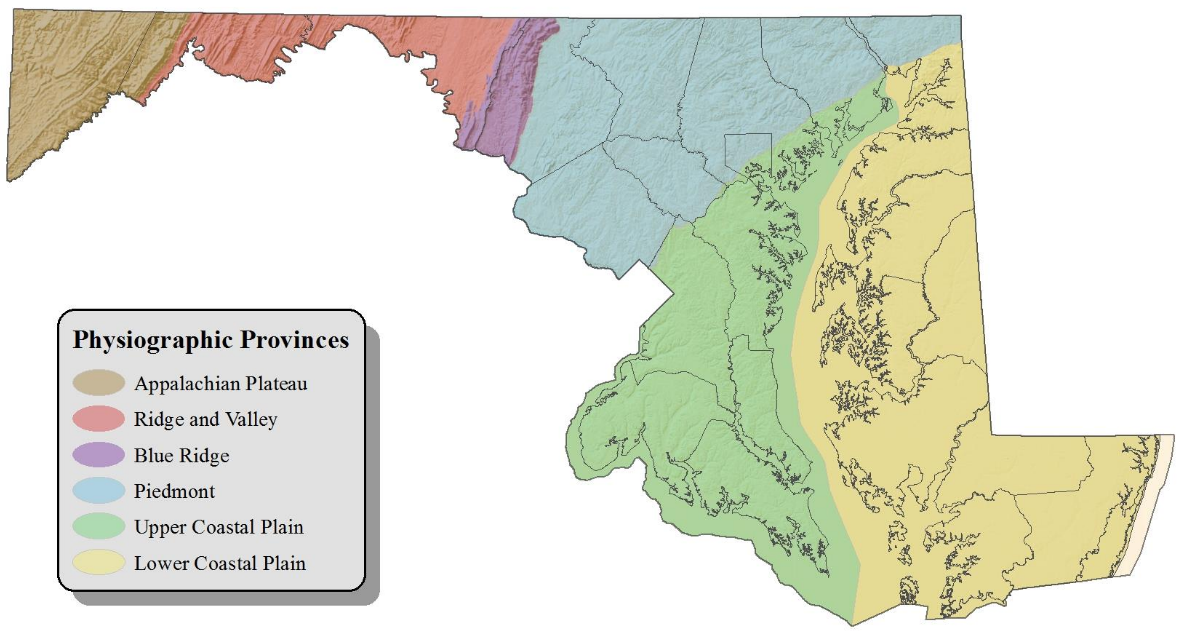
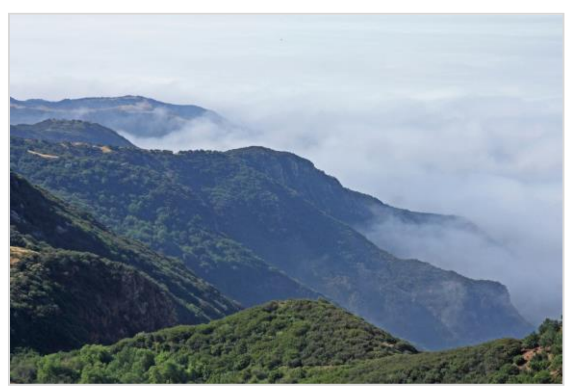


Figure 2.2 Physiographic Provinces of Maryland. Source: MD DNR.

The Appalachian Plateau Province, representing 8% of Maryland's landscape, has the state's highest elevations (generally 2000 to over 3000 feet), with parallel mountain ridges sometimes separated by dramatic gorges and whitewater rivers (Roth et al. 1999, MGS 2001b). The state's highest point is found on Backbone Mountain in Garrett County at an elevation of 3,360 feet above sea level (MGS 2004b). Garrett County shows 2,400 feet in relief, with the lowest elevation at 960 feet along the Potomac River at Bloomington.The state's highest free-



Backbone Mountain (Jim Belsey, NPS)

falling waterfall – Muddy Creek Falls – is located in Swallow Falls State Park in the Appalachian Plateau. Dan's Mountain in western Allegany County represents the Maryland portion of the Allegheny Front and forms the eastern edge of the Appalachian Plateau.

Muddy Creek Falls
(Danielle Grilli Marcus)

Continuing eastward, the Ridge and Valley Province comprises about 7% of Maryland's land area and is characterized by southwest to northeast oriented mountain ridges, deeply dissected trellis stream drainage patterns, and a high degree of topographic relief between parallel mountain ridges and river valleys (Roth et al. 1999). Elevation ranges from 200 to 2000 feet, with Warrior Mountain in Allegany County representing the highest point at 2,185 feet above sea level (MGS 2001b). The Great Valley, located in the eastern part of the Ridge and Valley, forms a broad lowland at about 500 to 600 feet in elevation and is dominated by karst topography (Roth et al. 1999).

East of the Ridge and Valley is the narrow Blue Ridge Province at the border of Frederick and Washington counties. This small province contains only 3% of Maryland's land mass. The geology of the Blue Ridge is characterized by a large anticlinal fold of sedimentary rock that shapes both Catoctin Mountain and South Mountain. At the heart of the fold, buried in the valley between the mountain ridges, lies the province's oldest volcanic and gneiss rock, with layers of progressively younger quartzite rock radiating from the core (MGS 2015). At 2,140 feet above sea level, Quirauk Mountain on the South Mountain ridge is the highest point in the Blue Ridge Province, and the eighth highest in Maryland (MGS 2015). The lowest elevation in this physiographic province is 250 feet along the Potomac River in Washington County near Harper's Ferry.

Covering 28% of the state, the Piedmont Province extends from Catoctin Mountain east to the Coastal Plain. As the different rocks found underlying the Piedmont weather and erode at different rates, they form the distinct topography of the Piedmont – rolling hills with deeply incised stream valleys. The Piedmont Province ranges from approximately 100 to over 1,200 feet in elevation, with its highest point being Sugarloaf Mountain (1,282 feet) in Frederick County (MGS 2004b). The irregular area of contact between the Piedmont and Coastal Plain in the Eastern U.S. is often called the Fall Zone or Fall Line because of the presence of rapids and falls where it is crossed by rivers and streams, such as at Great Falls along the Potomac River. This irregular line runs roughly along Interstate 95 (Pyzik et al. 2004).

For purposes of the Plan, the Coastal Plain is divided into two provinces – the Upper Coastal Plain and the Lower Coastal Plain. From its western edge at the Fall Line, the Upper Coastal

Plain generally grades downward to sea level at the waters of the Chesapeake Bay, although occasional cliff formations are found along the Chesapeake Bay shoreline. The highest point in the Upper Coastal Plain Province is approximately 440 feet in northern Prince George's County (MGS 2004a). The Upper Coastal Plain makes up 22% of Maryland's landscape. The largest of Maryland's provinces, the Lower Coastal Plain Province represents 32% of the state's landscape and includes the remainder of the Coastal Plain east of the Chesapeake Bay and Elk River. This province is known best as Maryland's "Eastern Shore" and is easily identified by its by flat, low-lying landscape dissected by the many tidal tributaries that drain into the Chesapeake Bay and the Coastal Bays on the Atlantic coast. Elevations are usually less than 60 feet above sea level. The Coastal Plain is underlain by unconsolidated sediments of gravel, sand, silt and clay, and represents the youngest region of the state in geological terms (MGS 2015).

Each of these physiographic provinces has characteristic habitats and associated wildlife species. Bats, freshwater crustaceans, and other highly specialized cave dwellers are found in the Appalachian Plateau, Ridge and Valley, and Blue Ridge Provinces, while blue crabs (*Callinectes sapidus*), eastern oysters *(Crassostrea virginica)*, and submerged aquatic vegetation beds are located in the estuaries of the Coastal Plain. The woodland songbird assemblages that are characteristic of the forests of the Ridge and Valley and Blue Ridge are often slightly different than those of the Appalachian Plateau or the other provinces. Black bears (*Ursus americanus*) have returned to the Appalachian Plateau, Ridge and Valley, and Blue Ridge habitats of western Maryland. The rivers and streams of the mountain provinces are more likely to have coldwater fish communities than the warmer streams of the Piedmont and Coastal Plain, which support spawning anadromous fish. Grassland suites of birds are more likely to be found in the Piedmont and Appalachian Plateau, whereas waterfowl and shorebirds are most abundant in the Coastal Plain. Highly migratory fishes like swordfish (*Xiphias gladius*), Atlantic blue marlin (*Makaira nigricans*), and several species of tuna are limited to the Atlantic Ocean off the Lower Coastal Plain Province.

Regional Context

Many conservation issues are broader than any one state or jurisdiction. Effective conservation requires a regional context: habitats and wildlife species' movement corridors pay no heed to political boundaries. Examples of such regional challenges include migration and dispersal patterns, species with large ranges, and watersheds that require the sharing of species, habitats, and entire ecosystems across county and state lines. Regional cooperation is required to address cross-boundary issues such as maintaining interconnectivity with surrounding habitats and populations, and mitigation of climate change and pollution impacts that affect entire regions. Restoring declining species with large distributions requires collaboration among many states to achieve stable populations. Multi-state or regional collaborations have many logistical advantages. Cooperation between different stakeholder entities produces a coordinated conservation effort that facilitates a greater species and habitat knowledge base and improved land acquisition systems, resulting in improved prioritization of communities and ecosystems. Likewise, coordinated conservation activities such as river management, invasive species control, and habitat connectivity are often most effective when implemented across multiple state jurisdictions (Terwilliger Consulting, Inc. & Northeast Fish and Wildlife Diversity Technical Committee 2013).

In order to facilitate work on a regional scale, the nation and region have been divided into biologically-based units called ecoregions, which provides a regional context for Maryland's ecological communities. Within its boundaries, Maryland covers three distinct ecoregions as defined by Bailey (1995): (1) the Mid-Atlantic Coastal Plain, (2) the Mid-Atlantic Piedmont, and (3) the Mid-Atlantic Ridge and Valley. These three ecoregions essentially mimic the aforementioned Maryland physiographic provinces, with the exception that the Appalachian Plateau, Ridge and Valley, and Blue Ridge physiographic provinces fall within the Mid-Atlantic Ridge and Valley Ecoregion and the Upper and Lower Coastal Plain provinces fall within the Mid-Atlantic Coastal Plain Ecoregion. Eastern Maryland also falls within the U.S. Forest Service's Southeastern Mixed Forest Ecological Province and western Maryland falls within the Appalachian Oak Forest Ecological Province (McNab & Avers 1994; Bailey 1995; LaBranche et al. 2003).

Using these large-scale divisions, some organizations promote ecoregional planning in order to assemble a portfolio of public and private conservation areas that collectively conserve the full biological diversity of an ecoregion. Each portfolio is meant to encompass multiple examples of all native species and ecological communities in sufficient number, distribution, and quality to insure their long-term persistence within the ecoregion. The Nature Conservancy (TNC) modified the Bailey (1995) ecoregions and placed Maryland's landscape into four ecoregions: (1) Chesapeake Bay Lowlands, (2) Lower New England/Northern Piedmont, (3) Piedmont [the southern continuation of the Lower New England/Northern Piedmont], and (4) Central Appalachian Forest. The Chesapeake Bay Lowlands encompasses the Maryland Coastal Plain, the two Piedmont Ecoregions contain the Maryland Piedmont physiographic province, and the Central Appalachian Forest closely follows the Maryland Blue Ridge, Ridge and Valley, and Appalachian Plateau provinces. TNC has prepared conservation plans for each of these ecoregions to facilitate effective ecoregion level conservation planning (Thorne et al. 2001; Barbour et al. 2003; Samson et al. 2003). Each of these plans summarizes the status and trends of the plant communities within the ecoregion, assesses threats to their conservation, identifies conservation needs, and sets priority targets for management of the ecoregion and its fish and wildlife resources. To address more specific needs for birds, Partners in Flight (PIF) and the North American Bird Conservation Initiative (NABCI), cooperative efforts involving a wide array of partners interested in bird conservation, have developed bird conservation plans for each physiographic area or Bird Conservation Region. These plans assess the abundance and distribution of avian species and recommend population targets for the conservation of individual species (Watts 1999; Kearney 2003; Rosenberg 2003).

Considering Maryland in a regional context is biologically justifiable and more practical and efficient in directing and prioritizing limited resources for effective conservation. For example, failure to base bird conservation objectives on regional or local science would ignore the value of species population objectives from the PIF Initiative (Rosenberg 2004). Table 2.1 provides examples of regional planning efforts by physiographic province to visualize coordinated efforts in the Northeastern U.S. In addition, two Landscape Conservation Cooperative (LCC) partnerships are carrying out broad regional planning efforts that include Maryland: North Atlantic and Appalachian Landscape Conservation Cooperatives. These relatively new efforts each cross several physiographic provinces and provide another opportunity for Maryland to participate in regional-scale planning. The North Atlantic LCC includes areas in Maryland's Lower and Upper Coastal Plains and Piedmont, while the Appalachian LCC includes Ridge and Valley, Blue Ridge, and Appalachian Plateau physiographic provinces.

Table 2.1 Correlation of Maryland's Physiographic Provinces to management initiatives used by other organizations and partners.

Physiographic Province	Name of Ecoregion	Initiative/Organization
Lower Coastal Plain	Mid-Atlantic Coastal Plain (44)	Partners in Flight (PIF) Physiographic Area
	New England/Mid-Atlantic Coast (Bird Conservation Region 30)	PIF/North American Bird Conservation Initiative (NABCI)
	Southeastern Mixed Forest Ecological Province	U.S. Forest Service
	Chesapeake Bay Lowlands	TNC Ecoregional Planning Units
	Outer Coastal Plain Mixed Province (232)	Bailey's Ecoregions
	Northeast	North Atlantic LCC
Upper Coastal Plain	Mid-Atlantic Coastal Plain (44)	Partners in Flight Physiographic Area
	New-England/Mid-Atlantic Coast (BCR 30)	PIF/NABCI
	Southeastern Mixed Forest Ecological Province	U.S. Forest Service
	Chesapeake Bay Lowlands	TNC Ecoregional Planning Units
	Outer Coastal Plain Mixed Province (232)	Bailey's Ecoregions
	Northeast	North Atlantic LCC
Piedmont	Mid-Atlantic Piedmont (10)	Partners in Flight Physiographic Area
	Piedmont (BCR 29)	PIF/NABCI
	Southeastern Mixed Forest Ecological Province	U.S. Forest Service
	Lower New England/Northern Piedmont (LNE/NP)	TNC Ecoregional Planning Units
	Piedmont (southern continuation of LNE/NP)	TNC Ecoregional Planning Units
	Eastern Broadleaf Forest (Oceanic) Province (221)	Bailey's Ecoregions
	Northeast	North Atlantic LCC

Physiographic Province	Name of Ecoregion	Initiative/Organization
Ridge and Valley	Mid-Atlantic Ridge and Valley (12)	Partners in Flight Physiographic Area
	Appalachian Mountains (BCR 28)	PIF/NABCI
	Appalachian Oak Forest Ecological Province	U.S. Forest Service
	Central Appalachian Forest	TNC Ecoregional Planning Units
	Central Appalachian Broadleaf Forest – Coniferous Forest – Province (M221)	Bailey's Ecoregions
	Appalachian	Appalachian LCC
Blue Ridge	Mid-Atlantic Ridge and Valley (12)	Partners in Flight Physiographic Area
	Appalachian Mountains (BCR 28)	PIF/NABCI
	Appalachian Oak Forest Ecological Province	U.S. Forest Service
	Central Appalachian Forest	TNC Ecoregional Planning Units
	Central Appalachian Broadleaf Forest – Coniferous Forest – Province (M221)	Bailey's Ecoregions
	Appalachian	Appalachian LCC
Appalachian Plateau	Mid-Atlantic Ridge and Valley (12)	Partners in Flight Physiographic Area
	Appalachian Mountains (BCR 28)	PIF/NABCI
	Appalachian Oak Forest Ecological Province	U.S. Forest Service
	Central Appalachian Forest	TNC Ecoregional Planning Units
	Central Appalachian Broadleaf Forest – Coniferous Forest – Province (M221)	Bailey's Ecoregions
	Appalachian	Appalachian LCC

Maryland's Landscape

Geology

The Coastal Plain is underlain by unconsolidated sediments, the Piedmont Province by a variety of hard igneous and metamorphic rocks, and the Blue Ridge, Ridge and Valley, and Appalachian Plateau provinces by folded and faulted sedimentary rocks (Figure 2.3). The Great Valley in Washington County and the Frederick Valley in central Frederick County include limestone and dolomite (Edwards 1981). A glimpse of Maryland's geological history can be seen in the largest road cut east of the Mississippi River, located along Highway 68 at Sideling Hill in Washington County, where nearly 810 feet of the folded rock layers of the Ridge and Valley Province can easily be seen (Brezinski 1994).

Maryland's geology is more diverse than its bedrock, however. The Appalachian Mountains in western Maryland were formed 250 to 450 million years ago and have been eroding ever since, forming the soils, rivers, and streams of most of the state in the intervening millennia (Grumet 2000). The formation of Chesapeake Bay was precipitated by a meteor strike that is believed to have occurred 35 million years ago, which created a depression that defined the region's drainage basins.

The state's geology is an important factor in determining the abundance, distribution, and integrity of several wildlife habitats. Not only does it influence the topography of the mountains and the estuaries, but several valuable habitats occur only on certain geologic features. For example, there are over 50 caves in the Appalachian Plateau, Ridge and Valley, and Blue Ridge Provinces, which provide habitat for numerous specialized, subterranean species (MGS 2004b). The distribution of limestone rocks creates karst (a landscape of caves, springs, and seeps) and limestone cliff habitats for other specialized species. Shale barrens and other bare rock habitats are present because of the occurrence of those particular geological layers in western Maryland. Further east, the Pilot Serpentine Barren in Cecil County and Soldier's Delight Serpentine Barren in Baltimore County have unique groups of plants and animals that favor the serpentine bedrock in those locations (Grumet 2000).

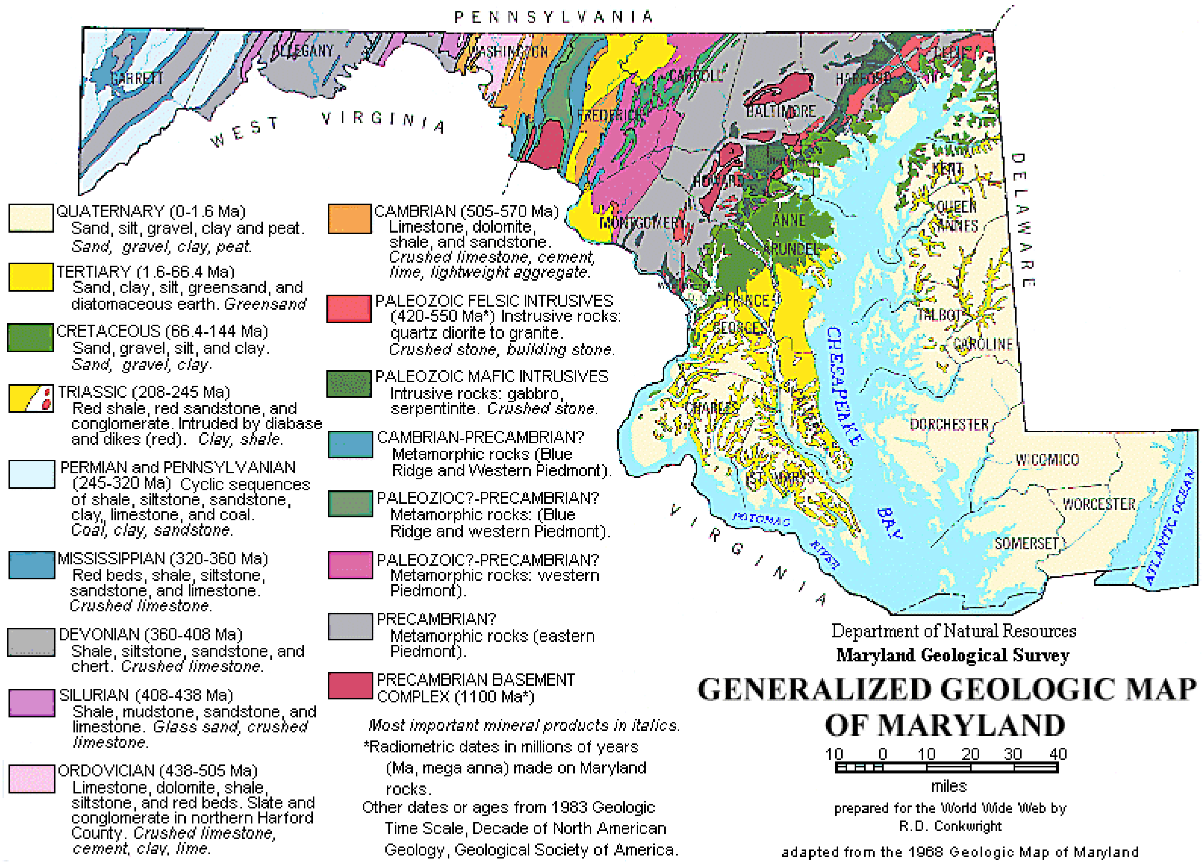


Figure 2.3 Maryland's geology. Source: MD DNR.

Soils

Maryland's soils are a reflection of their underlying geology. The most abundant soil type in Maryland is sassafras sandy loam, a loam that is deep, permeable, and well-drained (Maryland Department of Planning [MDP] 1973). This soil type is found throughout the state and is excellent for farming. Maryland also has bare rock areas without soil, very rocky soils that are less than two feet deep, fertile floodplain soils, loose sand soils, and mucky marsh and swamp soils that are wet most of or all of the time. Maryland does not have a state-wide soil map available in digital format; however some county soil maps are available through the Natural Resources Conservation Service.

Soils in the Appalachian Plateau, Ridge and Valley, and Blue Ridge Provinces are often thin, with loose rocks or bare bedrock exposed on the surface. The dramatic relief of the mountains creates steep slopes where soils may be easily eroded, especially if the land has been cleared. The mountain soils frequently contain gravel or rock fragments as the underlying rock is weathered to produce the soil; some of the gravel concentrations are high enough to be economically valuable for road fill and other uses. In some areas of central and western Maryland, bedrock is within 20 inches of the surface. Soils may be strongly acidic depending on the area's rock type (e.g., acid shale, sandstone). Ridges and hillsides composed of limey shales, limestones, and clays have created clayey soils interspersed with rock outcrops. River floodplains have deeper, well-drained soils of loamy alluvium deposited by their rivers or streams during floods, creating fertile soils excellent for farming. Floodplain soils located farther from the river or stream tend to have higher concentrations of finer sediments and are poorly to very poorly drained (MDP 1973).

The soils of the Piedmont tend to have a high proportion of clay. A band of red clay extends through northern Prince George's County, northwestern Anne Arundel County and eastern Washington D.C., covered by a few inches to several feet of surface soil. In other areas, the bedrock of the Piedmont creates an acidic, thin soil that contains a high percentage of shale or other rock fragments. Broad ridges or upland depressions often have moderately well-drained, thin (less than 2 feet) silty or loamy soils that are perched on top of an underlying clay or hardpan layer, which also seasonally traps the shallow water table and creates strongly acidic wetlands. Floodplain and rocky soils are similar to those found in the mountains (MDP 1973).

The Coastal Plain is characterized by soils of sand, silt, or clay that reflect the province's coastal heritage. In some areas of the Lower Coastal Plain, soils may be so sand-rich that they are economically valuable as sources of sand. These deep sand soils are very permeable and do not retain moisture well; in fact, when they are exposed at the surface without vegetation, they are easily eroded by wind. Along shorelines, these loose sand soils can easily be seen in dunes and beaches. Where organic material is available, the Coastal Plain's sandy soils become loams, becoming highly acidic and retaining more moisture. In some shallow or exposed areas, soils may have silts or clays that further enhance their ability to retain moisture, host more diverse plant life, and support agriculture. Wetlands are found where silt, clay, and/or very fine sand creates wet, acidic soils, especially on the Eastern Shore; these soils have been ditched and drained in many areas for use as farm fields. Tidal marsh and swamp soils are found along shorelines in the Coastal Plain and can either be sandy or rich in organic material, including peat; these wetland soils may be highly toxic to crops due to sulfur that oxidizes when wetlands are drained (MDP 1973). Some soils on the Lower Coastal Plain have also been influenced by a long history of human activity. At several shoreline sites, extensive Native American shell-middens, formed from accumulations of discarded oyster shells over thousands of years, have created an altered soil composition that supports a unique and diverse plant community (McAvoy & Harrison 2012). These rare natural and cultural resources represent special contributions to soil and habitat diversity resulting from the rich Native American history of Maryland.

Climate

Statewide, an average of around 40 inches of precipitation falls on Maryland each year (Maryland State Archives 2014). Precipitation varies throughout the state, however, with western Garrett County the wettest area and the Ridge and Valley region the driest (Figure 2.4). The statewide average annual temperature is 53.8^{o}F, with July being the warmest month on average (highs in the mid to upper 80s) and January the coldest (highs in the low to mid 20s) (National Climate Data Center 2015).

Maryland's temperate climate is moderated by coastal influences in the eastern part of the state and by the Appalachian Mountains in the western part. The climate is mild, humid, and relatively stable, which is a major factor in determining the plant and animal assemblages that occur in the state. The winter months of December to March tend to be the state's wettest and late summer to fall is the driest time of year. Maryland summers vary from mild to hot and the winters from very cold to moderate, depending on the location.

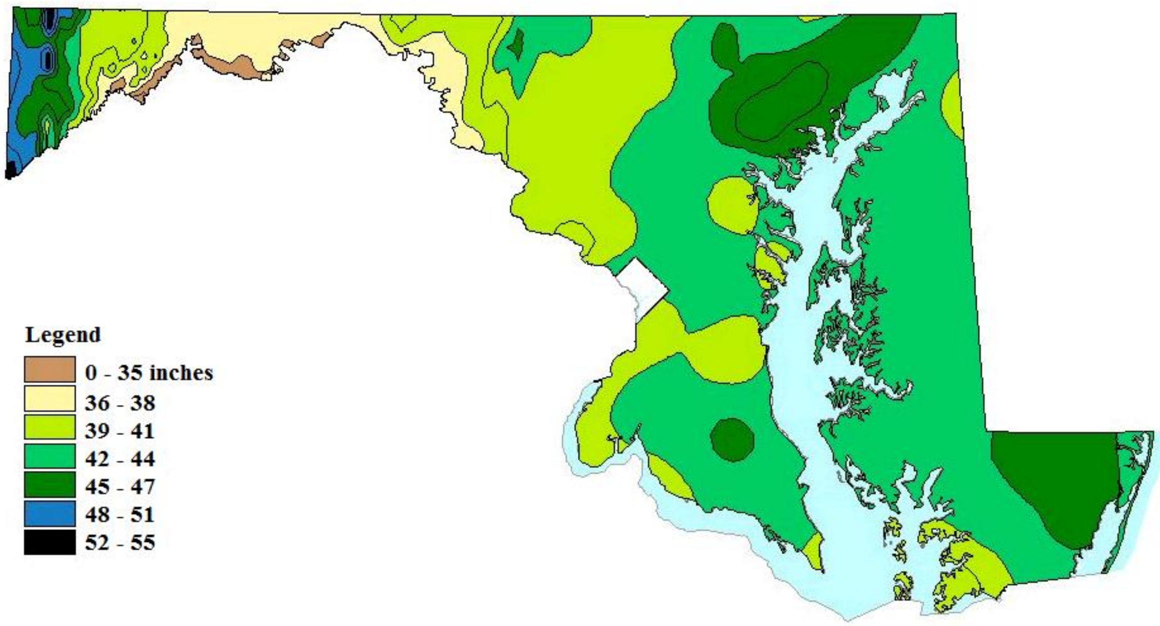


Figure 2.4 Annual precipitation in Maryland, 1961-1990. Source: NRCS Water and Climate Center.

The Appalachian Plateau is significantly cooler than eastern Maryland, averaging 150 days of sub-freezing temperatures each year compared to less than half that in the Lower Coastal Plain (MDP 1973). The annual growing season is accordingly much shorter (130 days) in the Appalachian Plateau region compared to the Lower Coastal Plain, where it can exceed 200 days. The mountains of the Appalachian Plateau create a rain shadow effect that causes great amounts of precipitation on the western slopes and dry weather on the lee side of the mountains. More than 50 inches of precipitation falls annually in the extreme southwestern corner of the Appalachian Plateau in western Maryland, while the eastern side of the Appalachian Plateau usually sees less than 36 inches per year (United States Geological Survey 1999).

The climate in the Ridge and Valley Province is also characterized by rain shadows (MDP 1973), with the Allegheny Mountain range blocking most of the precipitation from the west and the Blue Ridge Mountains blocking precipitation moving in from the east. The Ridge and Valley Province averages 36 to 40 inches of precipitation and 160 to 170 growing days a year.

The Piedmont averages 170 to 190 growing days a year, with the southern Piedmont warmer than the northern Piedmont (MDP 1973). Precipitation averages 40 to 44 inches a year. The Coastal Plain typically is wetter than the Piedmont, with an average of 44 to 48 inches of precipitation annually. The growing season is the longest in the Coastal Plain and can reach 230 days along the shores of the Chesapeake in the southern part of the state; the northern Coastal Plain's growing season averages 190 days.

Long-term trends indicate that Maryland is getting warmer and slightly wetter (Boesch 2008). Urban areas and cities such as Baltimore and the Washington, D.C. area have experienced increased temperatures as a result of high urbanization rates and increasing populations, while rural areas have seen temperature increases of lesser magnitudes. In the last century, average annual statewide precipitation has increased by over ¾ of an inch, although areas to the north and west of Maryland have seen a greater increase regionally (National Climate Data Center 2015). Additional information about how the climate in Maryland is changing and affecting SGCN and their habitats can be found in Chapter 6.

Land Use and Vegetative Cover

Land use decisions have direct impacts on species' occurrence and abundance. For thousands of years, Native Americans, whose descendants number more than 40,000 in Maryland today, have inhabited the state and influenced their surroundings. An understanding of their long and continuing interaction with the landscape comes from archaeological and cultural studies, oral and written histories, and present-day activities. Some examples of the particular influences of native cultures on Maryland's vegetative cover and species' distributions are presented later in this chapter. To summarize overall land use and land cover, an analysis was completed in 2010 and the resulting county and statewide maps are available through the MD Department of Planning. This analysis shows that Maryland is losing forest and agricultural lands, and there is an increase in submerged lands and an even more rapid increase in residential and urban development. Forestland is concentrated in the western and southeastern parts of the state and agricultural lands tend to be found in the rolling hills of the Piedmont and in the Coastal Plain (Figure 2.5).

Maryland's Coastal Plain is a region of relatively flat, low-lying landscape extending from central Maryland to the Atlantic Ocean. Prior to European settlement, the forests that covered the Coastal Plain consisted primarily of hardwoods, though they increasingly mixed with pine towards the south. These forests were likely combinations of oak-hickory, oak-gum, or oak-pine, and today exist in second growth form as a result of repeated cutting or agricultural abandonment. In addition, much of the contemporary forest consists of successional or silvicultural stands of loblolly pine (*Pinus taeda*). Wetland diversity in this region is exceptionally high and ranges from expansive freshwater to saline estuarine marshes, tidal and palustrine swamps (e.g., bald cypress *[Taxodium distichum]* swamps and Atlantic white cedar *[Chamaecyparis thyoides]* swamps), seasonally flooded depressions (e.g., Delmarva bays and interdunal swales), and seepage swamps. The Coastal Plain is one of the most heavily utilized areas in Maryland because of agriculture and silviculture in the lower regions and development and urbanization in the upper regions throughout the Baltimore-Washington, D.C. corridor and beyond.

The Piedmont is a region of gently rolling topography that extends across much of central Virginia, Maryland, southeastern Pennsylvania, and northern New Jersey in its northernmost extent. In general, habitat diversity in the Piedmont is high but very localized due to the numerous bedrock formations (i.e., calcareous, mafic, felsic) and high gradient rivers along the Fall Line. Historically, the forests of Maryland's Piedmont could have been characterized as oak-chestnut, but since the near eradication of the American chestnut by chestnut blight (*Cryphonectria parasitica)*, they have now been replaced by oak-hickory and oak-pine forests with scattered pockets of mixed mesophytic (moderate moisture level) forests. In addition, the thousands of acres of grasslands that once existed in northern Maryland (Mayre 1920) have been reduced to small pockets where soils are poorly developed and bedrock is exposed. Undeveloped areas are increasingly fragmented due to the continued conversion of forest and agricultural lands to residential use (and associated roads, power lines, and other infrastructure) as the urban centers of Baltimore and the District of Columbia continue to expand (Kearney 2003).

The Blue Ridge, Ridge and Valley, and Appalachian Plateau regions include western Maryland but also extend into Virginia and eastern West Virginia. Most of these physiographic regions consist of long mountain ridges and valleys. The headwaters of many rivers that feed the Chesapeake Bay are found in these provinces, including the Potomac River Basin in western Maryland. Predominant vegetation consists of oak and oak-hickory forests on the mountain ridges and northern hardwood forest in the Allegheny Mountains. Large portions of the lower valleys are devoted to agricultural production or urban development (MDP 2010).

Human populations are relatively sparse throughout the montane provinces and are mostly confined to the larger valleys. Suburban and second-home development from large urban centers (e.g., Baltimore, Washington, D.C., Pittsburgh), however, is rapidly encroaching on the mountain areas. Timber extraction has been historically important and continues to be important on both public and private forestlands. The Ridge and Valley and Appalachian Plateau provinces have traditionally been areas for coal extraction (both deep and strip mines). Other forms of energy development are increasing, including wind energy and, potentially, shale gas.

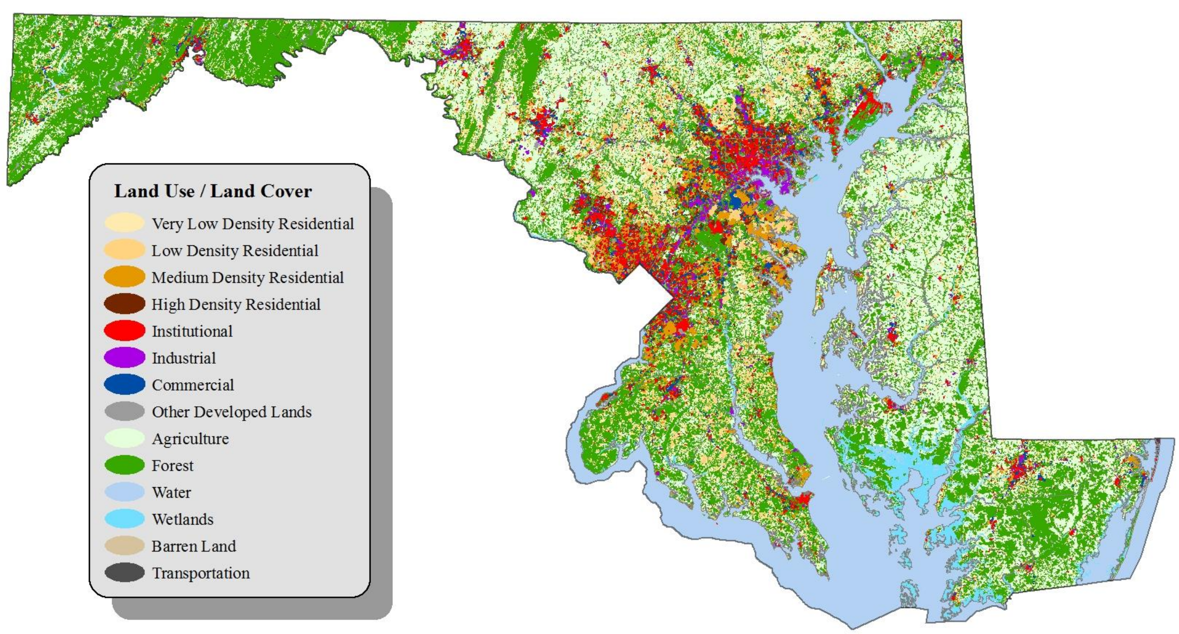


Figure 2.5 Maryland's land use / land cover. Source: MD Department of Planning.

As the undeveloped areas of Maryland continue to be impacted by urban and suburban development, the state population continues to increase. The Maryland population is increasing at an annual statewide growth rate of just greater than 1% (U.S. Census Bureau 2015). Over the last decade, the Maryland population has increased by 9%. Localized areas have growth rates much higher than the state average, with the highest human population growth rates in the last decade (2000-2010) occurring in St. Mary's County (22%), Charles County (21.6%), Frederick County (19.5%), and Calvert County (19%) (U.S. Census Bureau 2015). An average of 27,630 acres of agriculture and forest land has been lost annually, mostly to development, between 1973 and 2010, with a total of over one million acres having been developed since 1973 (MDP 2010a).

Table 2.2 Land use percentages in Maryland, 2010. Source: MD Dept. of Planning.

Land Use Category		% Coverage of MD Landscape
Very Low Density Residential	*Urban Development*	5.0
Low Density Residential		9.1
Medium Density Residential		4.9
High Density Residential		1.5
Commercial		1.6
Industrial		1.0
Other Developed Land[1]		3.6
Total Developed Land		26.7
Agriculture		30.6
Forest		38.7
Wetlands[2]		3.7
Barren Lands		0.3
Total Remaining Land		73.3

[1]Includes Transportation and Institutional categories. [2]Does not include forested wetlands.

The 2010 Maryland Department of Planning's Land Use Survey determined that 27% of Maryland's landscape is developed. Non-federal land was developed at an annual rate of nearly 16,000 acres a year between 2002 and 2010, with a nearly even split between agriculture and forest land being developed. Table 5.2 contains more detailed land use and land use change data, including acreages for each land use category in 1973 and 2010.

Maryland's forests decreased by almost 3% between 2002 and 2010, and covered only 38% of the state's landscape by 2010 (MDP 2010b). Almost a quarter of a million acres of forest were lost between 1973 and 2010 (MDP 2010b). Seventy-four percent of the state's forestland is privately owned, and oak/hickory forest is by far the most abundant forest type (USFS 2013). From 2002 to 2010 agricultural land decreased by 3.2% (MDP 2010b), but the longer term trend is a 19% loss in agricultural land from 1973 to 2010 (MDP 2010b). The area covered by wetlands decreased by more than 1,000 acres since 1973, while the amount of land covered by water grew by nearly 4,000 acres. Meanwhile, low-density residential land use has increased nearly three times over and industrial land use by a factor of four from

1973 to 2010 (MDP 2004, 2010b). The amount of land that is barren, including quarries and surface mines, doubled during the same time period (MDP 2010b).

Maryland's Forests

The USDA Forest Service classifies Maryland's forests into eight groups; oak/hickory, loblolly/shortleaf pine, northern hardwoods, oak/pine, oak/gum/cypress, elm/ash/cottonwood, white/red/jack pine, and exotic softwoods (USDA 2013). Each of these groups represents a broad association of multiple forest types covering the northeastern United States. For example, embedded within the oak/hickory group are forest types characterized by chestnut oak (*Quercus prinus*), white oak (*Quercus alba*), and northern red oak (*Quercus rubra*). Approximately 62% of Maryland's forests are classified as oak/hickory, covering 1.5 million acres (USDA 2013). Although relatively abundant and widely distributed throughout the state, the large Piedmont province of central Maryland contains the majority of oak/hickory forests with its diverse geology and undulating landscape.

The second largest forest group in Maryland is the loblolly/shortleaf pine group covering an estimated 13% or 308,576 acres (USDA 2013). Much like the oak/hickory forest group, the loblolly/shortleaf pine group is a broad one that includes forest types dominated by loblolly pine, shortleaf pine (*Pinus echinata*), Virginia pine (*Pinus virginiana*), table mountain pine (*Pinus pungens*), pond pine (*Pinus serotina*), or pitch pine (*Pinus rigida*). Throughout the state it is found on moist and poorly drained soils. At higher elevations on the Coastal Plain, it is found on drier soils and often on abandoned farmland. Combined, the Upper and Lower Coastal Plain physiographic provinces contain the majority of acreage of the loblolly/shortleaf pine group in Maryland, largely due to the presence of loblolly pine-dominated plantations. The loblolly/shortleaf pine coverage in Maryland is estimated to include 100,057 acres of planted trees (USDA 2015). Outside of the Coastal Plain, forest types embedded within the loblolly/shortleaf pine group (i.e., Virginia pine, table mountain pine) occupy forests in the Piedmont, Blue Ridge, and Ridge and Valley physiographic provinces.

An estimated 9% or nearly 230,000 acres in Maryland are classified as oak/pine forests (USDA 2013). These forests differ in composition from the loblolly/shortleaf pine forests by having a higher percentage of oaks and other hardwoods mixed with or co-dominated by pines. Examples within the oak/pine group include Coastal Plain forests of loblolly pine mixed with hardwoods of black gum (*Nyssa sylvatica*), sweet gum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*). Forests classified as northern hardwoods (beech, birch, and maple) account for approximately 5.5% or 137,000 acres in Maryland (USDA 2013). The majority of northern hardwood forests are found in the Appalachian Plateau and Ridge and Valley physiographic provinces where elevation and a cooler climate provide favorable growing conditions for northern tree species.

Forests classified as oak/gum/cypress and elm/ash/red maple are exclusive to swamps, bottomlands, and alluvial floodplains of major rivers and tributaries. The oak/gum/cypress forest accounts for approximately 5% or 115, 000 acres (USDA 2013) and is most abundant along the Chesapeake Bay and the lower western and eastern shore areas of the Coastal Plain. These forests are characterized by hydric soils that are often flooded during most of the growing season. The elm/ash/cottonwood group accounts for 4% of Maryland's forests but is much more widespread than the oak/gum/cypress group. The majority of forest types within the elm/ash/cottonwood group are found in the Piedmont and mountain regions in bottomland swamps, alluvial floodplains of major rivers, and along the banks of small streams. Due to the rapid spread of the destructive emerald ash borer beetle *(Agrilus planipennis)*, Maryland's ash trees are at risk of being wiped out of forests and urban areas across the state. Along with being commonly found in forests in western Maryland, ash trees are a popular landscaping tree in urban areas, and account for about 5.9 million of the Baltimore area's 6.6 million trees. Over 18 million ash trees live in Maryland today (USDA 2014), but foresters project that emerald ash borer will cause total mortality of this species in Maryland by 2025 (DeSantis 2013).

The two remaining forest groups classified by the USDA each account for less than 1% of Maryland's forests. Approximately 19,000 acres of Maryland's forests are classified as the white/red/jack pine group (USDA 2013). In Maryland, the white/red/jack pine forest group includes those forests dominated by white pine (*Pinus strobus*) and a mixture of northern hardwoods, as well as forests dominated by eastern hemlock (*Tsuga canadensis*). Although these forests are predominantly found throughout the mountain regions of Maryland, small stands of eastern hemlock can be found on cooler, north-facing slopes in the Piedmont and Coastal Plain. Hemlock forests are threatened by the invasive hemlock woolly adelgid *(Adelges tsugae)*: a small insect that has established itself in many of Maryland's older hemlock stands in the Piedmont region and westward. The woolly adelgid severely weakens trees, making them more susceptible to drought and pest species. Over 42,000 acres of vulnerable hemlock forests exist in Maryland, nearly all at risk of woolly adelgid infestation and eventual mortality. Maryland Department of Agriculture is working to implement a Hemlock Woolly Adelgid Treatment and Suppression Plan.

About 3,400 acres are classified as the exotic softwoods forest group. In Maryland, this group includes forests of red spruce (*Picea rubens*) and spruce-hardwood mixtures that are restricted to higher elevations and cooler microclimates found on the Appalachian Plateau physiographic province. Remnant red spruce trees are a natural part of the landscape in higher elevations while the presence of other spruce species and some pines is due to tree plantings. Due to their restricted geographic and elevation ranges, forest types within the exotic softwoods group are considered rare in Maryland.

Maryland's Grasslands

Maryland's natural areas have experienced dramatic changes since humans arrived in the area. These changes are especially evident in habitats like grasslands that depend on disturbances such as fire. Native Americans settled in Maryland as early as 10,000 years ago and introduced controlled human-made fire to Maryland's grasslands and forests to clear land for farming and to hunt. The vegetation in these areas adjusted to the occurrence of fire, and, over time, areas that experienced periodic ground fires prospered, using the destructive and rejuvenating properties of fire advantageously. Native American land use and the impacts of these activities continue to be an interesting interdisciplinary area of research today.

Tens of thousands of acres of native grassland dotted with blackjack oaks (*Quercus marilandica*) and post oaks (*Quercus stellata*) once stretched across northern Maryland and nearby Pennsylvania. Prior to European settlement, much of Baltimore, Harford, and Carroll counties and adjacent counties in Pennsylvania were covered by this prairie-like grassland intermingled among wooded valleys (Mayre 1920, 1955). English settlers seeing this virtually treeless expanse referred to it as "The Barrens." For thousands of years, Native American fire-hunting had kept the grasslands relatively free of woody vegetation. Native American hunters used fire to drive large game like deer and bison (*Bison bison*) into areas where the animal could be killed more easily, such as areas bounded by rivers or cliffs. (Williams 2000).

With European settlement, large-scale frequent fires were eliminated and woodlands replaced un-grazed grassland areas. Prairie-like vegetation persisted on outcrops of serpentine, a dry and nutrient-poor soil. One of the four remaining serpentine areas in Maryland, the Soldiers' Delight Natural Area near Baltimore is the largest serpentine barren in eastern North America, encompassing 2,000 acres, and is among the most species-rich in the world. Other types of much less diverse, anthropogenic grasslands have been created and are usually maintained for cultural uses, including pastures and hayfields, edges of commercial and military airfields, and reclaimed strip-mines.

Maryland's Waterscape and Wetlands

Maryland has a diverse waterscape that includes the Chesapeake Bay, Coastal Bays, Atlantic Ocean, and includes over 10,000 miles of streams and rivers. However, Maryland has no natural lakes. Approximately 3.7% of Maryland's landscape is wetlands, including forested wetlands. Including all areas where Maryland's land meets water, roughly 600,000 acres, or about 9.5% of Maryland's land area, is made up of wetlands and tidal areas (Clearwater et al. 2000). Unfortunately, an estimated 73% of Maryland's wetlands have been lost since pre-colonial times (Environmental Protection Agency 2014).

Rivers and Streams

Maryland harbors a tremendous variety of rivers and streams, including tidal, nontidal, fresh, brackish, cold water, and warm water. The abundant freshwater streams in Maryland are a valuable resource and significant component of the state's diverse landscapes. Ninety-five percent of these streams flow into the Chesapeake Bay (Boward et al. 1999). The United States Geological Survey classifies rivers and streams according to the hydrologic unit code (HUC). First order streams have no tributaries and are thus the smallest in size. A second order stream occurs where two or more first order streams merge into a larger stream. When second order streams merge, a third order stream results, and so on. About two-thirds of Maryland's stream miles are of the first order with an average width of less than 8 feet (Boward et al. 1999). Less than one-tenth are of the fourth order or larger. The Patapsco River is a fifth order river. The Susquehanna and Potomac rivers are larger order rivers with large drainage basins and many tributaries. For the purpose of this document, streams have been classified by ecological community distinctions as Coldwater, Limestone, Highland, Piedmont, Coastal Plain, and Blackwater streams, and rivers have been categorized as Highland, Piedmont, and Coastal Plain rivers.

There are 19 primary (six-digit) watersheds (and numerous sub-watersheds) in Maryland, most of which share their drainage basins with adjacent states (Figure 2.6). The Youghiogheny River in far western Maryland is on the western side of the continental divide and drains into the Monongahela River, which then merges with the Allegheny River to form the Ohio River. This drainage contributes unique aquatic diversity to the state because of the barrier to dispersal imposed by the continental divide. The Ocean Coastal basin drains into the Atlantic Ocean via the Coastal Bays. All of the other river basins empty eventually into the Chesapeake Bay. The majority of the Susquehanna River basin is outside of Maryland (its headwaters are in New York), but its mouth forms the northernmost extent of Chesapeake Bay. The Potomac River forms the southwestern boundary of the state, from its headwaters in the Appalachian Plateau Province to its mouth in the Upper Coastal Plain. The Middle Potomac river basin is the state's largest at 925 square miles in area with 1,102 stream miles. The smallest river basin measured by square miles (195) is the Bush, which drains into the northern Chesapeake Bay, and the smallest river basin measured by stream miles is the Ocean Coastal, which runs 74 miles (Versar, Inc. 2011).

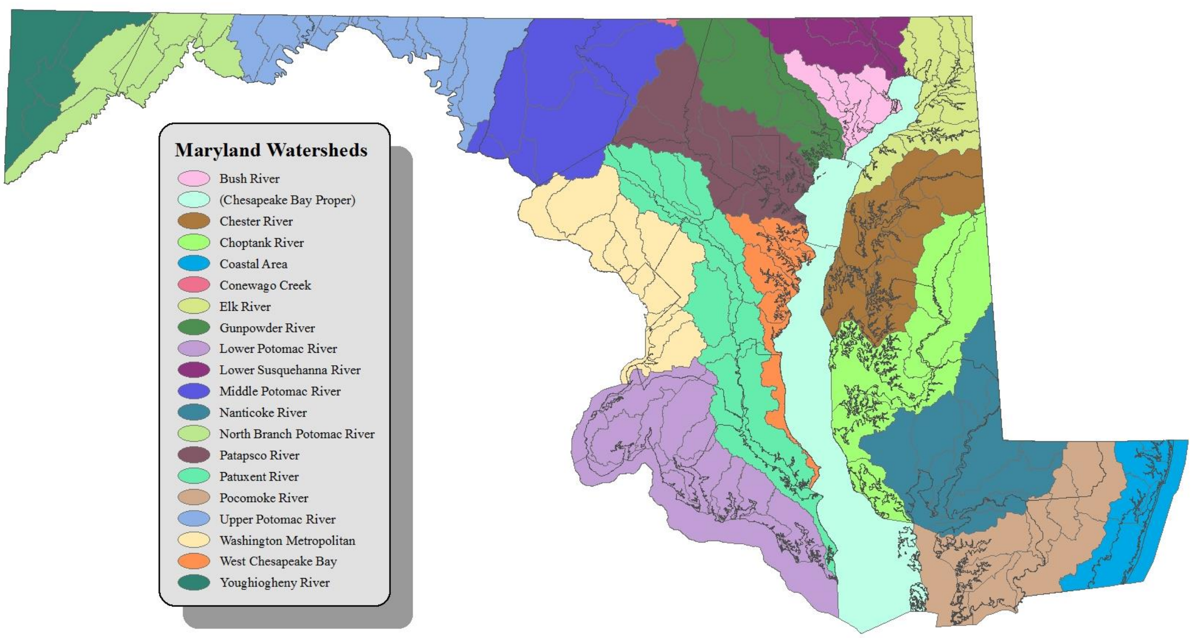


Figure 2.6 Maryland's watersheds. Source: MD DNR.

Maryland's rivers and streams (Figure 2.7) exhibit a diverse range of physical characteristics. Streams and rivers in the Coastal Plain tend to have sand and gravel substrates, while cobble, boulder, and bedrock commonly form the substrate of mountain and Piedmont streams. The steeper gradient, or topography, of the mountains and Piedmont creates swifter moving water. For example, the Youghiogheny River is known for its whitewater, a result of steep mountain gradients and large rock boulders and bedrock exposed in the river. Where the rivers of the Ridge and Valley or Appalachian Plateau pass through valleys, they meander on wide floodplains. The streams of the Coastal Plain, on the other hand, are generally lower in gradient, with Upper Coastal Plain streams typically steeper than those on the Lower Coastal Plain (Roth et al. 1999).

The temperatures of mountain and Piedmont streams are cooler than those of the Coastal Plain and tend to have higher levels of dissolved oxygen due to water tumbling over rocks. The Fall Line that divides the Piedmont from the Coastal Plain is defined as the area where streams tend to have falls as they pass from the rocky, higher-elevation Piedmont to the lower, flatter Coastal Plain. Coastal Plain streams typically have more woody debris (e.g., logs, fallen trees) than the streams in the Piedmont or mountains, and some are blackwater streams with high tannin concentrations created by decomposing leaves (Boward et al. 1999).

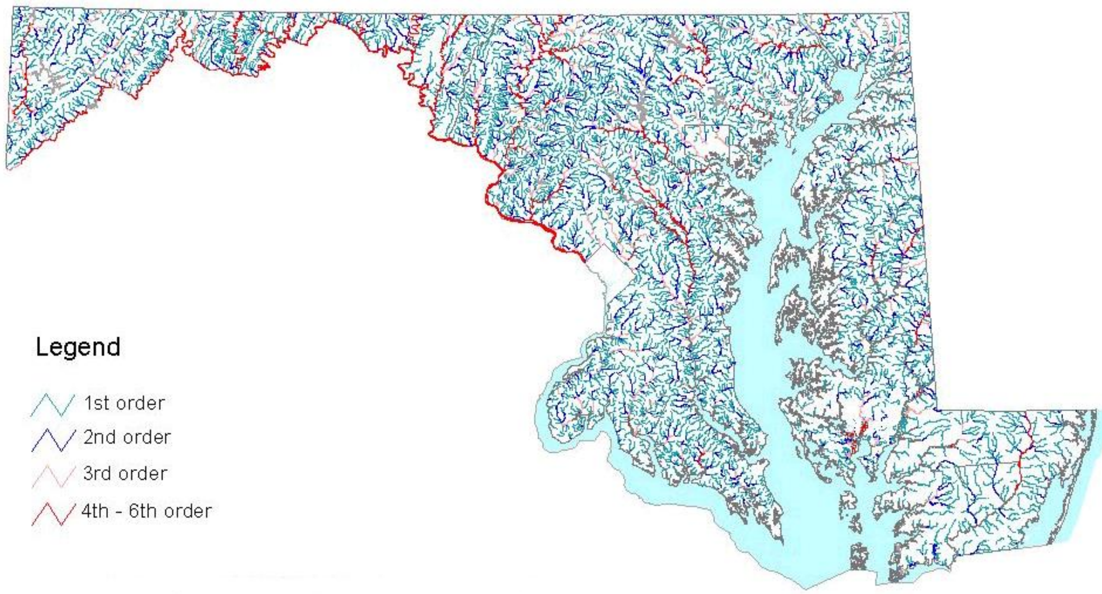


Figure 2.7 Maryland's streams and rivers. Sources: Versar, Inc., MD DNR.

The habitat adjacent to streams is critical for maintaining healthy streams. Statewide, about 50% of all stream miles have forested riparian buffers, whereas 20% are unbuffered or are buffered by less than 10 meters of shrubs, grasses, and other vegetation (Versar Inc. 2011). The 2015 Chesapeake Bay Executive Order, signed by representatives from Maryland, Virginia, West Virginia, Delaware, and Pennsylvania, committed to restoring riparian buffers to 63%, or 181,440 miles, of the watershed's total 288,000 riparian miles, by 2025. Two of the most extreme habitat changes come from stream channelization and acid mine drainage. About 20% of all Maryland streams are channelized, but the majority of these streams occur in the heavily farmed Pocomoke and Nanticoke/Wicomico river basins on the lower Eastern Shore. Conversely, acid mine drainage is the most significant water quality impactor in western Maryland, where abandoned mines leach acidifying compounds into rivers and streams. While Maryland's active mines are regulated by water quality regulations, older mines that operated before such regulations were established continue to release sediment, sulfates, iron, and manganese into Maryland's waters.

Statewide, nitrate concentrations are less than 1 mg/L in about 45% of Maryland's stream miles (Versar Inc. 2011). Concentrations greater than 1 mg/L are considered unnaturally high. Acid rain is the most widespread source of acidity in Maryland streams, impacting about 13% of streams. Only about 3% of Maryland's stream miles are naturally acidic, and most of those occur in five river basins of the Coastal Plain. About 4% of Maryland's stream miles are acidic due to other sources including fertilizers, organic pollutants, and acid mine drainage. Statewide, 5% of all stream miles have dissolved oxygen levels less than 5 mg/L, and on the Coastal Plain three river basins have low dissolved oxygen levels in more than 25% of the stream miles. Dissolved oxygen levels less than 5 mg/L are considered to be biologically stressful.

Reservoirs

Maryland contains 947 man-made lakes and ponds totaling nearly 78,000 acres; no natural lakes occur in the state (Maryland Department of the Environment [MDE] 2012). These impoundments provide many services to communities including hydroelectric power, drinking water, flood control, water for agriculture purposes, and recreation. However, they also come at great ecological cost, due not only to the impoundment and subsequent loss of natural free-flowing streams and rivers, but to the physical barriers to aquatic life they create. Over 1,000 barriers, mostly formed by man-made impoundments, block the state's rivers and streams, most of which form lakes or reservoirs of all sizes and shapes (Boward et al. 1999). Over half of the impoundments are less than 10 acres and only 15 exceed 500 acres (MD DNR 2000b). The largest lakes are reservoirs that were created primarily for water supply, flood control, and/or hydroelectric power (Reger 2004). These include Conowingo Reservoir, Deep Creek Lake, Liberty Reservoir, Loch Raven Reservoir, and Prettyboy Reservoir.

The most recent available data show that 13,765 acres of lakes designated for use by aquatic life and wildlife have been assessed for water quality. Of these, only 4,775 lake acres were found to attain water quality standards used in past MDE sampling, with nearly 9,000 lake acres falling below the water quality standards (MDE 2014). The principal cause of lakes not attaining water quality standards was found to be excessive nutrient loads and sediments flowing into the lake from upstream watershed sources. This influx of nutrients causes algae blooms, leading to low oxygen conditions in the water. Other major lake water quality impairments include high levels of mercury and pesticide-introduced chemicals in fish tissue and invasive aquatic vegetation (MDE 2014).

Wetlands

Maryland is a state with an abundance of wetlands, most of which are in the Coastal Plain surrounding the Chesapeake Bay. The historic extent of wetlands is difficult to estimate, but the best available estimates are that Maryland once had over 1.4 million acres of wetlands (Tiner & Burke 1995, LaBranche et al. 2003). Nearly 10% of the state is currently classified as wetland and tidal areas, ranging from 16% of the Eastern Shore to 0.04% of Baltimore City (LaBranche et al. 2003). Dorchester (44.6%) and Somerset counties (37.7%) have the highest proportions of wetlands, while Allegany (0.2%) and Washington counties (0.7%) in western Maryland have the least. The Blackwater-Transquaking-Chicamacomico (118,537 acres), Pocomoke (99,458 acres) and Choptank (65,655 acres) watersheds have the most wetlands (Tiner & Burke 1995, LaBranche et al. 2003). In fact, 66.4% of the state's tidal (coastal) wetlands are located in the Pocomoke, Nanticoke and Choptank river basins (LaBranche et al. 2003).

The Lower Eastern Shore has the state's greatest extent of wetlands due to its low topography, predominantly clay rich soils, and high groundwater tables (LaBranche et al. 2003). The Upper Eastern Shore has steeper gradients to its topography and more well-drained soils, so its wetlands are less extensive than the Lower Eastern Shore. Delmarva bays, bald cypress, and Atlantic white cedar wetlands are a few of the unique, non-tidal wetland types found on the Eastern Shore. Freshwater marshes dominate the wetlands of the Upper Western Shore, while the Lower Western Shore has predominantly brackish high marsh and submerged aquatic wetlands.

Forested wetland in the Pocomoke River watershed
(Dan Murphy, USFWS)

Wetland communities occur throughout the Piedmont, though not to the extent seen in the neighboring Coastal Plain (LaBranche et al. 2003). The Piedmont's wetlands tend to be less diverse than those of the Coastal Plain, consisting mostly of isolated palustrine and riverine wetlands (e.g., floodplains and upland depressional swamps). Wetlands are uncommon in the Blue Ridge and Ridge and Valley Provinces and they are located only in topographic slopes and depressions. The wetlands of the Appalachian Plateau are more diverse, including wet thickets, shrub bogs, seasonally-flooded wet meadows and marshes (LaBranche et al. 2003).

There are roughly 600,000 acres of vegetated wetlands in Maryland according to the National Wetlands Inventory (NWI) survey (US FWS, NWI 1995). Maps of Maryland's wetlands were created in the early- to mid-1980's. These maps presented most of the state's wetlands as palustrine wetlands (342,649 acres) and estuarine wetlands (251,549 acres) with a much smaller number of riverine, lacustrine, or marine wetlands (4,227 acres) (LaBranche et al. 2003). Forested wetlands are the most widely distributed and abundant palustrine wetland type and are found on riparian floodplains and in upland depressions (i.e., flat, broad areas between drainages). The estuarine wetlands are extensive on Maryland's tidal rivers, extending far upstream to freshwater areas. Brackish marsh is the most common estuarine wetland type, and estuarine shrub swamps are common in the coastal zone.

The degree of loss of the state's wetlands is difficult to determine, with some sources estimating 58% (LaBranche et al. 2003) and others 73% (Dahl 1990; Whitney 1994). The Maryland Wetland Conservation Plan (LaBranche et al. 2003) estimates that 821,339 acres of wetland may have been lost historically. The loss of wetlands has been partially offset by wetland gains in recent years. Approximately 178,000 acres of wetlands have been created, restored, or enhanced statewide since 1998 (MD DNR 2012).

Chesapeake Bay

The Chesapeake Bay is the largest and most productive estuary in the United States. The Bay is nearly 200 miles long and is fed by 48 major rivers, 100 smaller rivers, and thousands of small streams and creeks (CBP 2004a). Spanning six states from New York to Virginia, the Bay's diverse and complex watershed covers 64,000 square miles, of which approximately 14% is within Maryland. (Figure 2.8; Pyzik et al. 2004). The Bay's watershed provides habitat for at least 2,700 species of plants and animals. The upper, or northern, portion of the Bay is within Maryland and the lower, or southern, portion is in Virginia. Maryland's portion of the Bay contains an area of 1,726 square miles of water (MGS 2001a). All but two of Maryland's 18 major river basins drain into the Chesapeake Bay. The watershed is also a major population center where 18 million people live, work, and recreate. The human population in the watershed is expected to increase to over 21 million by the year 2040 (CBP 2014).

The Chesapeake Bay's shoreline is not uniform, with the eastern shoreline being relatively low and flat-lying while the western shoreline has more relief and occasional cliffs (e.g., Calvert Cliffs) (Ward et al. 1989). The shoreline may be fringed with salt or brackish marsh, sandy pocket beaches, low sandy banks, bluffs and cliffs of various materials, or manmade riprap, bulkheads, seawalls, and groins. The lower Eastern Shore is characterized by extensive marshes with some low sandy banks and estuarine beaches. Chesapeake Bay is a relatively shallow estuary, averaging 20 to 25 feet deep (Ward et al. 1989). The center of the Bay is deeper than its edges, where the original river channels (now drowned) lie and where navigation channels (35 to 50 feet deep) have been dredged along most of the upper Bay's length to service the port at Baltimore. The deepest point in the upper Bay is Bloody Point Hole at 174 feet deep (MGS 2004b).

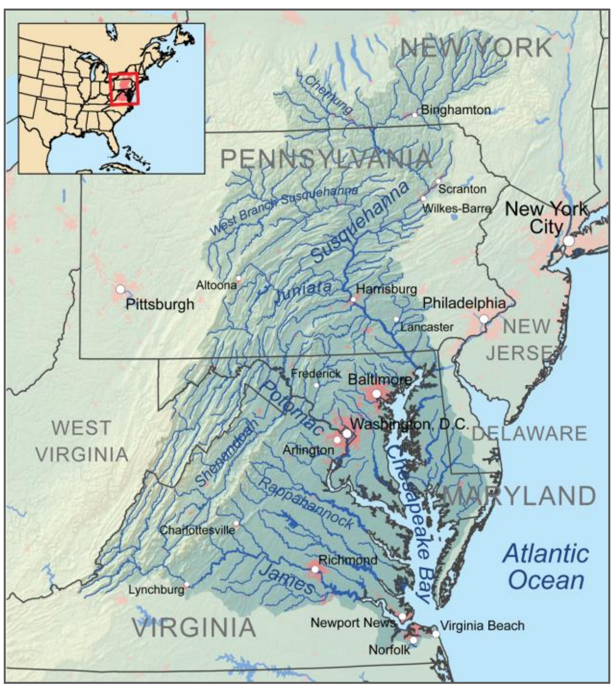


Figure 2.8 Chesapeake Bay watershed.
Source: MD DNR.

The Bay's substrate consists of varying amounts of clay, silt, and sand with sandier sediments along the edges and finer sediments in the middle of the Bay (Kerhin et al. 1988). Occasional oyster reefs (now uncommon) and beds of submerged aquatic vegetation (SAV) are also found on the Bay's bottom. The Bay is affected by daily tides, with tidal range increasing from the headwaters of the Bay towards its mouth. The tidal range is 1.4 to 2.8 feet on the Potomac River, 1.4 to 2.4 on the Choptank River, and 0.8 to 1.0 feet at Baltimore (Ward et al. 1989). The Bay's water level changes not only with the tides, but with wind and precipitation patterns as well. Hurricanes also affect the Bay, creating storm surges of 8 to 10 feet along Maryland's shores. In fair weather, waves are typically less than one foot high in the Bay, but during storms they may reach three or four feet in height. Water temperature in Chesapeake Bay fluctuates throughout the year from 34 to 84 ^{o}F (Pyzik et al. 2004), although ice can form along exposed upper portions of the water body.

Numerous islands dot the interior of the Bay, some of which are composed almost entirely of marsh (e.g., Bloodsworth, South Marsh) and as a result are frequently flooded and have high erosion rates (Ward et al. 1989). Shoreline erosion rates tend to be higher along shorelines facing the open Bay, and lower along the shorelines of tributary estuaries where they are more sheltered from waves. High erosion rates and rising sea levels have led to the rapid shrinking and outright disappearance of many Bay islands. Perhaps the most famed disappearing Chesapeake Bay island is Holland Island, which was home to a community of 360 people, mainly families of watermen, in 1910. The islanders realized their homes were at risk when the island began collapsing into the Bay, and by 1918 Holland Island was vacant. Even as the island disappeared underwater in the late twentieth century, a single Victorian house was left standing in the waves. The Bay finally inundated the house in 2010 and the island itself is now totally underwater.

Sharps Island, originally a 438 acre island at the mouth of the Choptank River, disappeared entirely by 1965 in just over a century's time. Tilghman Island was 2,015 acres in 1848 but was only 1,686 acres in 1901; its southern end is eroding at 20 feet per year. Smith and Poplar Islands are the subjects of federal restoration projects due to their severe land loss rates. These restoration projects add material dredged from various Chesapeake Bay harbors to counter erosive processes.

Rising sea levels, land subsidence, and coastal erosion have enlarged the Bay since the arrival of European colonists, with many sections of shoreline now 200 to 2,000 feet landward of their 17th century positions (Ward et al. 1989). Sea level rise continues to accelerate (more information can be found in Chapter 7). Maryland loses an estimated 580 acres a year to shoreline erosion (Boesch 2008). This retreat of the shoreline increases sediment loads in nearshore waters and shifts habitats in position as new areas flood with estuarine waters. Sea level rise has inundated 16,721 acres of estuarine-forested wetlands in Maryland, or 6.7% of the state's total acreage of estuarine wetlands (LaBranche et al. 2003).

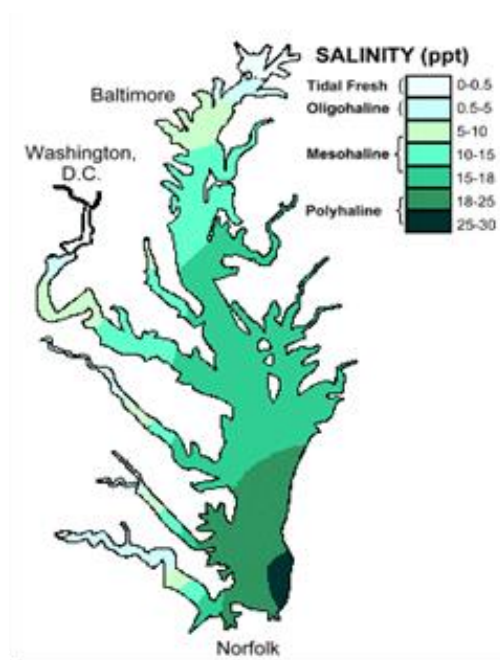


Figure 2.9 Salinity of the Chesapeake Bay during typical autumn.
Source: Pyzik et al., Chesapeake Bay Program.

The salinity of the Chesapeake Bay varies over time due to a number of factors including the time of year or season, tidal stage, precipitation levels and flow rates of tributaries, weather patterns, and storm events (Pyzik et al. 2004, Figure 2.9). On an incoming tide, higher salinity waters move up the estuaries and the Bay. Salinities also shift by season according to precipitation patterns, with spring rains creating large areas of lower salinity and the drier autumn months increasing salinity in most of the Bay. During a typical autumn, the majority of the Bay is considered mesohaline (5-18 ppt). Oligohaline (low salinity) waters are concentrated in the upper reaches of contributing estuaries and the upper Bay near Baltimore. Polyhaline waters are generally found in the southernmost of Maryland's portion of the Bay (MD DNR 2000b). During times of drought and along the Bay's bottom, salinities increase farther northward, and during times of high precipitation (and thus freshwater input into the Bay) lower salinities prevail in the upper estuaries. These changes, in turn, have a direct influence on what species inhabit various areas in the Maryland portion of the Bay.

The proximity of an estuary to the open Atlantic Ocean also influences salinity, with higher salinities found in the lower Bay and near the mouth of the Chesapeake and Delaware Canal, which connects Delaware Bay with the Elk River in northeastern Maryland. With a two foot increase in sea level projected by 2050, a marked change in salinity zones will happen and important spawning and nursery habitats such as tidal freshwater will shrink in size. In addition, areas that are now farmland will be submerged, causing substantial additions of nutrients and sediment to the estuary.

By the 1980's, the Bay's waters were enriched with nutrients from agriculture and loaded with pollutants from urban and suburban areas (Flemer et al. 1983). The Bay's submerged grasses were disappearing, fisheries two centuries old were in serious decline, and wetlands and other natural habitats were under continuing threats of development. In 1983, the federal government, Virginia, Maryland, Pennsylvania, the District of Columbia, and the Chesapeake Bay Commission formally declared their intent to work cooperatively to restore the natural resources of the Bay. Their partnership, known as the Chesapeake Bay Program and formally documented in the periodically updated Chesapeake Bay Watershed Agreement, attacked water-quality problems by adopting measures to reduce inputs of nitrogen and phosphorus from urban, industrial, and agricultural sources and to increase levels of dissolved oxygen in Bay waters. Simultaneously, scientists and managers determined the status of Bay species and natural habitats and began to track historical and ongoing trends (Pendleton 1995). The 2014 Bay Agreement reaffirms and renews the Chesapeake Bay Program's goals and highlights management strategies planned to achieve these goals. For the first time in Program history, signatories of the Agreement included representatives from the watershed's headwater states. The Agreement defines 10 goals within categories of abundant life, clean water, climate change, conserved lands and engaged communities. The Chesapeake Program partnership, which represents the authors and signatories of the Bay Agreement, is formulating new management strategies to achieve the goals set forth in the Agreement.

Coastal Bays

The Coastal Bays (Figure 2.10) are complex, lagoon-like estuaries that provide habitat for a wide range of aquatic life. The Bays are contained by the barrier islands on Maryland's east coast and a small, 175 square mile watershed on the mainland with its 23 creeks and tributaries. The five named Bays collectively known as the Coastal Bays include Chincoteague, Newport, Sinepuxent, Isle of Wight, and Assawoman Bays. The Bays are shallow water bodies with an average depth of four feet. Salinity in the Bays and their tributaries comes from the ocean, so the areas closer to the ocean have higher salinities. This causes the mid-bay area to be polyhaline, the creek mouths to be mesohaline, and the upstream creeks to be oligohaline to fresh (U.S. Environmental Protection Agency 2007). Together, the Coastal Bays are one of the most diverse estuaries in the eastern seaboard, supporting numerous plant (89) and animal species (19) that are on Maryland's list of Threatened and Endangered species (Maryland Coastal Bays Program 2015). They also provide forest and wetland habitats vital to migratory songbirds and waterfowl, with 115 species of fish, 17 species of molluscs, 23 species of crustaceans, 360 species of birds, and 44 mammals calling the Coastal Bays home (U.S. Environmental Protection Agency 2007).

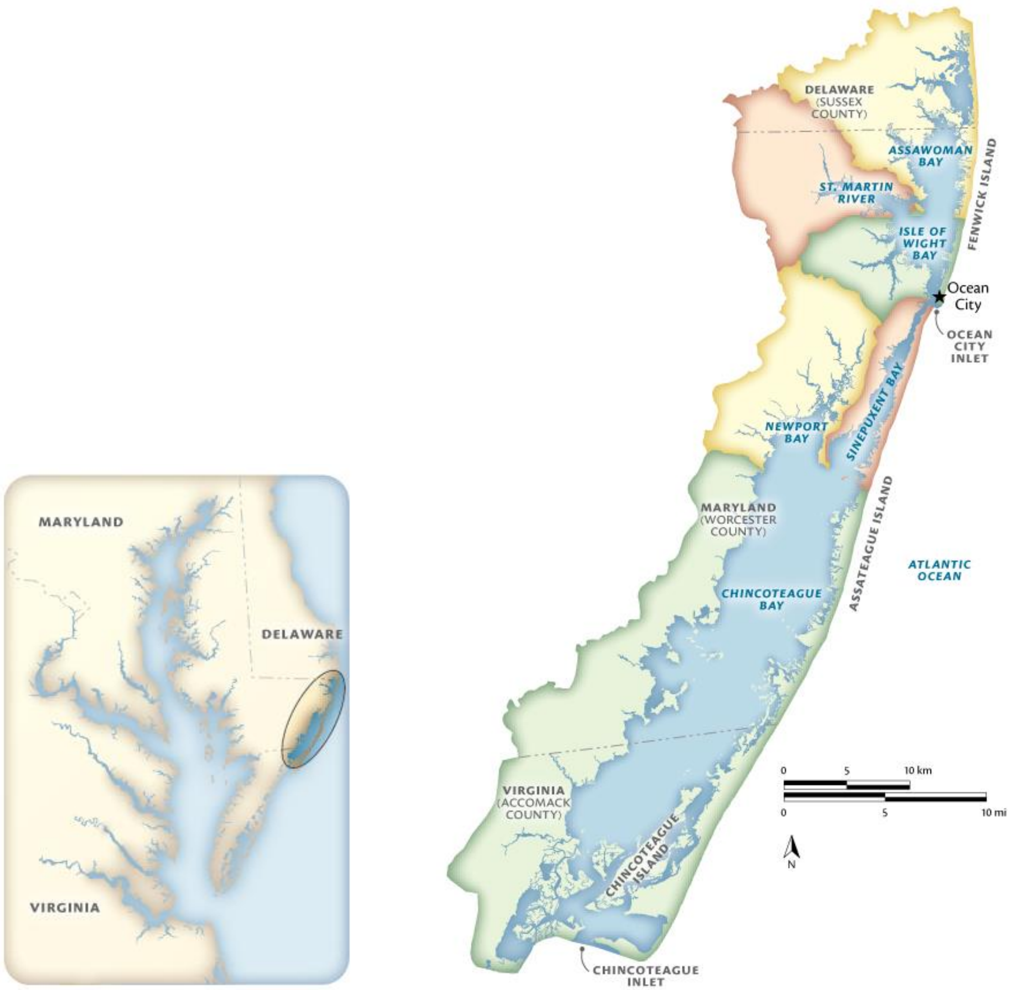


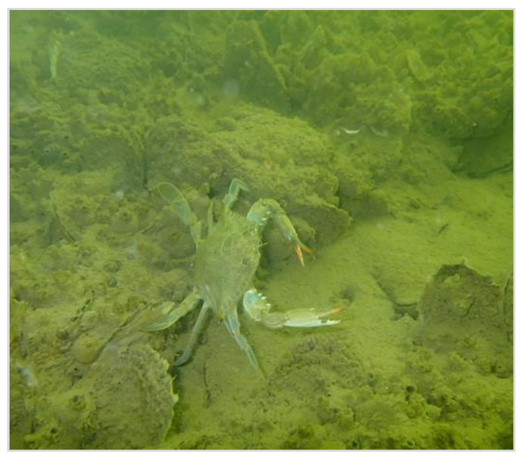
Figure 2.10 Maryland Coastal Bays. Source: MD Coastal Bays Program.

The National Park Service (NPS) owns and operates Assateague Island National Seashore, which includes the seaward portion of estuarine habitats in Chincoteague and Sinepuxent Bays. Assateague State Park and the Sinepuxent Bay Wildlife Management Area also have conserved land and waters in the Coastal Bays ecosystem. The Coastal Bays Program, a part of the EPA's National Estuary Program, formalized a partnership amongst MD DNR, EPA, federal and state agencies, local governments, NGOs, and other organizations to protect the Bays' ecosystems. A Comprehensive Conservation and Management Plan for Maryland's Coastal Bays (2015-2025) was completed in 1999 and revised in 2015. The plan identifies steps to monitor the status and trends of the ecosystem and manage its conservation and threats through collaborative partnerships and strategic actions (MD Coastal Bays Program 2015). In addition, the Maryland Coastal and Estuarine Land Conservation Program (CELCP) identifies threats and priority conservation needs throughout the state's coastal and estuarine areas, including the Coastal Bays.

The Atlantic Ocean

Maryland's Eastern Shore has 32 miles of marine shoreline along the Atlantic Ocean. Ocean City, a highly populated urban area, forms the northern portion of the state's Atlantic coastline, while the undeveloped and preserved Assateague Island forms the southern portion. Maryland has state jurisdiction of the waters and seafloor from these shorelines seaward for three miles. Ocean City and Chincoteague Inlets allow the exchange of water and marine species between the Atlantic Ocean and the Coastal Bays. Anadromous fish such as river herring, as well as spawning horseshoe crabs, utilize these habitat corridors to travel between freshwater and estuarine spawning and juvenile habitats and adult marine habitats. Ocean City Inlet is stabilized with jetties and actively managed by the U.S. Army Corps of Engineers, while Chincoteague Inlet is unstabilized and managed by the USFWS National Wildlife Refuge System as a part of Chincoteague NWR in Virginia. Assateague Island National Seashore (NPS) has management responsibilities over the nearshore region of Assateague Island extending one-half mile seaward.

The northwest Atlantic Ocean coastal region, where land meets water, is shaped by currents and tides, receiving nutrients and sediments from coastal watersheds. The water in this region is especially productive as it is shallow and able to capture sunlight. The shallowest regions support important sheltering habitats like salt marshes, oyster reefs, and seagrass meadows, which are also some of the habitats that are the most sensitive to development and pollution. Shellfish beds, once a prominent feature of coastal regions, provide important ecological services as species like oysters, mussels, and scallops build habitat areas, modify currents and wave energy, and filter sediments and nutrients present in the water. Shellfish are a crucial food source for a variety of organisms in both larval and adult forms (Nature Conservancy 2010).



Blue crab foraging in a shellfish bed
(Steve Allen, MD DNR)

Within the state jurisdictional waters, the seafloor consists of sandy and muddy substrates that support a diverse and adaptive ecosystem of epibenthic and benthic species (MGS 2004a). Benthic and epibenthic organisms inhabit specific regions, depths, and sediment types, such as clay, sand, and rocks. The food web in the ocean system is intricate, so much so that fifteen major groups of organisms are wholly marine. Ocean-dwelling organisms' feeding habits mirror their physical habitat: sessile filter-feeders like sponges consume particles in the water column, while deposit feeders like worms sift soil for food. Mobile species such as crabs and sea stars hunt prey or scavenge for dead animals (The Nature Conservancy 2010). Several linear sand shoals run obliquely parallel to the shoreline but are threatened by mining for beach nourishment projects; over 8 million cubic meters of sand have been removed from the shoals and placed on nearby beaches since 1988. Numerous artificial reefs and shipwrecks provide localized vertical relief to the seafloor, creating hard substrates for epibenthic fauna and attracting reef species.

Further out over the continental shelf, natural hard bottom habitat is relatively scarce and medium to coarse-grained sands are common (The Nature Conservancy 2010). The topography of this section of the Mid-Atlantic is mostly flat with major submarine canyons at the shelf-slope break. When warmer, higher salinity Gulf Stream currents cross over topographic highs such as these canyon heads, they create significant coldwater upwellings and extremely productive biological events. Gulf Stream currents can also bring large mats of *Sargassum* macroalgae rich with marine animals and plants. Due to its intermediate position between the cool New England and warm southeastern United States waters, Maryland waters provide a critical migratory pathway with abundant forage resources for many species, including sea turtles and whales.

The nearshore region is impacted by beach nourishment projects in Ocean City and northern Assateague Island, as well as the dual jetty system at Ocean City Inlet. These large scale water resource development projects modify the hydrology, sediment loads, and substrates of the nearshore ecosystem. The ocean ecosystem in Maryland waters is managed by MD DNR's Coastal Zone Management Program. Its fisheries resources are managed by the MD DNR Fisheries Service, with some species also managed by the National Marine Fisheries Service, the Atlantic States Marine Fisheries Council, and the Mid-Atlantic Fishery Management Council. Offshore wind energy development and extraction activities beyond Maryland waters are overseen by the federal Bureau of Ocean Energy Management.

This chapter has summarized the land and waterscapes of Maryland and its regional context, and has laid the groundwork for describing the key wildlife habitats found in the state (addressing **Element #2**). Chapter 4 lists these key wildlife habitats. The next chapter will provide information on the full array of wildlife found in Maryland and will identify those Species in Greatest Conservation Need (addressing **Element #1**).

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