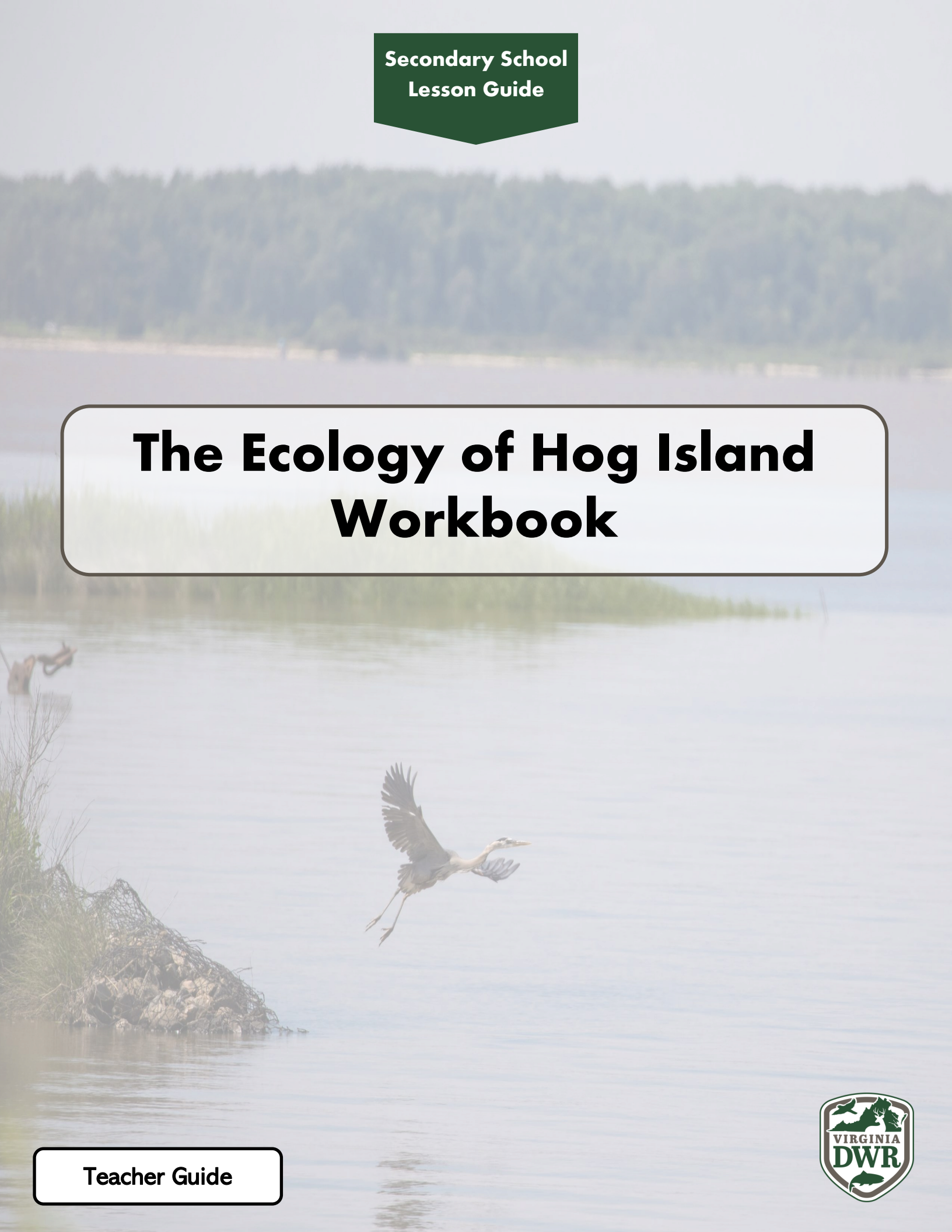
Secondary School
Lesson Guide

The Ecology of Hog Island Workbook



Teacher Guide

VIRGINIA DWR

WORKBOOK OVERVIEW

GRADE LEVEL:

Secondary (Middle and High School)

CORE CONTENT AREAS

Life Science, Biology, Environmental Science, Ecology, 6th grade Science and Earth Science (Watersheds only)

CROSS CURRICULAR CONNECTIONS

Technology: Even though this workbook can be used without a Marsh Cam Classroom takeover we highly suggest scheduling your class to takeover the Marsh Cam in conjunction with using this workbook for a more engaging student experience.

History: explore the history of the Hog Island area in the Deeper Learning Opportunity- Exploring the Hog Island Historical Timeline.

ABOUT THIS WORKBOOK...

The Ecology of Hog Island workbook is one component of the educational resources available for DWR's Marsh Cam; a livestreaming camera located on the southern end of the Hog Island Wildlife Management Area in Virginia

This Teacher Guide to the Ecology of Hog Island workbook is written for educators and includes student objectives, correlations to the Virginia Standards of learning, and cross-curricular connections and extensions within its first few pages. The remainder of the workbook mirrors the student workbook and contains informational text on the history, watershed, habitats, and ecology of Hog Island. Embedded throughout the text are Knowledge Check questions to keep students engaged and Deeper Learning Opportunities for your students to learn more about the history, watershed, habitat management, and ecology of the island.

While it is ultimately up to you, the educator, to decide how to best incorporate this workbook into your classroom, we suggest using it with your students before they complete any other marsh cam educational materials or participate in the Marsh Cam Classroom Takeover.

Access the Student Workbook* HERE

***This workbook was created to be used digitally as a fillable PDF and we can not guarantee quality or layout if printed.**

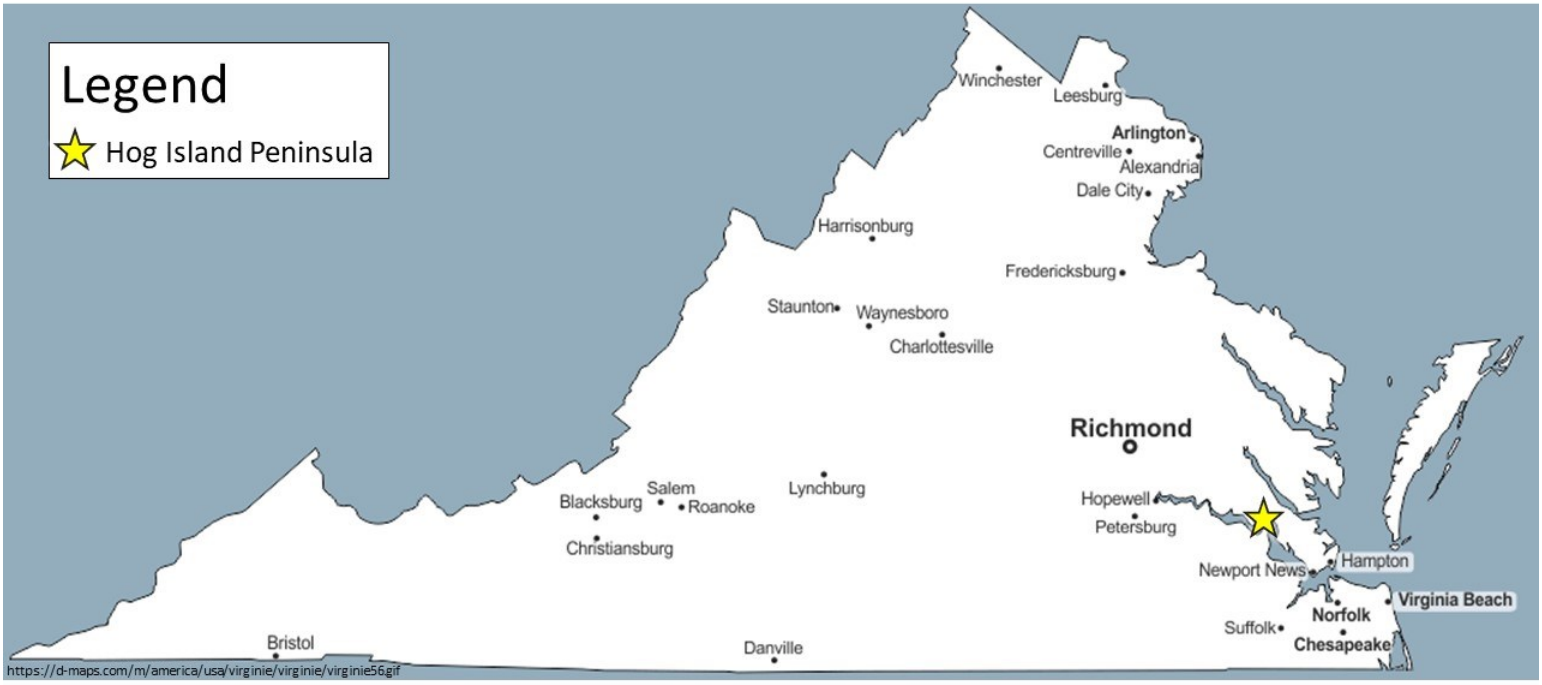
WORKBOOK LEARNING OBJECTIVES AND VIRGINIA STANDARD OF LEARNING CONNECTIONS

The students will be able to:

- Explain and appraise the value of wetlands to ecosystems, including humans (6.8 d) (ENV. III a, V a) (Ec. 12)
- Explain the importance of estuaries, including their importance to people (6.8 d) (ENV. III a , V a) (Ec. 12)
- Identify abiotic and biotic components of the environment (L.S. 5 a) (BIO. 8 a) (ENV. III a)(Ec. 12)
- Develop a model of a food web using organisms found in Virginia and classify the organisms as producers and 1st, 2nd, and 3rd order consumers. (L.S. 5 b,c) (BIO 8 b) (ENV. III a) (Ec. 9)
- Recognize examples of producers, consumers, and decomposers in the Hog Island Marsh and explain the role of each in the flow of energy and the cycling of matter through an ecosystem (L.S. 5 c) (BIO. 8 a) (ENV. III a) (Ec. 9)
- Explain how the interactions of populations form communities within an ecosystem (L.S. 6 a) (BIO. 8 a) (ENV. III b) (Ec. 8)
- Explain the effects of resource availability on organisms and populations in an ecosystem (L.S. 6 b) (BIO. 7 b, 8 a) (ENV. III a) (Ec. 4, 6)
- Predict the effect of limiting factors on organisms in a food web/ecosystem (L.S. 6 b) (BIO. 8 a) (ENV. III a) (Ec. 6)
- Compare the biotic and abiotic factors that distinguish land, marine, and freshwater ecosystems (LS. 7 a) (ENV. III a) (Ec. 12)
- Classify the various types of changes that occur over time in ecosystems, communities, populations, and organisms as long-term, short term, or seasonal (L.S. 8 b) (BIO 8 c) (ENV. III b) (Ec. 6, 8)
- Argue, citing evidence, that changes to physical or biological components of an ecosystem affect populations (L.S. 8 b) (BIO. 8 a) (ENV. III b) (Ec. 6)
- Describe ways that human interaction has altered habitats positively and negatively (L.S. 9 a) (BIO. 8 d) (ENV. IV b, V a) (Ec. 13)
- Describe the impact of human activity on the biotic and abiotic factors within an ecosystem (L.S. 9 c) (BIO. 8 d) (Env. Sci. IV b, V a) (Ec. 11, 13)
- Provide an example of how the introduction of an invasive species can disrupt an ecosystem and threaten the survival of species (BIO. 8 d) (Env. Sci. III b) (Ec. 6, 11, 13)

ADDITIONAL EXTENSION ACTIVITIES AND LINKS

- Marsh Cam Website and Livestream
- Marsh Cam Takeover Signup
- Marsh Cam iNaturalist Project
- A Field Guide to Hog Island



Above: Map of Virginia with the location of Hog Island marked with a yellow star.

A SENSE OF PLACE...

The prominent peninsula now known as **Hog Island** has long been a gathering spot for both wildlife and people. On the island sits the 3,908-acre Hog Island Wildlife Management Area which is considered a key refuge for migrating and wintering waterfowl as well as shorebirds and songbirds alike. To date, over 275 species of birds have been observed on the WMA, and it is a well-known concentration area for bald eagles where nesting occurs every year. In 2022, the **Virginia Department of Wildlife Resources** (otherwise known as DWR) launched the 'Marsh Cam', a live streaming camera focused on some of the wetland **habitat** located on the property.

Above left: Overhead imagery of Hog Island Wildlife Management Area. The property boundaries are marked with an orange line and the location of the Marsh Cam is marked with a yellow star.

Above right: Photo of the camera installed on top of a twenty foot tower and the solar panel that provides it with power to operate.

The Hog Island area has a rich history steeped with ties to Indigenous peoples and the founding of our nation. Evidence of people inhabiting this area dates back to before the end of the Pleistocene, the last major Ice Age. Back then, inhabitants were migratory groups of people that settled in the area for short periods of time hunting for megafauna, fishing, and foraging.

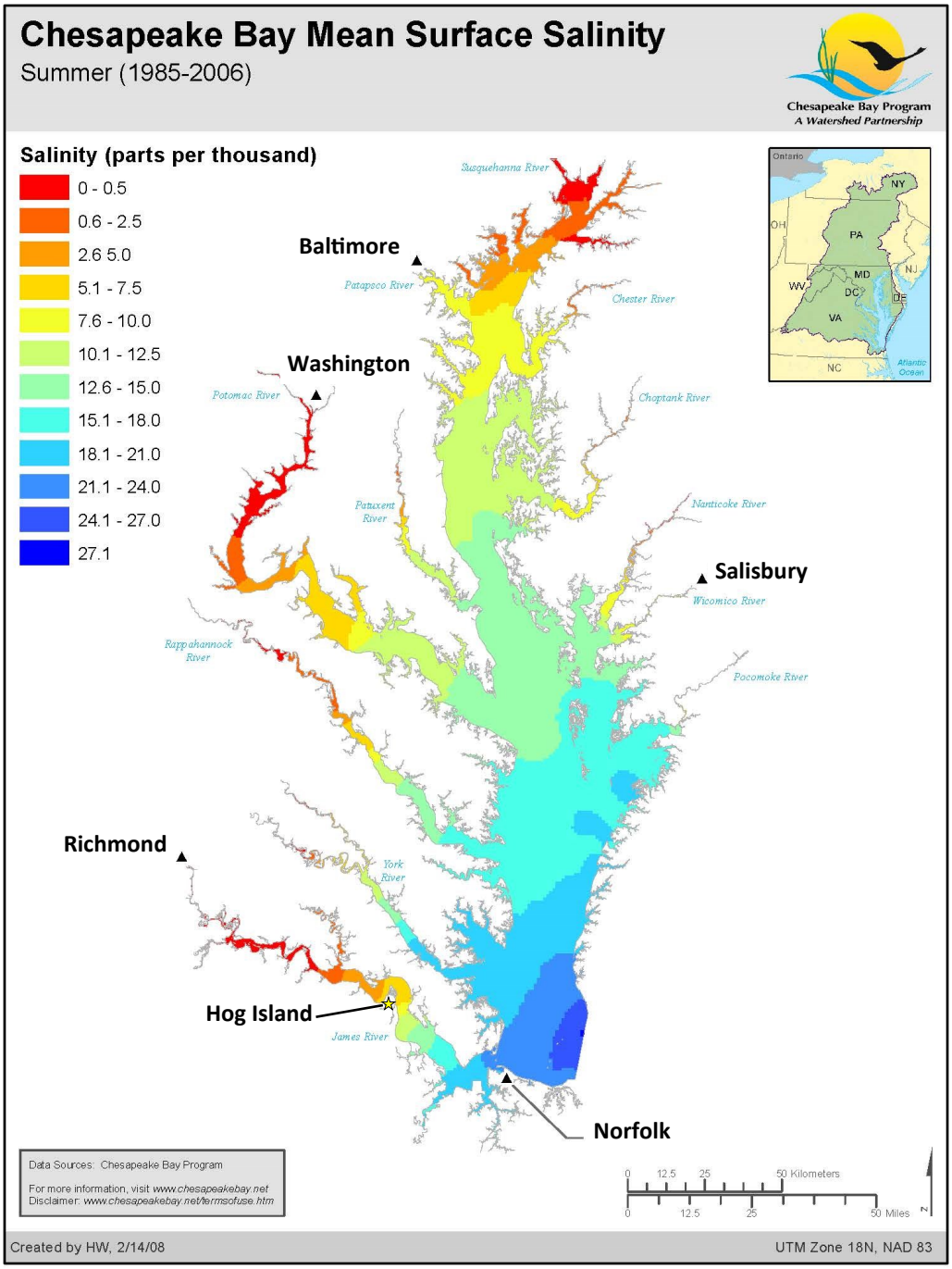
As time moved on and agriculture grew, the Algonquian speaking Powhatan became the dominant group of this region's permanent villages for thousands of years. In April of 1607, settlers, including Captain John Smith, arrived in the now Chesapeake Bay area of the New World and began exploring what they dubbed the "James River" in honor of England's reigning King. By May of 1607, America's first permanent English settlement, Jamestown, was established on the banks of the James River, approximately 2.5 miles from the center of what is today's modern Williamsburg and less than ten miles northwest of the Hog Island WMA.

Above left: Captain John Smith's 1612 map of the Chesapeake. Above right: Jamestown Settlement's recreation of a Powhatan village.

DEEPER LEARNING OPPORTUNITY:
EXPLORING THE HOG ISLAND HISTORICAL TIMELINE

The Hog Island peninsula is surrounded by Virginia's southernmost major river of the Chesapeake Bay, the James River. The water of the James River at Hog Island is uniquely tidal and somewhat salty. This is due to the freshwater of the James River mixing with the salty water of the Atlantic Ocean, creating an **estuary**. Estuaries are the tidal areas where freshwater rivers flow into, and mix with, the salty waters of the ocean. Estuaries have **brackish water** which is less salty than pure ocean water because it is mixed with inland freshwater.

Did you know that the DWR considers Hog Island Point as the official boundary between freshwater and saltwater in the James River? Although a straight-line boundary has been placed at Hog Island Point to help fishermen know what type of fishing license they need, this part of the James River is really a transitional zone where the amount of salt in the water, or **salinity**, changes with the seasons, tides, and weather. This area will be saltier and will have higher salinity levels when ocean water is flooding in during very high tides. If there have been heavy rains upstream, the increase in the amount of freshwater will cause this section of river to have lower salinity levels. In the summer months, the Atlantic Ocean is generally five to ten times saltier than the water in this section of the James River (see the Chesapeake Bay Mean Surface Salinity Map). Isn't it interesting how the amount of salt within the water isn't always the same?



Above: Map of salinity values associated with the Chesapeake Bay. The higher the salinity value, the saltier the water is.

KNOWLEDGE CHECK: Does the section of the James River near Hog Island have higher or lower levels of salinity compared to the Norfolk area? What about Richmond? Use the map above to help answer this question.

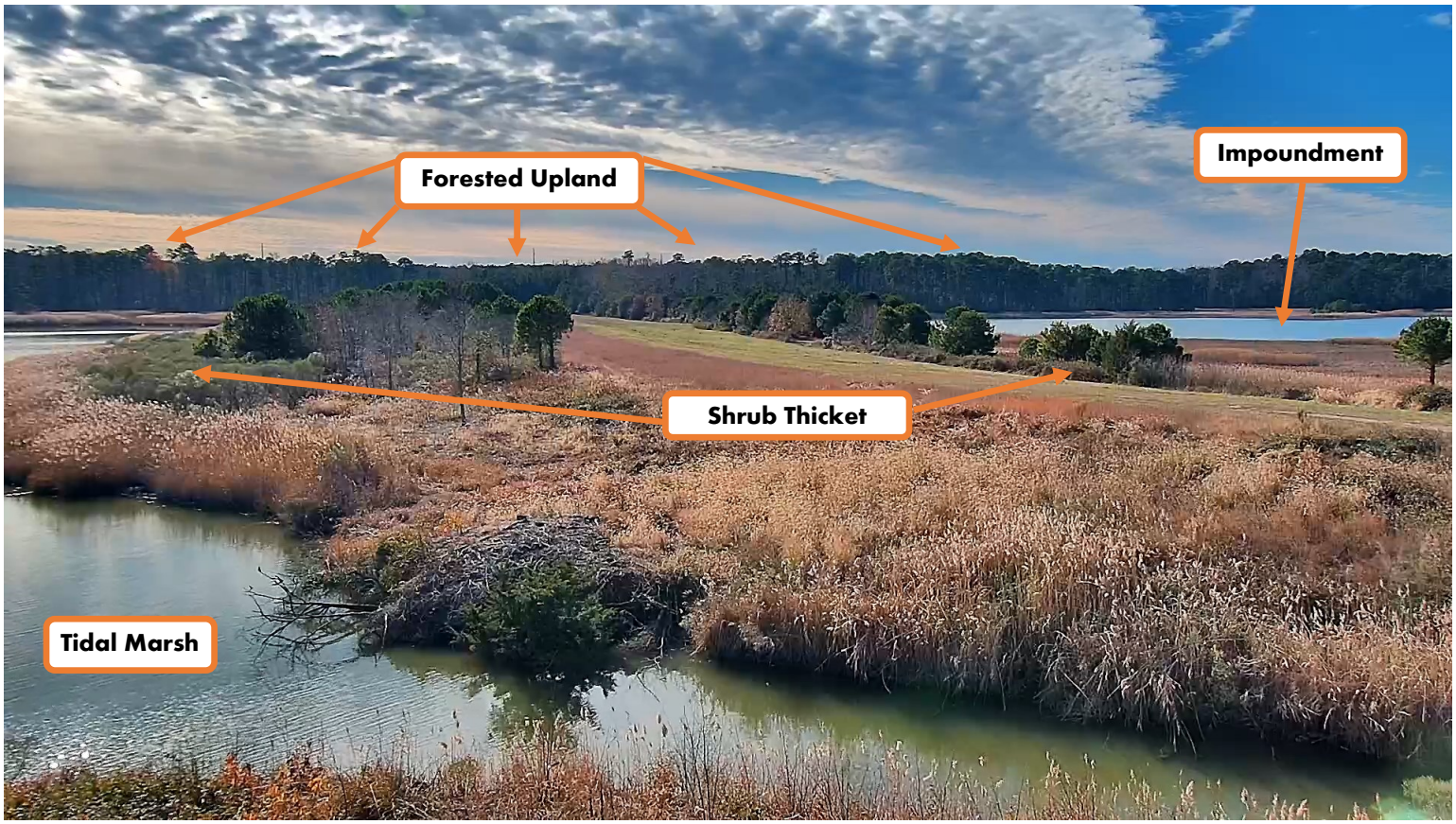
The James River at Hog Island has lower salinity levels compared to Norfolk but higher than Richmond.

DEEPER LEARNING OPPORTUNITY:

EXPLORING YOUR WATERSHED ADDRESS

THE HABITATS OF HOG ISLAND

Hog Island has been a hot spot for wildlife long before English settlers arrived over 400 years ago. The WMA is composed of multiple different habitat types such as tidal marsh, inland wetland impoundments, shrub thickets, and forested uplands all of which can be seen on the Marsh Cam. Each habitat type provides unique benefits to both people and wildlife. The many benefits provided by natural environments to humans are often referred to as **ecosystem services**. Read the sections below to learn more about these habitats and how they are managed.



Above: The various habitat types which can be observed from the Marsh Cam. Note that tis photo was taken in the winter and vegetation color will change based on season.

THE WETLANDS OF HOG ISLAND

Wetlands are exactly what they sound like – areas of land that are "wet", or covered with water, all year or for some portion of the year. Because the ground is so wet, only certain types of plants can survive and grow which creates distinct habitat types. There are many types of wetland habitats across the world including forested swamps, grassy marshes, mangroves and many more. The water that flows through the wetlands of the world can be freshwater, brackish water, or saltwater.

Since colonial settlement, it is estimated that Virginia has lost 40% of its wetland habitats. During America's early history, many wetlands were drained for farming or filled in with soil so they could be built upon. This loss of wetlands contributed to severe flooding events and poor water quality in many of our rivers and bays. People did not yet realize the numerous ecosystem services provided by wetlands, but over time we began to understand the true importance of wetlands. Now most wetlands are protected under the Clean Water Act because we know they provide numerous ecosystem services, like spreading out and slowing down floodwaters, protecting nearby uplands, absorbing excess toxins and nutrients, and providing critical habitat for a diverse range of wildlife.

Today, Hog Island is teeming with life because it contains some of the largest intact wetlands along the James River. These wetlands act as transitional habitats between the tidal waters and the fields and forests of the mainland. These transitional areas serve as a natural gathering place for both aquatic and terrestrial wildlife, providing food, water, and shelter. From the Marsh Cam, you can see two different types of wetland habitat...tidal marshes and man-made inland wetland impoundments. Depending on the season, you are likely to see herons, egrets, ducks, eagles, deer, turkeys, minks, otters, turtles, or fish, and if you're lucky you may see some of them mingling together!

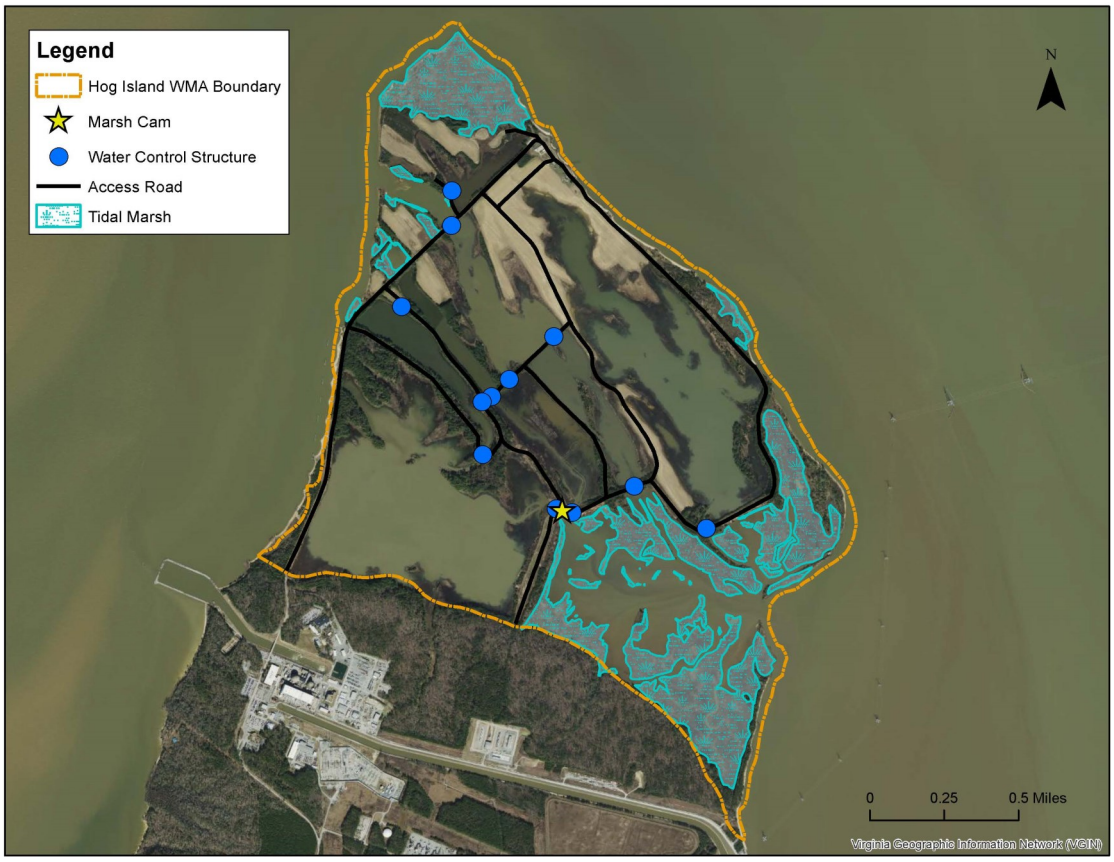
KNOWLEDGE CHECK: What percentage of original wetlands remain in Virginia following colonial settlement? What Federal Act protects these remaining wetlands?

60% of Virginia's original wetlands remain and the Clean Water Act protects wetlands in the United States.

Above: Various wildlife pictures taken with the Marsh Cam

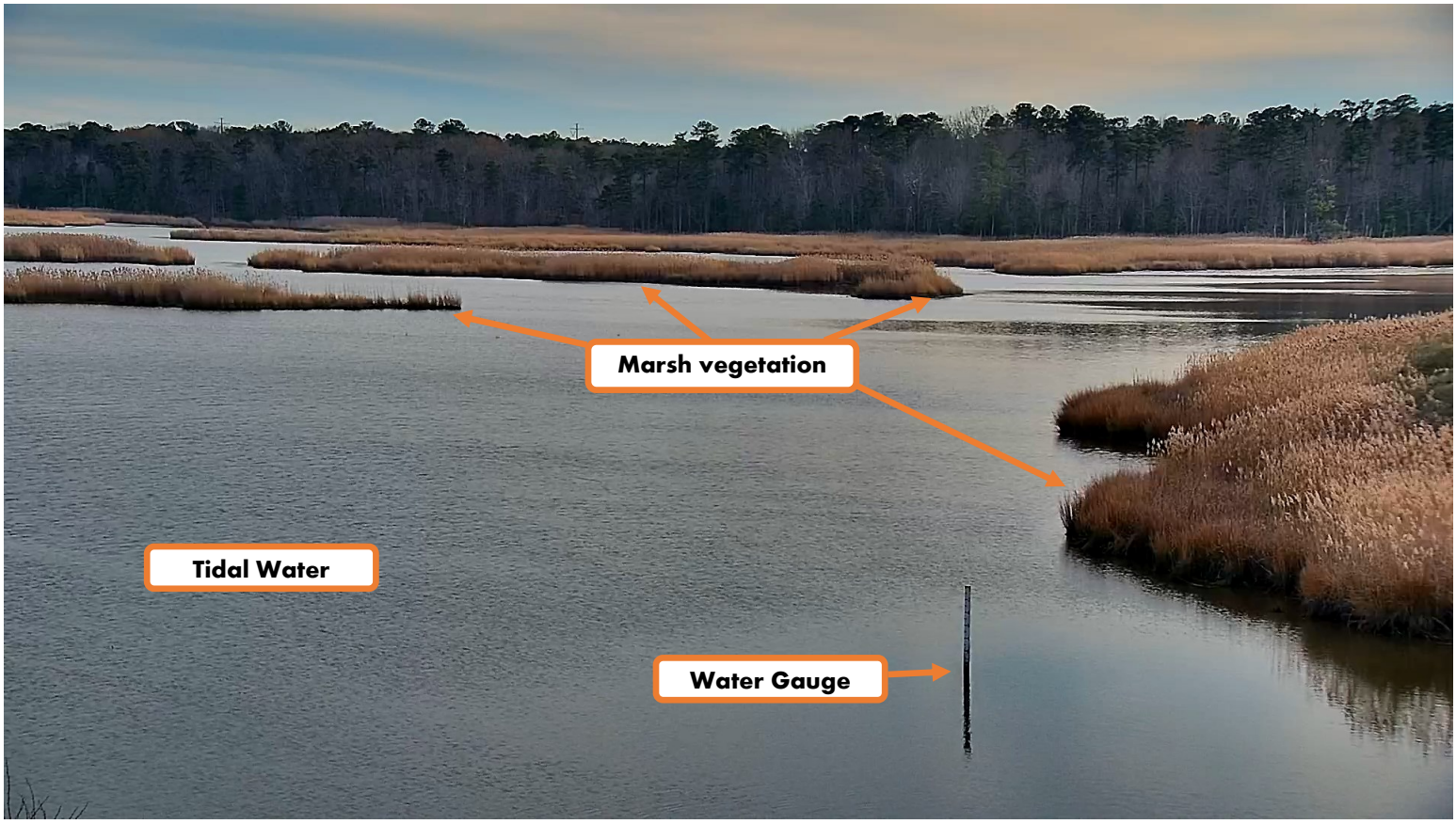
TIDAL MARSHES

As the name suggests, the Marsh Cam provides a great view of some of the **tidal marshes** at Hog Island. The water in these areas go through a daily rise and fall with the tide which floods vegetation at high tide and exposes muddy banks at low tide. The water level in these tidal marshes generally fluctuates 2-3 feet each day and is dominated by grass-like plants that can thrive in brackish conditions.



Above: Overhead imagery of Hog Island highlighting the tidal marsh habitat, the Marsh Cam, and water control structures

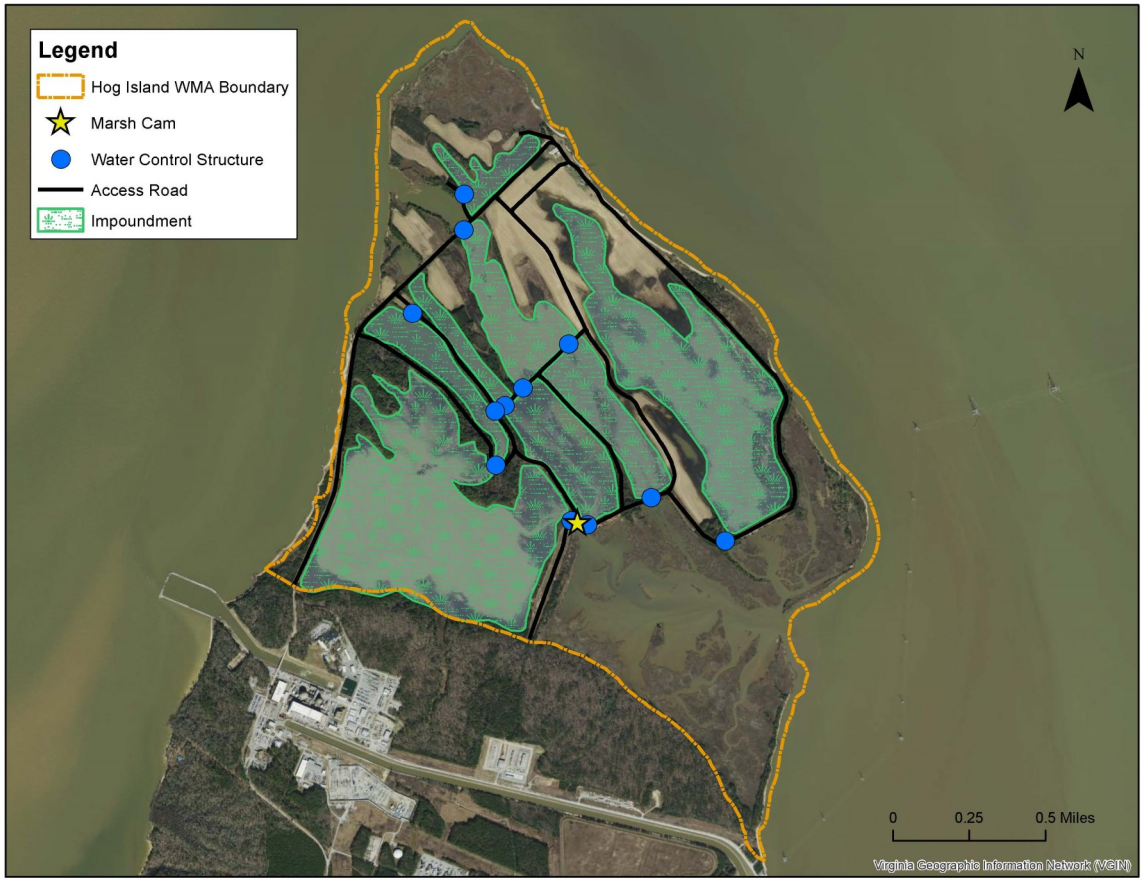
These marshes provide several important ecosystem services. They slow down potentially harmful floodwaters, protect the surrounding upland from strong waves that build during storms, and provide important nesting grounds for many wading birds and waterfowl.



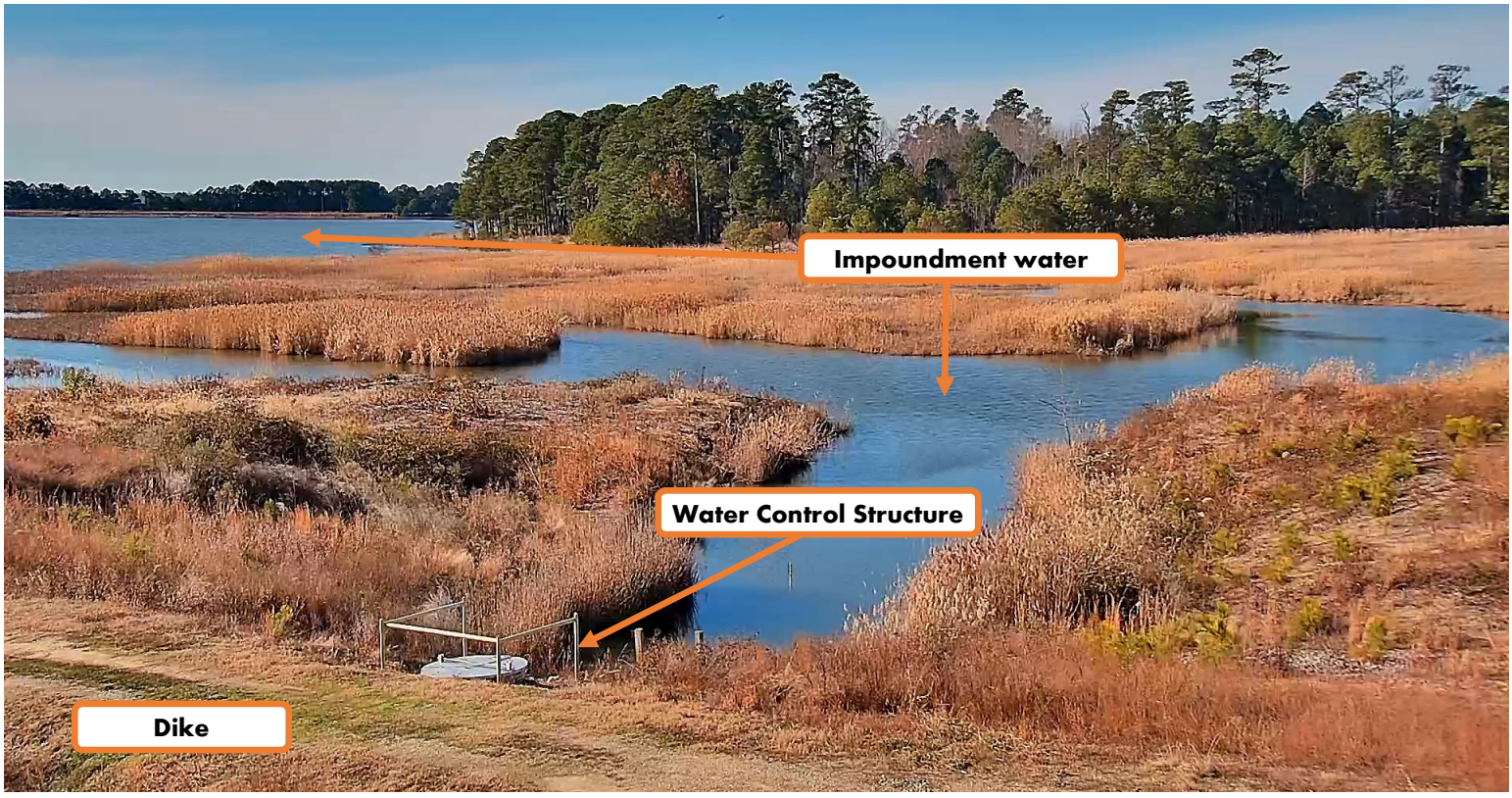
Above: Hog Island tidal marsh habitat as seen from the Marsh Cam

INLAND WETLAND IMPOUNDMENTS

The interior of Hog Island contains large inland wetland **impoundments** which unlike the tidal marsh habitat, are man-made and managed. These managed wetland impoundments are surrounded by either constructed **dikes** or naturally occurring high ground on all sides to retain water. These dikes double as access roads and help create the eight independent wetland impoundments. A **water control structure** is strategically installed at the lowest spot along the impoundment edge where water can naturally enter or exit. These structures contain a gate that land managers can open and close at will allowing water to flow from the tidal marsh into the impoundment or vice versa. Although they may not always be on camera, two of these water control structures are within view of the Marsh Cam!



Above: Overhead imagery of Hog Island highlighting the impoundments, the Marsh Cam, and water control structures



Above: Hog Island tidal impoundment habitat as seen from the Marsh Cam. The Dike separates the impoundment from the tidal marsh.

INLAND WETLAND IMPOUNDMENTS

The water level in the impoundments is usually lowered in the late spring and summer to expose soil and encourage plant growth. A wide diversity of plants that ducks, geese, and other waterfowl like to eat will easily grow in these impoundments. The water level is then raised through the fall and winter to provide quality wetland habitat loaded with food for migrating waterfowl.

The deeper sections of these wetland impoundments hold water all year long and support the growth of plants you can't see from the Marsh Cam. That's because **Submerged Aquatic Vegetation (SAV)** grows completely underwater! These out-of-sight plants serve as food and shelter for aquatic animals, like fish, release oxygen, and absorb toxins and excess nutrients from the water.

The continued management of these impoundments allows DWR to ensure quality habitat for migrating waterfowl and other water birds, and provides superb public access to hike, birdwatch, hunt, and fish around some of Virginia's most impressive wetland habitats.

Ducks feeding on submerged aquatic vegetation

KNOWLEDGE CHECK: What are some examples of benefits that the wetlands at Hog Island provide? Describe one benefit provided by tidal marshes and one benefit provided by the inland wetland impoundments.

The tidal marshes at Hog Island slow down potentially harmful floodwaters, protect the surrounding upland from strong waves that build during storms, and provide important nesting grounds for many wading birds and waterfowl. The impoundments at Hog Island provide quality habitat loaded with food for migrating waterfowl. The SAV's growing in the impoundments serve as food and shelter for aquatic animals, like fish, and release oxygen into the water, and absorb toxins and excess nutrients from the water.

DEEPER LEARNING OPPORTUNITY: EXPLORING HABITAT MANAGEMENT AT HOG ISLAND

THE SHRUB THICKETS OF HOG ISLAND

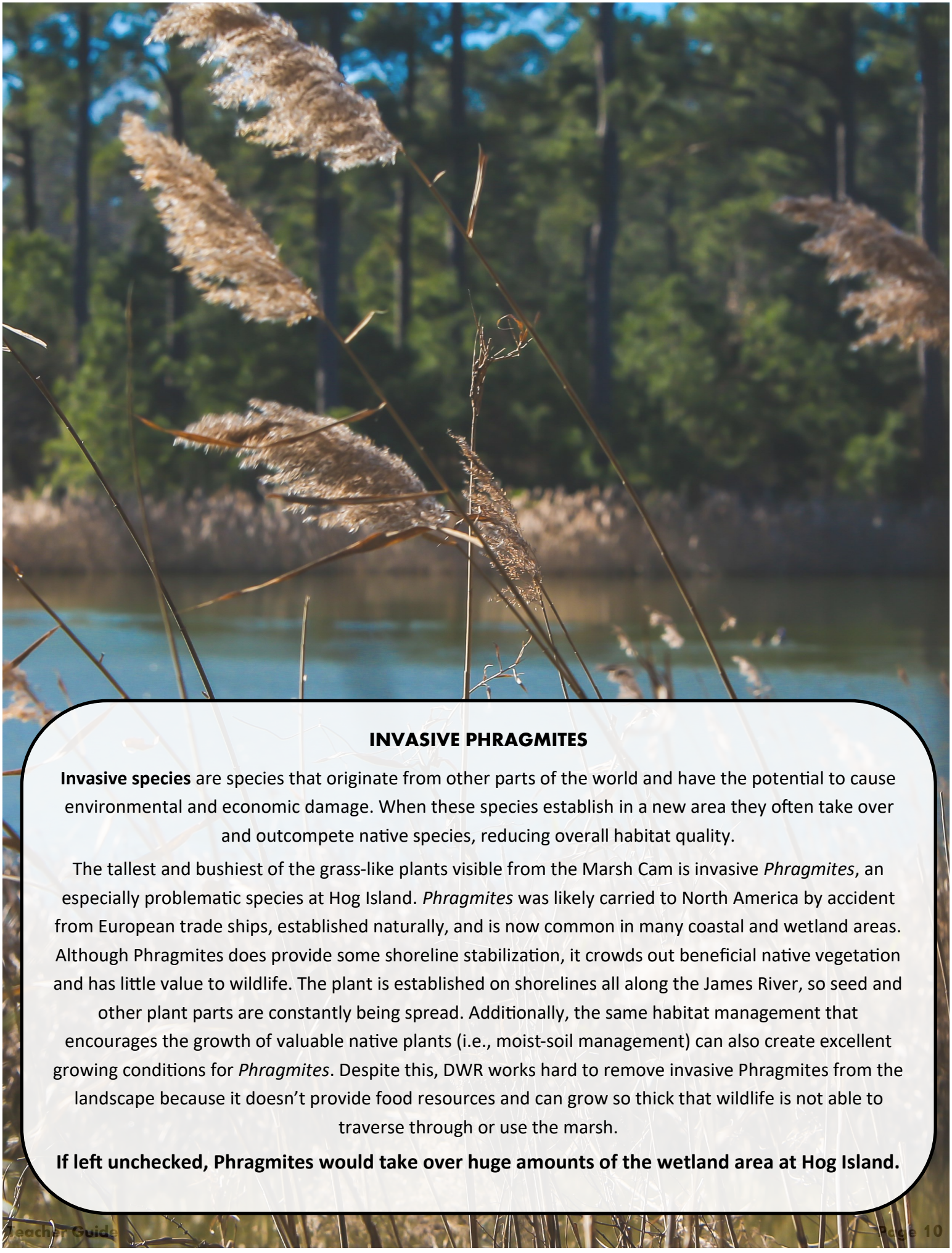
As the land rises above the normal tide line, you can see a narrow section, usually 10 to 20 feet wide, containing **shrub thickets**. The shrub habitat along the banks of Hog Island is formed by a thicket of relatively short growing woody shrubs that can survive occasional flooding during unusually high tides. Shrub habitats provide excellent cover for smaller animals, and many migratory birds build their nests in these thickets because they are tough for predators like eagles and raccoons to access. The shrub's strong woody roots hold tightly to the soil and stabilize the shore. Without these different wetland habitats protecting the shoreline of Hog Island the land could **erode** away!

THE FORESTED UPLANDS OF HOG ISLAND

Finally, as the landscape transitions to higher ground, you can see **forested uplands**. These drier wooded areas are made up of mature trees and provide habitat for a great variety of wildlife and are where many deer, turkey, songbirds, and other upland wildlife spend much of their time. The mature tree canopy is utilized as nesting habitat for bald eagles, with several active nests located on Hog Island WMA each year. These forested areas also provide a host of ecosystem services such as producing quality soils, cleaning the air and creating oxygen, and producing the timber that is used for wood products and fuel.

KNOWLEDGE CHECK: What are some benefits provided by both shrub thickets and forested uplands? What are some benefits that are unique to each of these habitats?

Both the shrub thicket and forest uplands provide habitat for nesting birds. The shrub thicket also provides great cover for smaller animals and the roots of the shrubs hold the soils of the shore and stabilize it. The forest uplands provide quality soils, clean the air and create oxygen, and produce timber that is used for wood products and fuel.



INVASIVE PHRAGMITES

Invasive species are species that originate from other parts of the world and have the potential to cause environmental and economic damage. When these species establish in a new area they often take over and outcompete native species, reducing overall habitat quality.

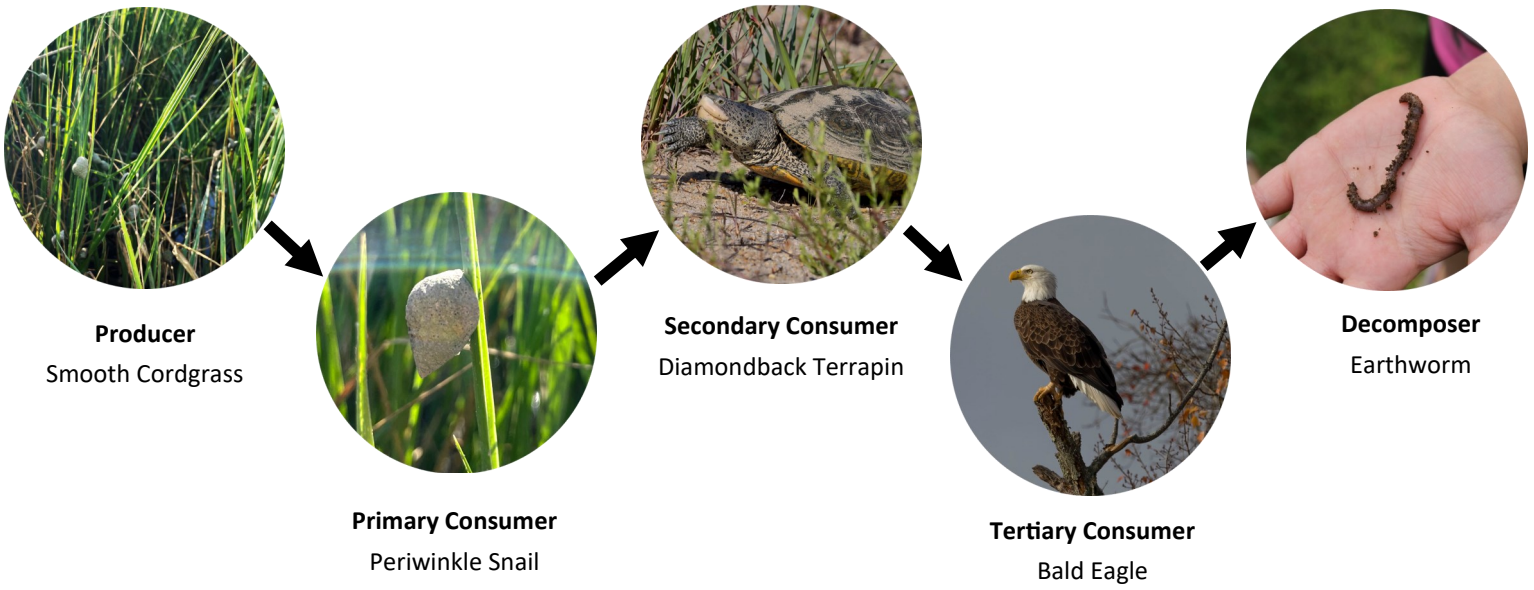
The tallest and bushiest of the grass-like plants visible from the Marsh Cam is invasive *Phragmites*, an especially problematic species at Hog Island. *Phragmites* was likely carried to North America by accident from European trade ships, established naturally, and is now common in many coastal and wetland areas. Although Phragmites does provide some shoreline stabilization, it crowds out beneficial native vegetation and has little value to wildlife. The plant is established on shorelines all along the James River, so seed and other plant parts are constantly being spread. Additionally, the same habitat management that encourages the growth of valuable native plants (i.e., moist-soil management) can also create excellent growing conditions for *Phragmites*. Despite this, DWR works hard to remove invasive Phragmites from the landscape because it doesn't provide food resources and can grow so thick that wildlife is not able to traverse through or use the marsh.

If left unchecked, Phragmites would take over huge amounts of the wetland area at Hog Island.

HOG ISLAND ECOLOGY

All organisms, whether they are plants, animals, fungi, or even bacteria, must acquire the energy to survive. A **food chain** is a simple diagram which demonstrates how energy is transferred from one living organism to another through food consumption. Essentially, it shows what any given organism eats, and what eats it.

Hog Island is incredibly diverse in terms of both terrestrial plant and animal life as well as aquatic plant and animal life. This means that there are hundreds of different food chains that could be constructed using the organisms that occur there. Look at the below example which shows one of the many possible food chains relevant to Hog Island.



Producer
Smooth Cordgrass

Primary Consumer
Periwinkle Snail

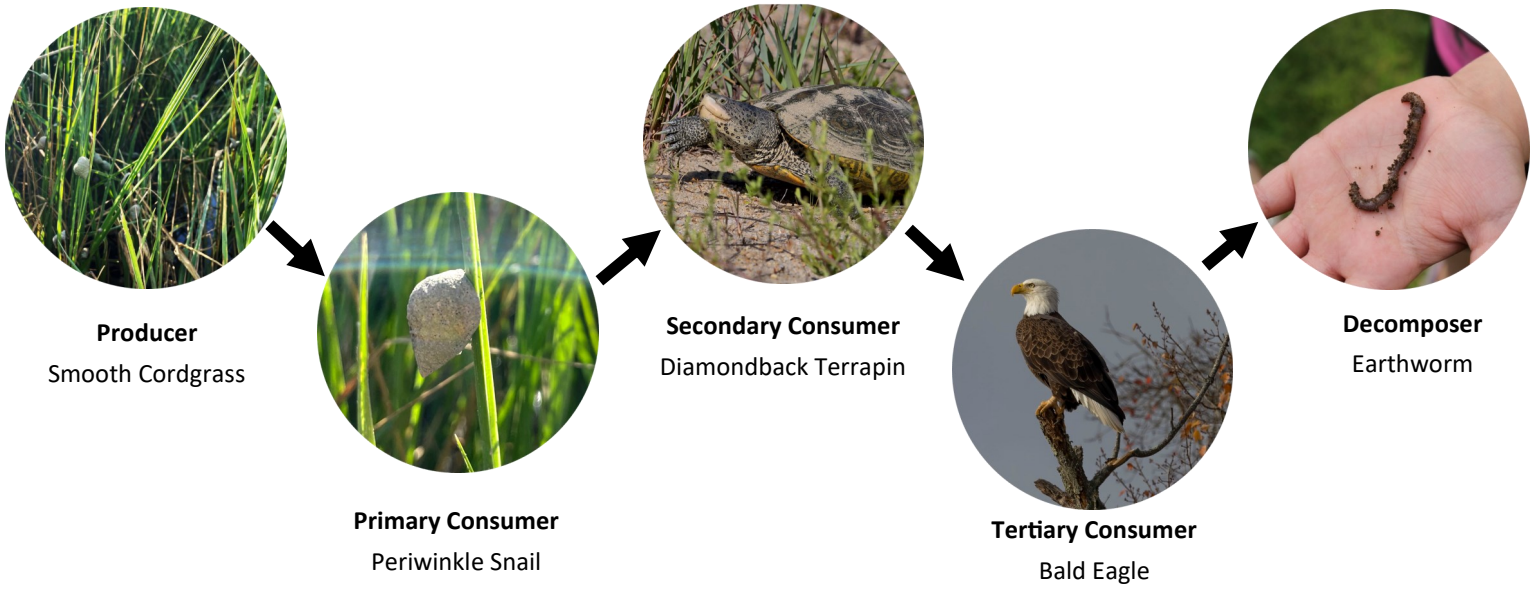
Secondary Consumer
Diamondback Terrapin

Tertiary Consumer
Bald Eagle

Decomposer
Earthworm

Because a food chain is basically just a sequence of organisms that feed on each other, they should always begin with an organism that gets its energy from an **abiotic source**. An organism that gets its energy from an abiotic source is called a **producer.** Although there are multiple abiotic sources of energy on earth, the most commonly utilized energy source is the sun. Plants are a great example of a producer because they get their energy from the sun and mineral nutrients from the soil. The producer in our food chain example above is smooth cordgrass which is a native species of grass that grows in Virginia's tidal marshes.

Only producers are able to use abiotic sources like the sun for energy. All other organisms acquire their energy by eating, or consuming, other organisms or **biotic sources** which is why they are referred to as the **consumers** of a food chain. Whatever animal eats the producer would come next in the food chain. These animals are referred to as primary consumers and are typically **herbivores** or **omnivores**. In our example, the primary consumer in the Hog Island food chain is the periwinkle snail which feeds on smooth cordgrass within the tidal marshes. The next spot in the food chain would correspond to whatever animal eats the primary consumer. This organism is considered the secondary consumer of the chain and could be either an omnivore or a **carnivore**. In our Hog Island food chain, the secondary consumer is the diamondback terrapin, a species of turtle which lives in estuaries and eats snails and crabs.



Producer
Smooth Cordgrass

Primary Consumer
Periwinkle Snail

Secondary Consumer
Diamondback Terrapin

Tertiary Consumer
Bald Eagle

Decomposer
Earthworm

From there, the sequence of consumers will continue until the chain reaches the point that the final consumer is no longer fed on by any other consumers. Secondary consumers are followed by tertiary consumers which are followed by quaternary consumers, etc. In our example, the bald eagle, which is known to feed on diamondback terrapins, is the tertiary and final consumer in the chain because it has no predators. Although this example only has three consumer roles depicted, it is important to remember that food chains can contain any number of consumers based on the organisms it contains.

No matter how many consumers are involved, **decomposers** will make up the final part of any food chain. Decomposers are organisms that feed on the nonliving remains of other plants and animals. Often referred to as 'natures recyclers' decomposers are critical to every environment as they turn organic wastes, like decaying plants, or dead animals into inorganic materials, such as nutrient-rich soil. Along with the sun, this nutrient-rich soil is then used to generate self-sustaining energy by the producers.

Most decomposers are microscopic organisms like bacteria however other decomposers like fungi and worms can all be observed without a microscope. Typically within any habitat, there are tons of different decomposer species that play a role in breaking down dead matter. Although our Hog Island example ends with an earthworm as the decomposer, there are lots of other decomposers at Hog Island that could also take its place!

KNOWLEDGE CHECK: Create and label your own food chain with organisms found in Virginia. Incorporate a producer, a primary consumer, a secondary consumer, and a decomposer. Label these levels of your food chain and use arrows to show the transfer of energy between your organisms.

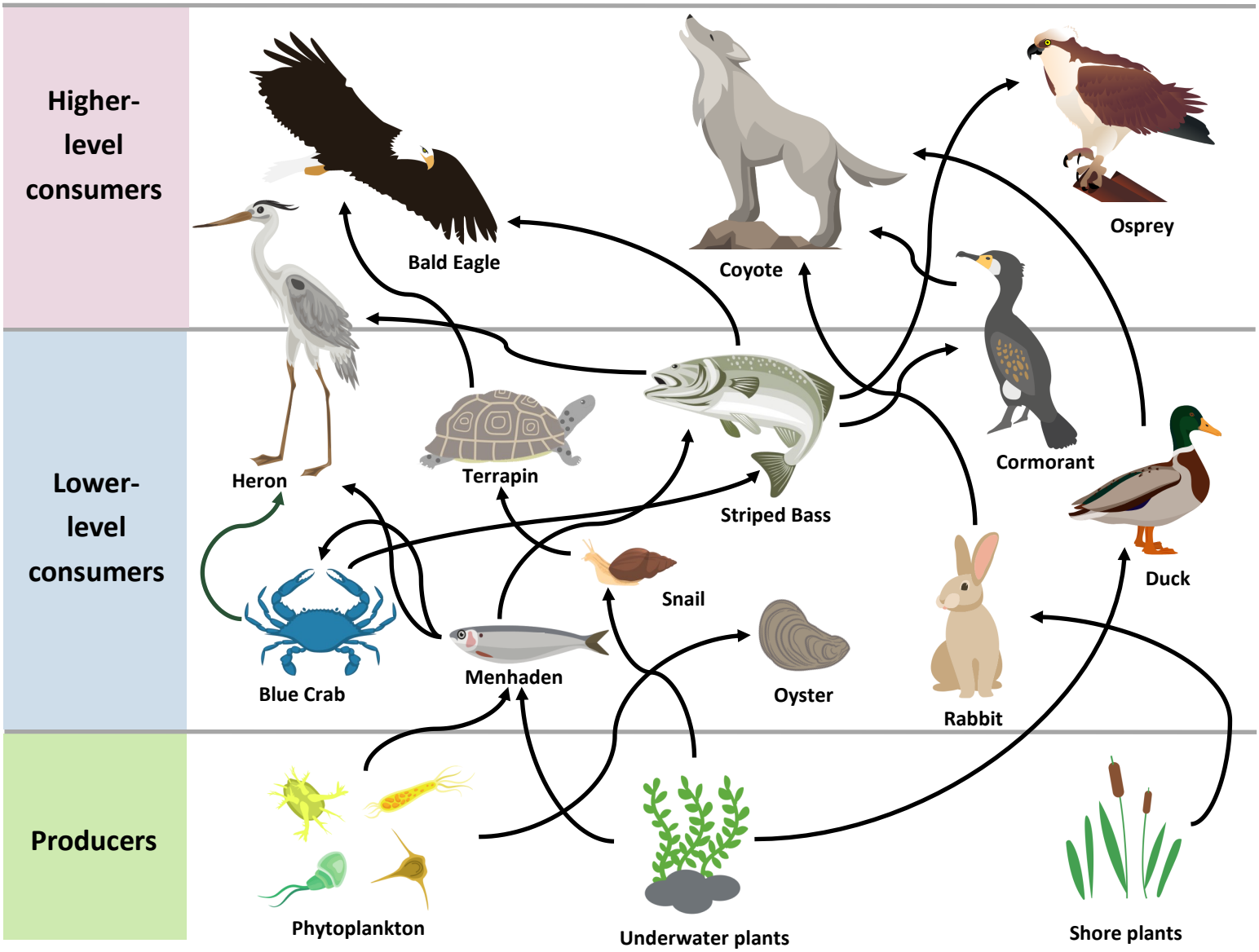
Answers will vary

Our Hog Island food chain example is just one possible sequence of events that could occur at Hog Island considering the animals in the food chain are capable of eating other food items as well. Likewise, each of them could also be eaten by other animals, which means that there are a seemingly endless number of other possible food chains that could occur at Hog Island.

In order to more accurately describe the flow of energy within a community of organisms, ecologists can construct a **food web**, which is essentially a combination of related food chains within the environment. Food webs are much more realistic than food chains because in addition to showing what eats what, they display the larger network of interconnected feeding relationships between organisms. Just like in a food chain, energy enters the food web at the producer level where it is then passed through numerous consumers. Ultimately that energy is recycled by the decomposers to be used again by the producers in an endless cycle. View the below food web from Hog Island and see if you can trace the flow of energy throughout the web.

Despite being able to display multiple food chains within one diagram, even food webs often depict only a few of the feeding relationships from one habitat. Because of this, ecologists often create simplified versions of food webs which focus specifically on the organisms they are interested in studying. If you look at the below food web example from Hog Island, you can probably think of multiple other organisms that could be added to it!

Hog Island Food Web



DEEPER LEARNING OPPORTUNITY: CREATING A VIRGINIA FOOD WEB

As you can see, food webs can be incredibly complex due to all of the different direct and indirect relationships between the depicted organisms. This also means that major increases or decreases in the population size of any of the organisms within the web can impact the population sizes of numerous other organisms in the same web. For example, if the population of periwinkle snails was to suddenly decrease, the diamondback terrapin population that feeds on the snails would also decrease. On the other hand, the amount of smooth cordgrass in the area would increase as there are not as many snails feeding on it.

KNOWLEDGE CHECK: Fisheries biologists would like to stock more Striped Bass in the James River. Examine the Hog Island Food Web and describe what you think would happen to Cormorant, Heron, and Menhaden populations due to the stocking event?

Cormorant populations would increase due to the increase in prey items (Striped Bass), the Menhaden populations would decrease due to the increase in predators (Striped Bass), and the Heron populations would likely stay the same considering prey (Striped Bass) populations have increased but prey (Menhaden)

Carrying capacity refers to the number of animals within a species that can be supported in a given area or habitat. The carrying capacity for a species is usually controlled by some **limiting factor** like the amount or quality of available food or shelter. This also means that each species within a habitat is likely to have a different carrying capacity based on what the species needs from its environment in order to survive and reproduce.

When there is an excess amount of resources available for a species, the population size of that species will eventually grow. Likewise, if there are more animals of a species in an area than there are resources to support them, that species population size will eventually decrease. This results in a pattern where the population size fluctuates up and down repeatedly over time. The average number that the population size fluctuates around is the carrying capacity.

Above: Graph of a species population growth over time. The dotted line which population size fluctuates around is the carrying capacity.

DEEPER LEARNING OPPORTUNITY: EXPLORING INFLUENCES OF CARRYING CAPACITY

Glossary

Abiotic Source – the non-living physical or chemical components of the environment.

Biotic Source – the living components of the environment

Brackish Water – Water occurring in a natural environment that has some salt content but is not as salty as the ocean.

Carnivore – an organism that feeds on and obtains its energy from mostly animals and provides an important ecosystem service by controlling animal populations.

Carrying Capacity – refers to the number of animals within a species that can be supported in a given area or habitat.

Consumer – an organism that eats plants, animals, or other living things for energy and nutrients.

Decomposer – an organism that feeds on and gets its energy from dead plant and animal matter and turn these materials into organic matter that can be used by autotrophs/producers.

Dike – A low wall or dam, often made of earthen material and vegetated, that divides or encloses land.

Ecosystem Services – The many processes occurring in natural environments and healthy ecosystems that benefit humans and social welfare.

Estuary – A brackish tidal area where an inland freshwater river meets ocean saltwater.

Erode – A geologic process where earthen material wear away by natural forces like wind or water.

Food Chain – a single chain of energy transfers in the form of food from organisms to organism.

Forested Upland – an area which contains mature forests and does not typically hold standing water.

Habitat – A particular type of natural environment where plants and animals can live and grow.

Herbivore – an organism that feeds on and obtains its energy from mostly plants and provides an important ecosystem service by controlling plant populations.

Hog Island – the peninsula on the James River where Hog Island Wildlife Management Area and the Marsh Cam is located.

Impoundment – An enclosed body of water, such as a pond or lake reservoir, flooded rice/agricultural field, or managed wetland.

Invasive Species – An organism that is not native to the area under consideration and whose introduction causes or is likely to cause economic or environmental harm to human health.

Limiting Factor – the limiting resource which prevents an organisms population from growing above the carrying capacity.

Omnivore – an organism that feeds on and obtains its energy from a variety of materials including plants, animals and fungi and provides an important ecosystem service by keep those plant and animal populations from overpopulating.

Glossary

Producer – an organism that makes its own food using light, water, carbon dioxide, or other chemicals.

Salinity – the amount of salt dissolved in water.

Shrub Thicket – a natural area densely vegetated with shrubs.

Submerged Aquatic Vegetation – plants that grow completely underwater and provide shelter, and food for fish and wildlife.

Tidal Marsh – a type of wetland where the water level goes through a daily rise and fall with the tide.

Virginia Department of Wildlife Resources – the state agency responsible for the management of inland fisheries, wildlife, and recreational boating in the Commonwealth of Virginia.

Water Control Structure – a structure between the tidal marsh and the impoundments which allows land managers to raise or lower water level within the impoundment, based on the tide.

Wetlands – areas where the ground is covered or soaked with water for portions of the year or for the entire year.

Deeper Learning Opportunity- Exploring the Hog Island Historical Timeline

Objectives and Virginia Standards of Learning:

The students will be able to:

- explaining the impact of geographic environment on hunter-gatherer societies (WHI. 2)
- analyzing how technological and social developments gave rise to sedentary communities (WHI. 2)
- analyzing how archaeological discoveries are changing current understanding of early societies (WHI. 2)
- describe the characteristics of early exploration and evaluating the impact of European settlement in the Americas (VUS.2)
- describe the cultural interactions among American Indians, Europeans, and Africans. (VUS.2)
- analyzing how social and political factors impacted the culture of the colonies (VUS.3)

Instructions :

Visit the Hog Island Timeline at https://dwr.virginia.gov/marsh-cam/history-of-hog-island/ and answer the following questions:

1. Prior to it being named the 'James River' by the English Settlers, what name did the Tsenacomoco People have for this water body and who was it named after?

The Tsenacomoco People named the river The Powhatan River and it was named after Chief Powhatan, the paramount chief of Tsenacomoco

2. On what date was the settlement of Jamestown established and what was its approximate location relative to Hog Island?

Jamestown was established on May 13, 1607, and it is 10 miles northwest of Hog Island

3. How did John Smith's explorations of the Chesapeake Bay help the development of the region in future years?

During his explorations, Captain John Smith mapped the Chesapeake Bay and many of its tributaries which were used to guide development of the region

4. Who likely lived on Hog Island at some point between 1614 and 1617. What was the relationship of these individuals to Chief Powhatan?

It is believed that Pocahontas and her husband, John Rolfe lived on Hog Island during this time. Pocahontas was Chief Powhatan's daughter.

5. In addition to using Hog Island to raise their pigs, what are three other kinds of crops that early families grew here?

In addition to hogs, families grew fruits, grains, and tobacco.

6. How was Hog Island utilized during the American Revolutionary War and the American Civil War?

During the American Revolutionary War Hog Island was used as a commissary depot by the French and American forces. Cattle and other food supplies were held here to supply the troops involved in the siege

7. What is the only remaining structure of Homewood still visible at Hog Island today?

The brick smokehouse is the only remaining structure.

8. In what year did the Commission of Game and Inland Fisheries (now known as the Virginia Department of Wildlife Resources) purchase Hog Island?

The DGIF (now DWR) purchased Hog Island in November of 1950.

9. What was it about Hog Island that aided in the recovery of bald eagles to the region?

The rich waters of the James River are a home to a diversity of fish species which provide plentiful food to the eagles.

10. What is shoreline erosion and what was one example of a recent restoration project used to combat shoreline erosion at Hog Island?

Shoreline erosion is the process of water wearing down and carrying away the rocks, soils, and sands that create the shoreline. The most recent shoreline restoration project at Hog Island occurred along the western shoreline. The project included beach grass and riparian buffer planting, the construction of 7 new rip-rap breakwaters, and beach nourishment to form tombolos- a sand or gravel bar connecting to the mainland of the island.

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Deeper Learning Opportunity- Exploring Your Watershed Address

Objectives and Virginia Standards of Learning:

The students will be able to:

- Define a watershed (6.8 a)
- Use maps to determine the location and size of Virginia's regional watershed systems (6.8 b)
- Locate the local watershed and the rivers and streams associated with it (6.8 b) (E.S. 8 d)

Teacher's note: You may want to show the students how the https://river-runner.samlearner.com/ website works and how they can figure out their watershed address through this simulation by completing your schools mailing address together as a class before the students attempt to figure out their individual watershed address. Few answers are included in the answer key as they will vary based on locations around the state of Virginia.

Watersheds

What is a Watershed?

To fully understand a place, you need to know its history and its **watershed**. A watershed, or drainage basin is an area of land drained by a river and its tributaries to a common outlet, such as a lake, bay, or ocean. Each step you take is in a watershed. Some watersheds, like that of a stream or creek, are small. Others, like the Atlantic Ocean watershed, are very large. A watershed includes all the land, plants, and animals within its borders. It includes cities and farms, streams and lakes, paved roads and undeveloped land. All of us, anywhere in the world, are living, working, and playing somewhere on water's route from higher points to lower ones as gravity keeps a steady pull guiding water's path. Healthy watersheds reflect human communities that are aware of and provide care for the watersheds they are a part of.

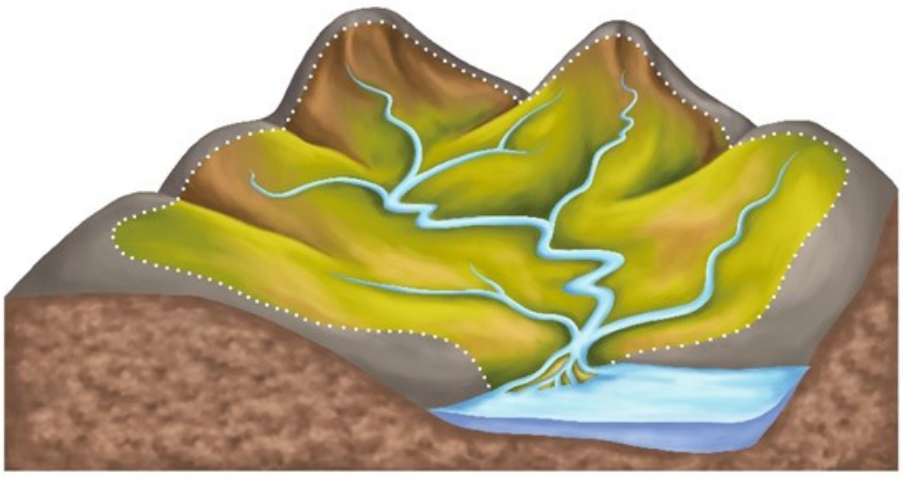


Figure 1 The dotted line here represents a watershed's Drainage Divide

Each watershed begins at a **drainage divide**, or high areas of land (ridges, mountains, hills) where rainwater or snowmelt will drain down into a river. The dotted line in Figure 1 represents the drainage divide for this watershed and everything within that dotted line would be a part of this area's watershed. Notice how when it would rain or when snow would melt, the water would drain off the mountains into the main river shown and then out into the ocean. A new watershed would begin on the other side of those high points in the image.

As you can see in Figure 2, the largest drainage divide in North America is the **Continental Divide**, which creates the division of water flowing west into the Pacific Ocean (shown in red) and the remainder of the water which either flows north into the Arctic Ocean (shown in purple), or east into the Atlantic Ocean. Most of the land mass of North America is in the Atlantic Ocean watershed, which includes the smaller watersheds of the Hudson Bay (shown in brown), the Gulf of Mexico (shown in light green), and the watersheds that flow directly into the Atlantic Ocean (shown in dark green).

Figure 2 The Watersheds of North America

Just like the Atlantic Ocean example above, larger watersheds are often made of up smaller watersheds. One the of smaller watersheds that is part of the larger watershed that directly flows into the Atlantic Ocean is the Chesapeake Bay watershed.

Let's examine the Chesapeake Bay Watershed a bit more closely. The 64,000 square mile watershed includes parts of New York, Pennsylvania, Maryland, Delaware, West Virginia, and Virginia. Figure 3 shows you the entire drainage area of the Chesapeake Bay watershed and its drainage divide boundary which is in purple.

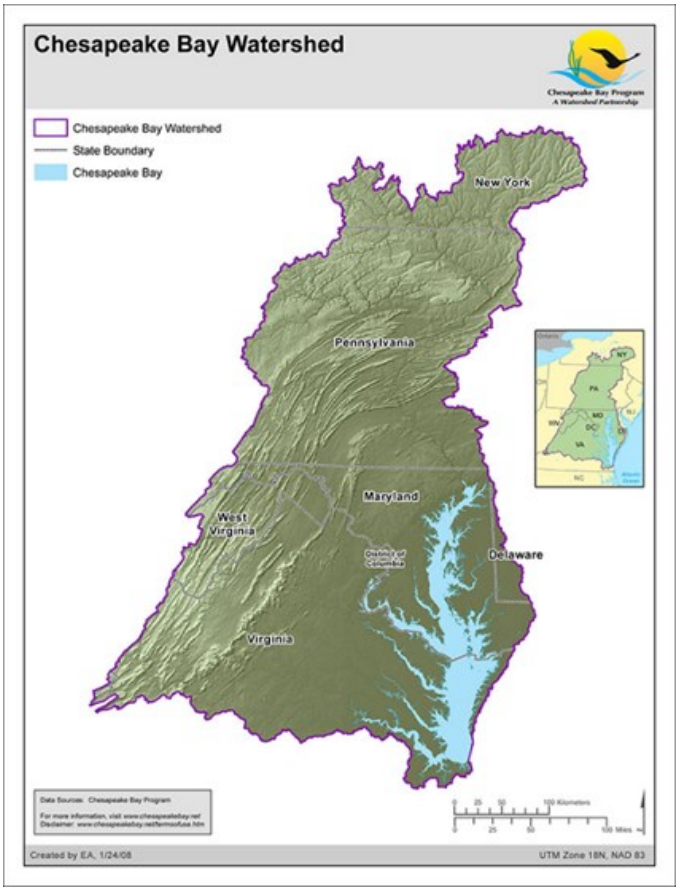


Figure 3 The Chesapeake Bay Watershed

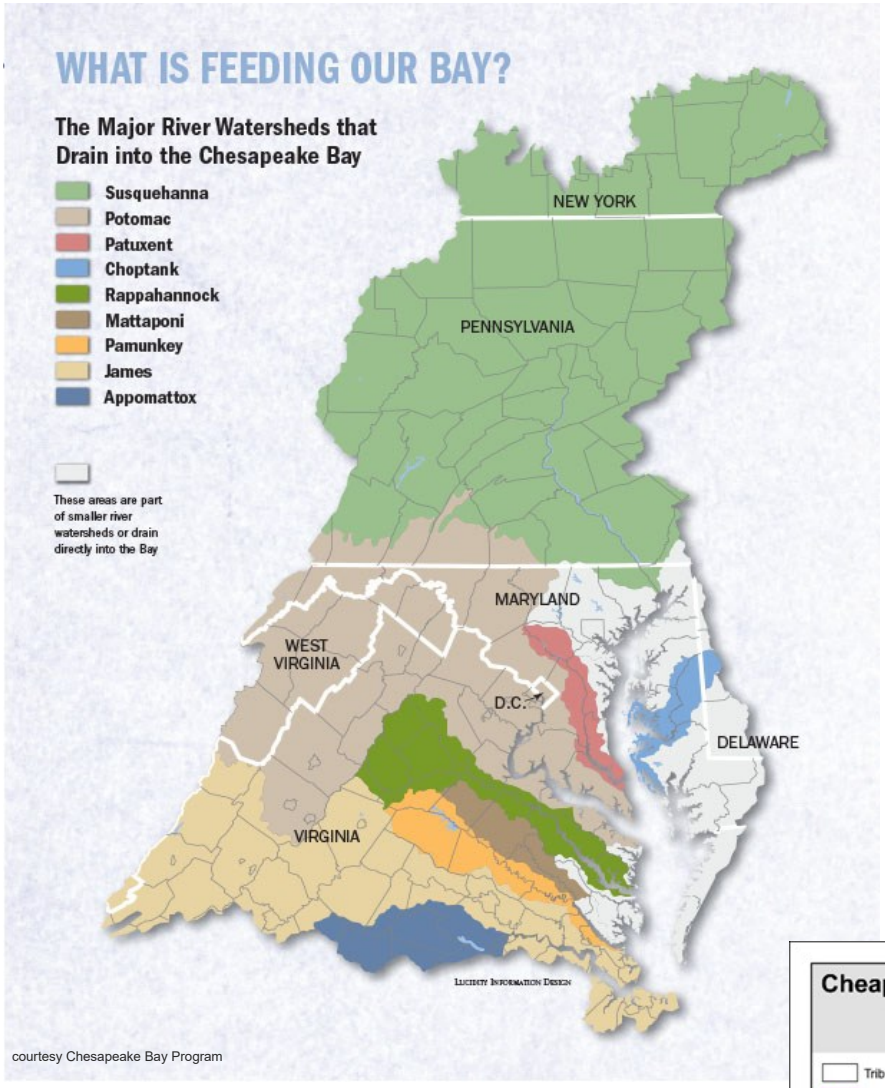


Figure 4 Major Rivers Watersheds of the Chesapeake Bay

Within this large Chesapeake Bay watershed, there are 9 smaller watersheds each depicted in a different color in Figure 4. Smaller watersheds can join to create larger watersheds and larger watersheds can be broken into smaller watershed, like these nesting dolls.

Some of these watersheds can be broken down into even smaller watersheds, depicted in Figure 5. Compare Figures 4 and 5 and notice how many different smaller watersheds make up the larger Susquehanna watershed.

You can continue to continue to break larger watersheds down into smaller ones until you arrive at a specific location. As an example, let's use the location of our Marsh Cam at Hog Island, Virginia.

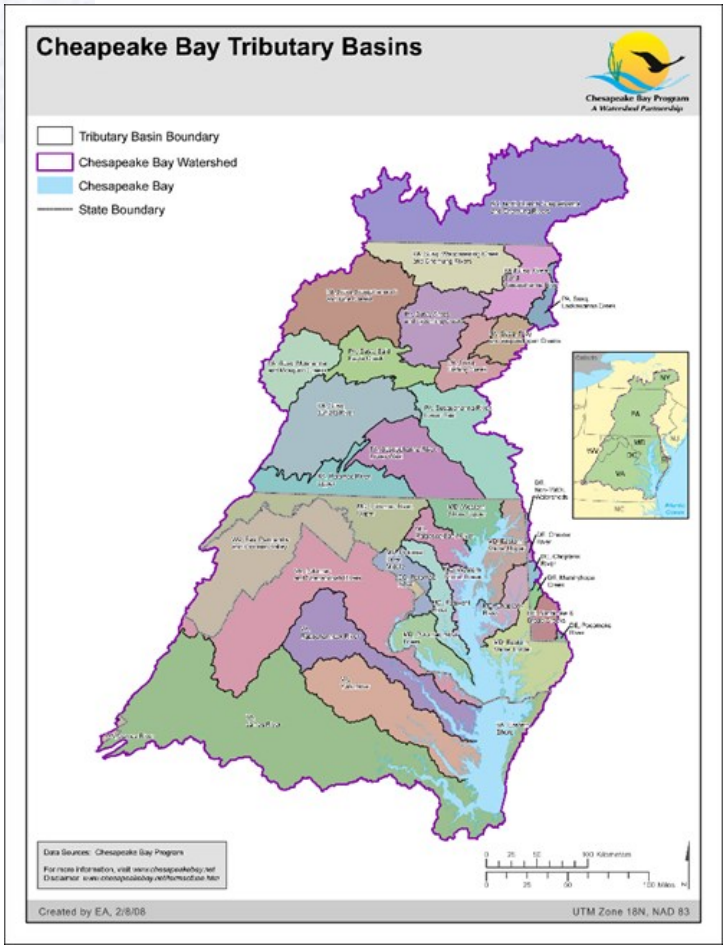


Figure 5 Tributary watersheds within the 9 major river watersheds of the Chesapeake Bay

The Watershed of Hog Island

The smallest watershed that the Hog Island Marsh Cam is a part of is the James River watershed due to its location directly on the banks of the James River- find the star in Figure 6. The James River is the southernmost watershed of the Chesapeake Bay in Virginia and the only watershed that flows across the entire state. Its watershed covers 10,000 square miles or about 1/6 of the total Chesapeake Bay watershed. The James River has 8 major river tributaries, or smaller streams that flow into it, including the Appomattox River, Chickahominy River, Cowpasture River, Hardware River, Jackson River, Maury River, Rivanna River, and Tye River.

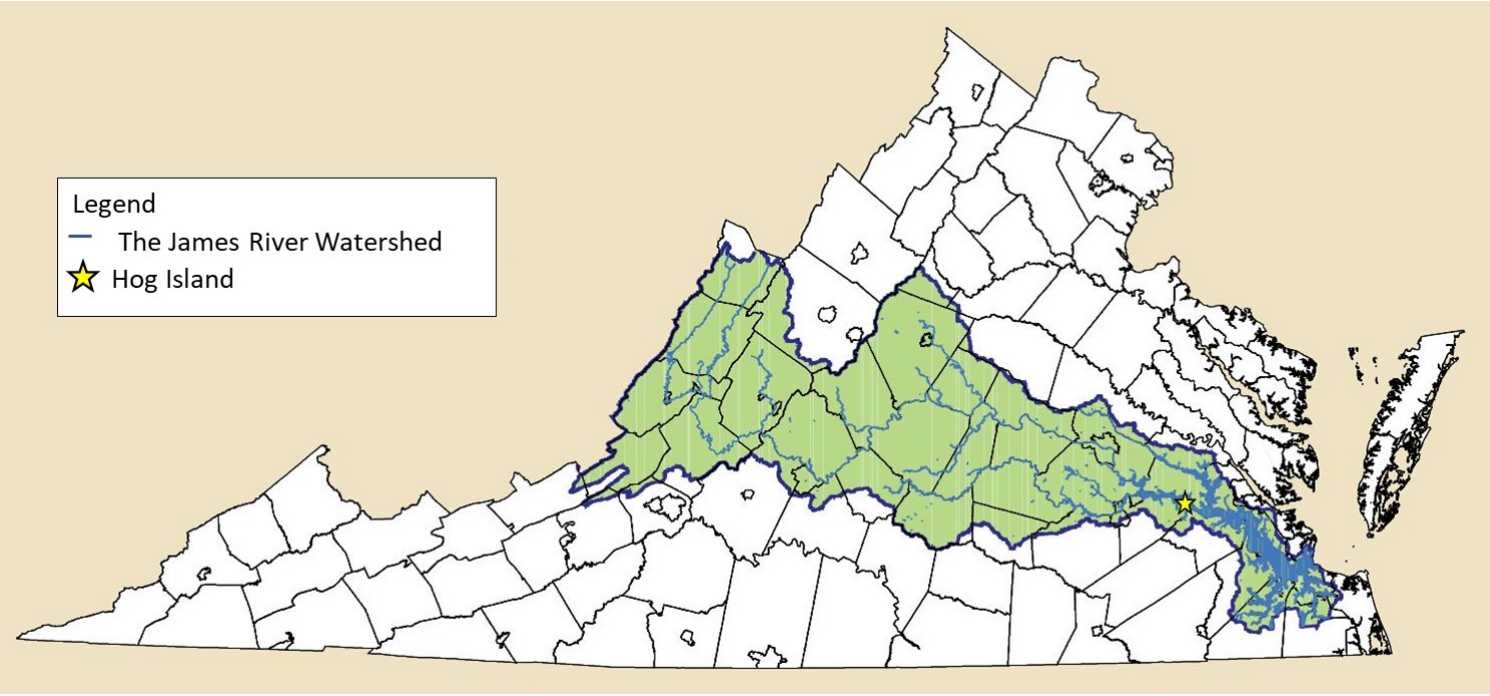


Figure 6 Hog Island labeled within the James River watershed. The watershed boundary is outlined in blue and the entire watershed area is colored green.

At Hog Island the freshwater that has flowed down from the higher elevations mixes with the tidal salty water from the Chesapeake Bay creating brackish or slightly salty water. This brackish water continues until the river completely flows into the Chesapeake Bay at Norfolk. The water of the Chesapeake Bay then flows into the Atlantic Ocean.

A Watershed Address

Just as most everyone has a mailing address, everyone also has a watershed address. Your mailing address starts with your name, then your house by number, then the road you live on, then the town, and finally the state you live in. Each part of your mailing address is a larger area. Watersheds work the same way. The small stream near your house is part of a larger river system that may drain into an even larger river system until the water most likely drains into the largest waterbody of all, the ocean. Everybody lives in a watershed and has a watershed address!

Let's think about our Hog Island Watershed from the previous section. The watershed closest to Hog Island was the James River. The James River flowed into the Chesapeake Bay. The Chesapeake Bay flowed into the Atlantic Ocean. Therefore, using arrows to show the flow of the water, the watershed address of Hog Island Marsh Cam would be

The James River → Chesapeake Bay → Atlantic Ocean

Visually the watershed address of the Hog Island Marsh Cam can be seen in Figure 7 below.

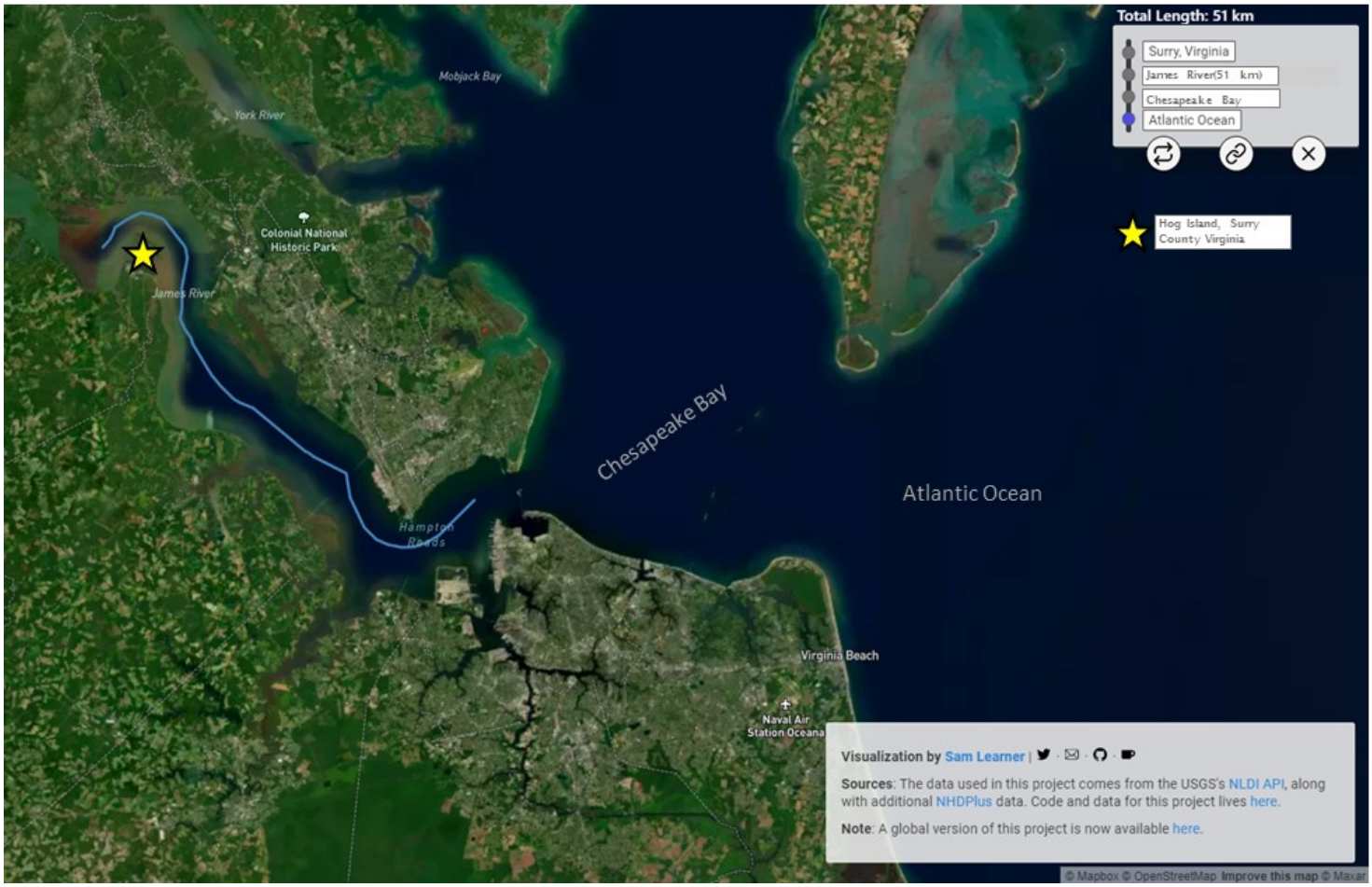


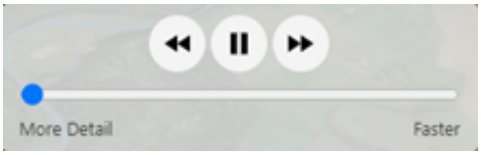
Figure 7 The Hog Island Marsh Cam watershed address shown through the https://river-runner.samlearner.com/ watershed trip simulation. In the image the watershed address is located in the upper right hand corner, starting with the city of origin then moving to the James River, the Chesapeake Bay, then the Atlantic Ocean.

It is important that everyone knows their watershed address since everyone is living, working, and playing in a watershed every day. Healthy watersheds reflect human communities that are aware of and provide care for the watersheds they are a part of. Clean water is the result of their individual and collective efforts to prevent water pollution from entering the watershed.

What is your school's watershed address?

Instructions:

1. Go to https://river-runner.samlearner.com/
2. In the upper right-hand corner, type in your school's mailing address. As you are typing you should see address begin to popup below the box, click on your school's address once it shows up.
3. Allow the page to "find the downstream path from your location" aka, your watershed address.
4. Once the page load it will automatically begin to take you on an aerial tour of all the waterbody's (rivers, lakes, bays, oceans) that make up your watershed address.
5. Pay attention to what is on the land as you take your watershed tour. Watch the tour as many times as needed by clicking on the 🔁 to get a feel for the types of land uses in your watershed (forests, farm fields, mountains, houses, buildings, etc.). You can also slow down or speed up the tour using this box on the right



6. Now that you have toured *your school's watershed* address, please answer the questions below

Question 1: Using the legend in the upper right-hand corner of your School's River-runner screen:

a. What is your school's watershed address? Be sure to list the local stream/creek/river first then continue to list all the way until t the largest watershed (usually an ocean or bay). You can find these in the upper right-hand corner.

Answers will vary

b. Insert a screen shot that captures your total watershed address here:

Answers will vary– students may need to research how to take a screenshot on their particular devices

c. What is the total length of your school's watershed address in km? In miles? Hint: To convert from kilometers into miles, multiply the distance in kilometers by 0.6214.

Answers will vary

Question 2: Does your school's watershed completely exist within the state boundary of Virginia or does it include other states? You may need to scroll out to answer the question.

Answers will vary

7. Repeat instructions 1-5 above to figure out *your home's watershed address*, then answer the following questions:

Question 3. Using the legend in the upper right-hand corner of your home's River-runner screen:

a. What is your home's watershed address? Be sure to list the local stream/creek/river first then continue to list all the way until the largest watershed (usually an ocean or bay). You can find these in the upper right-hand corner.

Answers will vary

b. Insert a screen shot that captures your total watershed address here:

Answers will vary– students may need to research how to take a screenshot on their particular devices

c. What is the total length of your home's watershed address in km? In miles? Hint: To convert from kilometers into miles, multiply the distance in kilometers by 0.6214.

Answers will vary

Question 4: You may need to scroll out a bit on the map for this one, does your home's watershed completely exist within the state boundary of Virginia or does it include other states? Explain

Answers will vary

Question 5: How would managing the pollution in your watershed be different if your entire watershed exists within a single state vs your watershed address flowing through multiple states?

Answers will vary but can include: if your watershed crosses into other states the governments and people of all of the states would have to work together to keep the watershed healthy. While this may sound easy, states often differ in how they manage different lands

Question 6: Think about the land uses you saw while touring your watershed address, what impacts do you think these land uses might have on your watershed?

Answer will vary but can include: Activities that could increase erosion on the land, like construction or crop farming, could increase the amount of dirt or sediment that enters the stream. Too much sediment can harm fish by clogging their gills and covering their eggs. A golf course can introduce a lot of fertilizers and pesticides into the watershed to maintain the grass. Etc

Question 7: If your watershed gets polluted it affects you! List 2 things you can do today to help keep your watershed clean.

Answers will vary but can include: Place all trash in appropriate bins and if safe, pick up trash that I come across. Properly dispose of paint, oil, and other chemicals.

Extension Activity: Learning more about your local watershed

For this extension activity we are going to use the "How's My Waterway" tool from the Environmental Protection Agency (EPA) to learn more about your local watershed. Remember, this is the watershed closest to your house and the one you most directly impact every day. Using the EPA's How's My Waterway tool, you can find information* out about the following:

	**Overview** of the watershed
	**Swimming:** EPA, states, and tribes monitor and assess water quality to keep you safe while swimming, wading, or boating.
	**Eating Fish:** EPA, states, and tribes monitor and assess water quality to determine if fish and shellfish are safe to eat.
	**Aquatic Life:** EPA, states, and tribes monitor and assess water quality to determine the impact of impairments on plants and animals living in the water.
	**Drinking Water:** Who provides drinking water in your community?
	**Monitoring:** View water quality monitoring locations in your watershed.
	**Identified Issues:** View identified water quality issues in your watershed.
	**Restore:** View EPA funded nonpoint source pollution grants and waterbody restoration plans.
	**Protect:** How can you help keep your watershed clean?

* Not all waterways have monitoring stations, so some waterways may not have all of this information available.

Instructions:

1) Go to https://mywaterway.epa.gov/
2) In the box, type your home's location and click Go
3) Once the page loads, you should see a map on your left. On this map you should see your local or home's watershed outlined in a dotted white line.
4) On the right, you should see the various tabs described in the table above. Click through these various tabs and read through the information.
5) What surprising thing(s) did you learn about the health of your local watershed after reading through the swimming, aquatic life, and identified issues tabs?

Answers will vary

6) Are there any restoration projects  happening in your watershed?

Answers will vary

6) Click on the "Protect" tab. Within the "Tips" window, click on the "Tips" tab. Read through the community, school, yard, and home tips. What addition actions can you take to help protect the health of your watershed at home or at your school/community?

Community /school actions include: contribute to local water cleanup efforts, volunteer to help monitor water quality, lead a campaign to educate your community about impairment from nonpoint sources, like stormwater, sponsor a watershed festival in your community to raise awareness about the importance of watershed protection.

Home/yard actions include: Use fertilizer responsibly, don't overwater gardens and yards, landscape with native plants, reduce runoff, choose phosphate-free soaps and detergents if possible, pick up after your pet, use water efficiently, wash your car on your lawn or in commercial car washes,

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Deeper Learning Opportunity- Exploring Habitat Management at Hog Island

Objectives and Virginia Standards of Learning:

The students will be able to:

- explain that changes in the interactions among the living and nonliving components of an ecosystem can cause change in the system (L.S. 9 a) (BIO. 8 c) (ENV. III b) (Ec. 8, 11)
- explain that natural and human caused factors can positively and negatively affect the cycles of matter and life processes of living things within an ecosystem (L.S. 9 a, b, c) (BIO. 8 d) (ENV. III b, V a) (Ec. 6, 8, 9, 11, 13)
- cite examples of how human input can disturb the balance of populations positively or negatively in a habitat (L.S. 9 a, b, c) (BIO. 8 a, d) (ENV. III b, V a) (Ec. 6, 11, 13)
- provide an example of how the introduction of an invasive species can disrupt an ecosystem and threaten the survival of species (BIO. 8 d) (ENV. III b) (Ec. 7, 9, 11, 13)

Instructions:

Visit the Habitat Management Practices at Hog Island website at https://dwr.virginia.gov/marsh-cam/management-practices-at-hog-island-wma/ and answer the following questions

1.What is moist-soil management and what are its benefits?

Moist-soil management is a practice that allows land managers to manipulate water levels so they can mimic natural wetland flooding and drying cycles. This practice ensures the managed wetlands promote the growth of beneficial wetland plants in the spring and summer and provide high-quality wetland habitat through the fall and winter.

2.What is a drawdown and how does it encourage plant growth?

A “drawn down” is when the water level in moist-soil wetlands is or lowered in the late spring and summer to encourage plant growth. Drawdowns promote both emergent vegetation and SAV growth by exposing soils in shallow areas and allowing light to penetrate deeper through areas that hold standing water year-round.

3. What is emergent vegetation and how does it differ from submerged aquatic vegetation?

Emergent vegetation is a plant that grows in the water but pierces the surface so that it is partially in the air. Submerged aquatic vegetation is a plant that grows completely underwater.

4. Explain how rising tide can be used in conjunction with water control structures to fill an impoundment.

Most of the water control structures at Hog Island contain tidal gates which take advantage of daily and seasonal tidal cycles to flood and drain the wetland units. A gate inside the water control structure can be set to allow water to flow into the impoundment at high tide, but keeps water from flowing out at low tide, effectively raising the impoundment water level. The gates can also be switched to drain or lower the water levels within the impoundments using the low tide.

5. What is the benefit of staggering flooding and drawdowns of Hog Island's impoundments?

The timing of the drawdown influences the plant and habitat diversity. For example, an early growing season drawdown in April would favor different plant species compared to a late growing season drawdown in August. If the impoundment was then flooded (i.e. water level is raised) through the fall and winter it could provide quality wetland habitat loaded with food for migrating waterfowl and other waterbirds. The water level can also effect which birds use the impoundment, for example, dabbling ducks prefer 4-18 inches of water.

6. What are some examples of crops that have high value for wildlife?

A rotation of corn and soybean is planted, and following harvest, residual grain provides food for migrating waterfowl. Other crops that can provide value to wildlife include millet, wheat, and milo. Having these readily available foods can be especially important during cold snaps. After harvest, these fields are planted with a cover crop (e.g., typically winter wheat) which prevents soil erosion and provides an additional food resource.

7. Why are fields planted with a cover crop after harvest?

A cover crop (e.g., typically winter wheat) prevents soil erosion and provides an additional food resource.

8. Is *Phragmites beneficial to wildlife? Why or Why not?*

The invasive species, Phragmites, is not beneficial to wildlife. It is spreads and reproduces aggressively and often crowds out all native vegetation. While Phragmites provides dense cover and shoreline stabilization, it doesn't provide food and can grow so thick and tall that wildlife is not able to move through the marsh.

9.What are some of the reasons why Phragmites is hard to control at Hog Island?

Unfortunately, the same habitat management that encourages the growth of valuable native plants (i.e., moist-soil management) can also create excellent growing conditions for Phragmites. Phragmites can be controlled through carefully selected aerial herbicide treatment, but this treatment can also harm native plant species and is only sprayed when environmental conditions ensure that impacting native species can be avoided.

10. Why is Hog Island particularly vulnerable to shoreline erosion?

The shorelines at Hog Island are particularly vulnerable to loss during a storm surge because of the fetch or large distance of open water where the wind can blow across the James River estuary. Unusually high waters and strong winds blowing across a large fetch can create powerful waves which crash along and erode shorelines.

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Deeper Learning Opportunity: Creating a Virginia Food Web

Objectives and Virginia Standards of Learning:

The students will be able to:

- develop a model of a food web using organisms found in Virginia (L.S. 5 b) (BIO. 8 b) (ENV. III a) (Ec. 9)
- classify the organisms as producers and first-, second-, or third-order consumers. (L.S. 5 c) (BIO. 8 b)

Instructions for Creating a Class Virginia Food Web:

Work together as a class, or in small groups, share your Virginia food chains from your Knowledge Check with one another. As a class, combine your food chains together to try and make as complete a food web as possible. You can do this by rewriting and connecting your individual food chains on the large piece of poster paper, on the board, or even outside on the pavement with chalk if you have the room.

Food Web Challenge:

For an extra challenge, have the students label the consumer level(s) of your class food web as primary consumers, secondary consumers, tertiary consumer, quaternary consumer, etc.

*Note- if you choose to do this challenge you may find that organisms that the omnivores in the class food web can be labeled as more than one type of consumer. For example, if a bear is eating berries, the bear would be a primary consumer, but if in your class food web someone had a food chain where the bear was eating bees, the bear would be a secondary consumer as well. In real-world food webs, omnivores often sit in more than one consumer level at the same time as it all depends on what they are eating! Omnivores are not the only organisms that can sit at one level. Depending on what the carnivore is eat it may sit at more than one level in your food web too! For example, seed is eaten by a mouse (primary consumer), the mouse is eaten by a hawk (secondary consumer). But a mouse can also eat a grasshopper (primary consumer), this means the mouse is also a secondary consumer and the hawk is then a tertiary consumer!

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Deeper Learning Opportunity: Exploring Carrying Capacity

Objectives and Virginia Standards of Learning

The students will be able to:

- explain the effects of resource availability on organisms and populations in an ecosystem (L.S. 6 b) (BIO. 7 b, 8 a)(ENV. III a, b) (Ec. 6, 9)
- analyze and interpret data and graphs about the effects of resource availability on populations of organisms (carrying capacity) in an ecosystem (LS.6 a) (BIO.8 a) (ENV. III a, b) (Ec. 6)
- predict the effect of limiting factors on populations in an ecosystem (LS.6 b) (BIO.8 a) (ENV. III a) (Ec. 6)
- argue, citing evidence, that changes to physical or biological components of an ecosystem affect populations (L.S. 8 b) (BIO. 8 a) (ENV. III a, b) (Ec. 6)
- describe ways that human interaction has altered habitats positively and negatively (L.S. 9 a) (BIO. 8 d) (ENV. V a) (Ec. 11, 13)

White-tailed deer may garner more interest than any other wildlife species in Virginia. Today, many Virginians relish the chance to hunt, watch, or photograph this popular and widespread herbivore. However, did you know that white-tailed deer were once on the verge of extinction in Virginia in the early 1900's?

Under perfect conditions, white-tailed deer populations can double in size each year. Deer populations can grow rapidly because does, or female deer, breed early (generally at 1 year-old), have twins most years, and continue to breed into old age (often 8-10 years). With no predator, a deer population will expand to the point where some resource, generally food, becomes limited. Deer have few natural predators in Virginia, and other sources of mortality like disease or injury do not typically have a large impact on the population. However, for as long as humans and white-tailed deer have existed in the same habitat, white-tailed deer have been harvested for their meat, hide, and sinews (cordage).

While having a small overall impact to Virginia's state-wide white-tailed deer population, the local indigenous tribes that lived in Virginia prior to 1600 did impact local deer populations. The combination of indigenous hunting and natural fluctuations in the deer population, due to limited resources, indigenous people may have had to travel further to harvest animals. However, the real impact to Virginia's white-tailed deer occurred after Europeans settled in Virginia.

Records indicate that when the first European settlers arrived in North America in 1607 at Jamestown Island, Virginia white-tailed deer were present statewide. The exact number of deer that inhabited the Commonwealth of Virginia at the time of European settlement is unknown but is estimated to be between 400,000-800,000 deer.

During the 300 years following European settlement, Virginia's deer population began to decline due to over-harvest and habitat loss due to deforestation and the conversion of land to agriculture. At first the Europeans' harvest of white-tailed deer was for survival, providing essential food and clothing. In addition to harvesting for essentials, overtime the commercial trade in deer hides increased heavily, with approximately 14,000 deer hides being exported to Europe every year between 1698 and 1715. Market hunting, or hunting with the intent to sell the animal, also increased. One market hunter in northwestern Virginia was reported to have killed over 2,700 deer prior to 1860.

Knowledge Check: What human activities caused the decline in Virginia's white-tailed deer population?

Over-harvesting (for consumption, market hunting, and hide trade) and habitat loss (deforestation and conversion to farmland)

Settlers noticed the deer population decreasing over time and attempted to stop the overharvesting. Beginning in 1699, Virginia was one of the first colonies to establish a closed season, or time of year you could not harvest deer. However, from August 1st to January 31st, Virginians could harvest an unlimited number of deer. It wasn't until 1738, that additional regulations were put in place to establish separate buck and doe seasons; unfortunately, there were not enough officers, especially in the western frontier, to enforce these regulations. Market hunting continued until the passage of the federal Lacey Act in 1900, which outlawed the buying and selling of wildlife taken illegally.

Knowledge Check: Why do you think the deer populations kept decreasing from 1699 to the early 1900's, even though the colony of Virginia enacted strategies like a closed season and separate buck and doe seasons?

These strategies were not well-enforced, regulations do not have an impact without enforcing them.

By the 1900's, the deer population in nearly all of Virginia's Mountain and Piedmont regions had been destroyed. Virginia's white-tailed deer population was estimated to be below 50,000. White-tailed deer were not the only species suffering from overharvesting and habitat destruction; black bear and turkey populations were at their lowest during this time as well. To combat the extinction of these game species, in 1916, Virginia established the Virginia Game Commission (now known as the Department of Wildlife Resources or DWR) and tasked them with restoring and regulating the population of white-tailed deer, among other species.

Since DWR's founding, the white-tailed deer population has rebounded. DWR initially started with protective game regulations and effective law enforcement of these regulations. From 1926 -1952, DWR also relocated white-tailed deer from more than 11 states to the mountains of Virginia, see Figure 1. During this time white-tailed deer habitat also improved due to reforestation efforts and farm abandonment. These efforts combined led to exponential growth in the deer population until the late 1990's, see Figure 2.

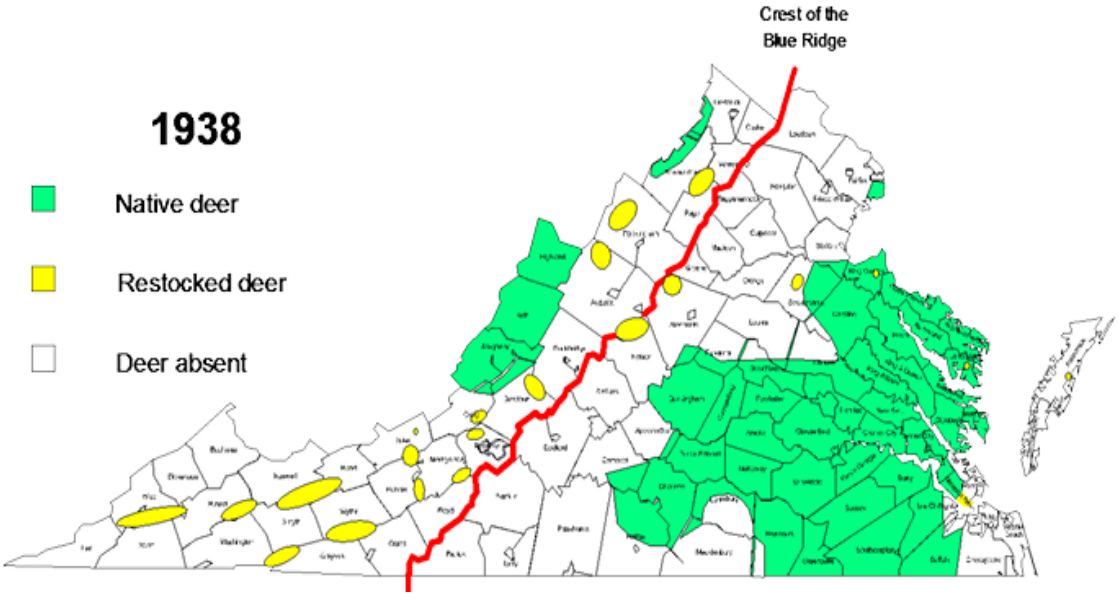
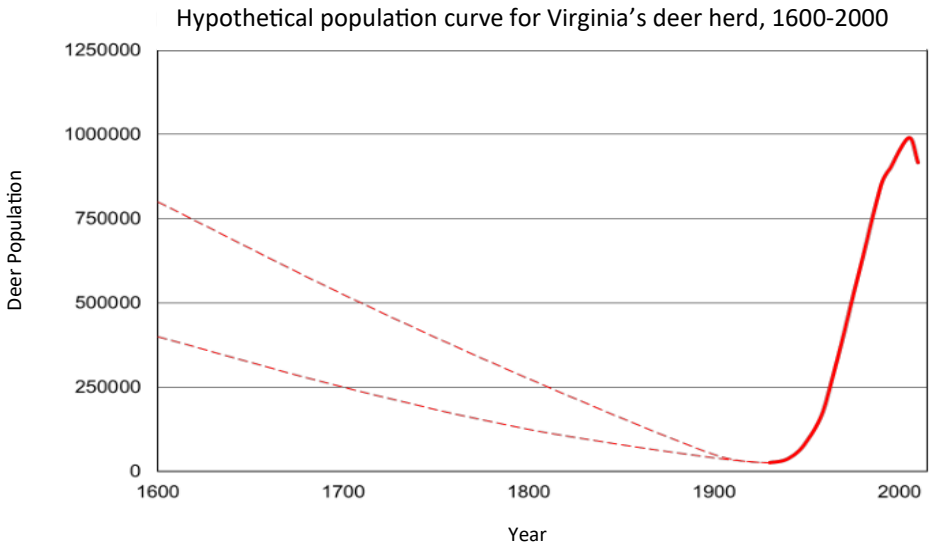


Figure 1 Virginia deer distribution in 1938



Year	Approximate Number of White-tailed Deer in Virginia
1600	400,000-800,000
1931	25,000
1950	150,000
1970	215,000
1980	422,000
1987	575,000
1995	950,000
2000	1,000,000

Figure 2 Hypothetical population curve for Virginia's deer herd, 1600-2000

Today, white-tailed deer in Virginia are considered fully restored across the Commonwealth and DWR's management of the deer population is guided by sound science, public input, and the Virginia Deer Management Plan. This plan incorporates the white-tail deer's optimum **biological carry capacity** (BCC) as well as considering the number of deer the human population of Virginia can tolerate, also known as **cultural carrying capacity** (CCC). When studying carrying capacity in school we often think about animal populations according to their biological carrying capacity and this is important to consider. However, in the real-world, the cultural carrying capacity must also be considered and reflected in how populations are managed.

In textbooks, we see carrying capacity represented in graphs by a dotted line as in Figure 3. This line represents the populations biological carrying capacity. Typically, as shown in Figure 3, a population fluctuates above and below the biological carrying capacity over time depending on the amount of resources (water, food, etc.) in the environment. If the environment drastically changes, a population's carrying capacity in that environment can change in response.

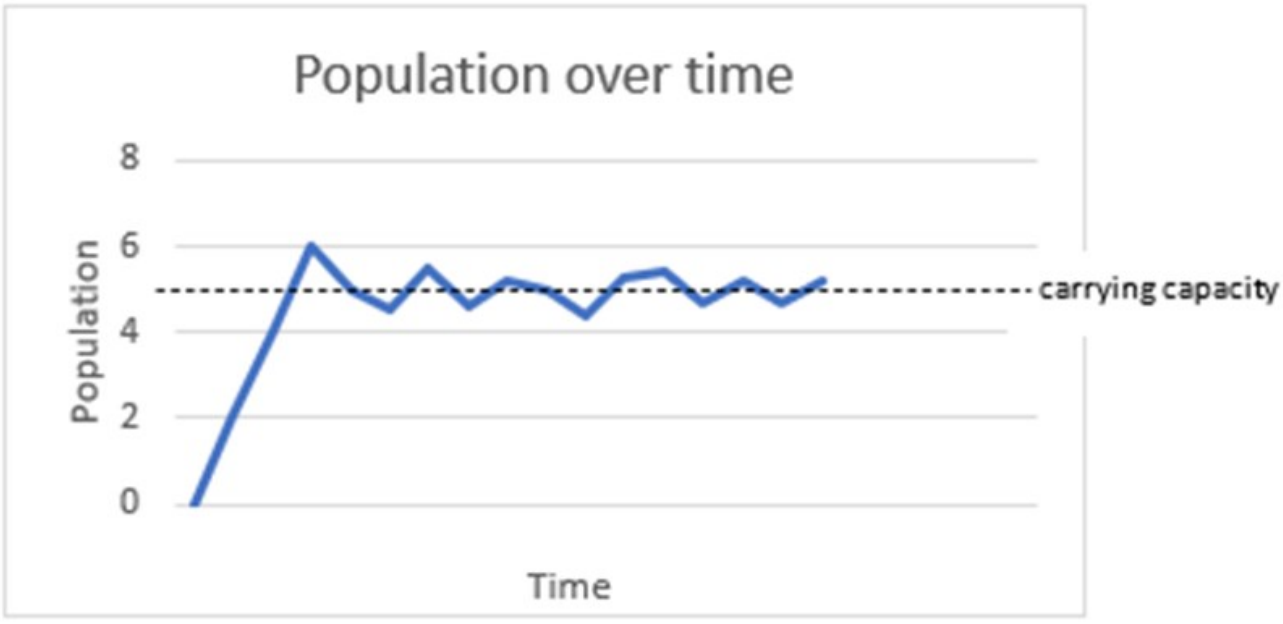
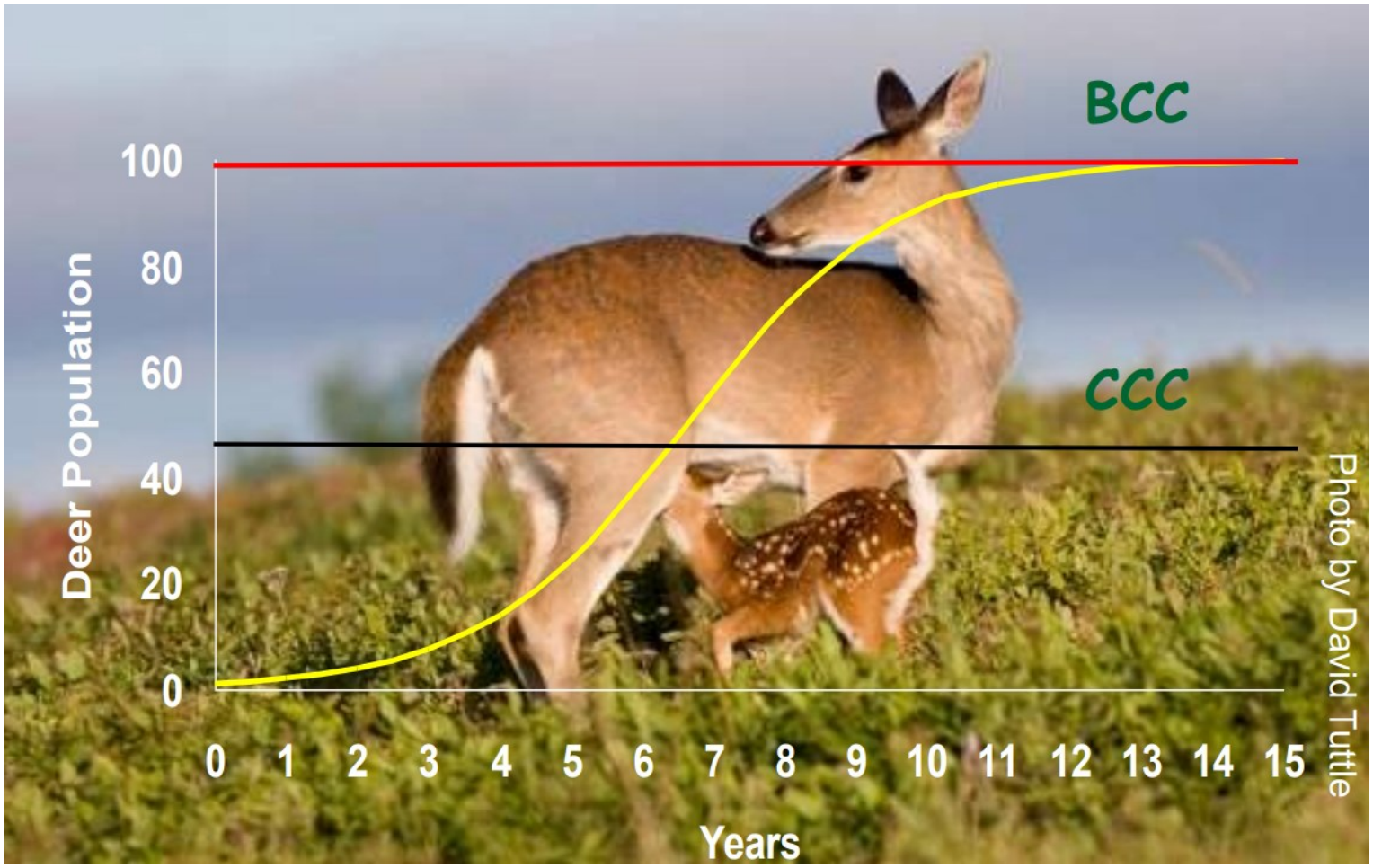


Figure 3 Population growth over time with biological carrying capacity labeled

Knowledge Check: What is biological carrying capacity based on? What is cultural carrying capacity based on?

Biological carrying capacity is based on the quality/amount of resources in the habitat needed to sustain the population. Cultural carrying capacity is based on the number of individuals of a population the human population can tolerate. CCC is often determined by surveying the human population.

Analysis Questions:



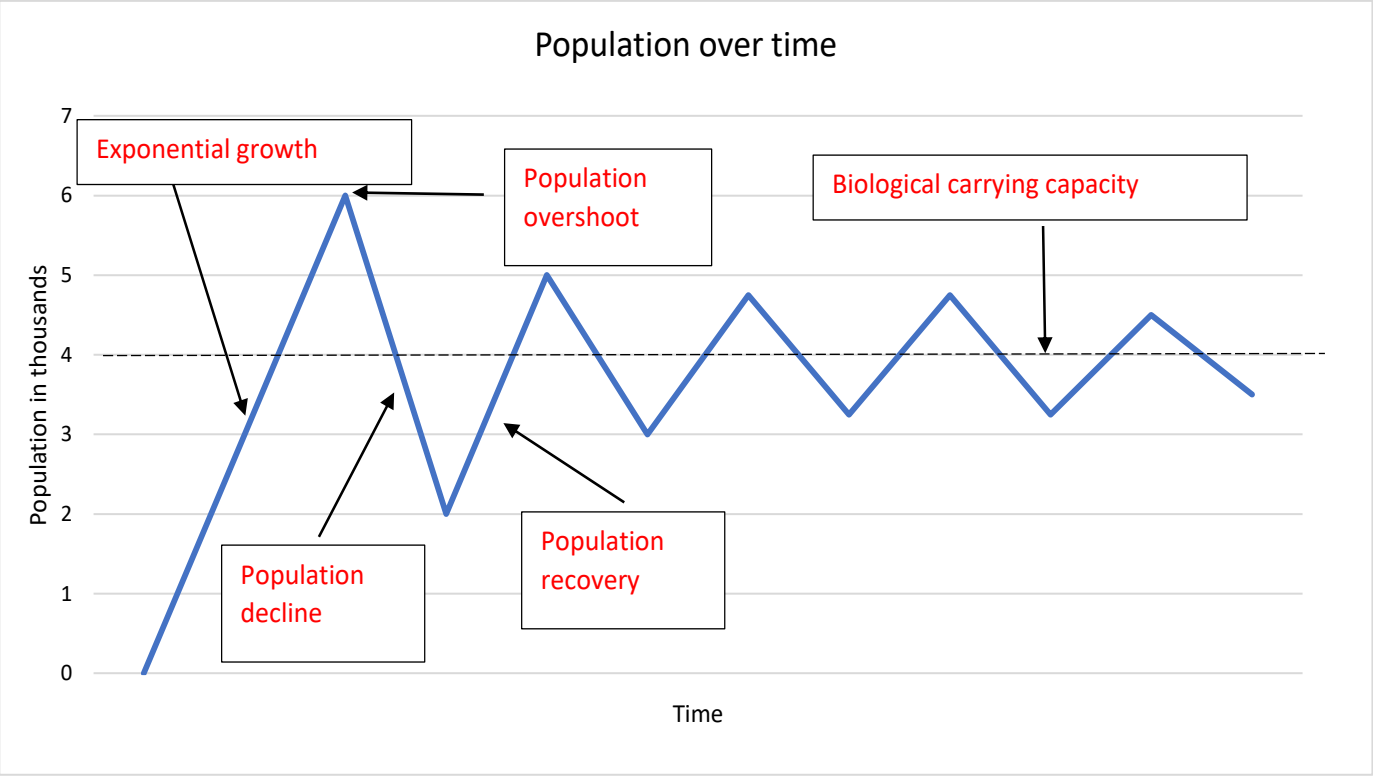
1) This graph is showing deer population growth over time with biological carrying capacity (BCC) and cultural carrying capacity (CCC) labeled. According to this graph, which is larger, the deer population's biological carrying capacity or the cultural carrying capacity?

The deer's biological carrying capacity tends to be larger. In this case, the environment can tolerate a larger number of deer (biological carrying capacity) than the people (cultural carrying capacity) of this area.

2) Label each of the blanks on the graph with the following stages of a population growing rapidly then responding to the biological carrying capacity of the environment.

Population overshoot **Biological carrying capacity** **Population decline**

Exponential growth **Population recovery**



3) If the quality and amount of resources in the environment decreases drastically, would the biological carrying capacity of the population living there likely increase or decrease and why?

The biological carrying capacity of the population would likely decrease if the resources continued to decrease. This is because biological carrying capacity depends on the quality/amount of resources in the environment.

4) List 2 examples of resources in the environment that could impact a population's biological carrying capacity.

Water, space, nutrients, food, mates (these resources are called limiting factors because they limit a populations biological carrying capacity)

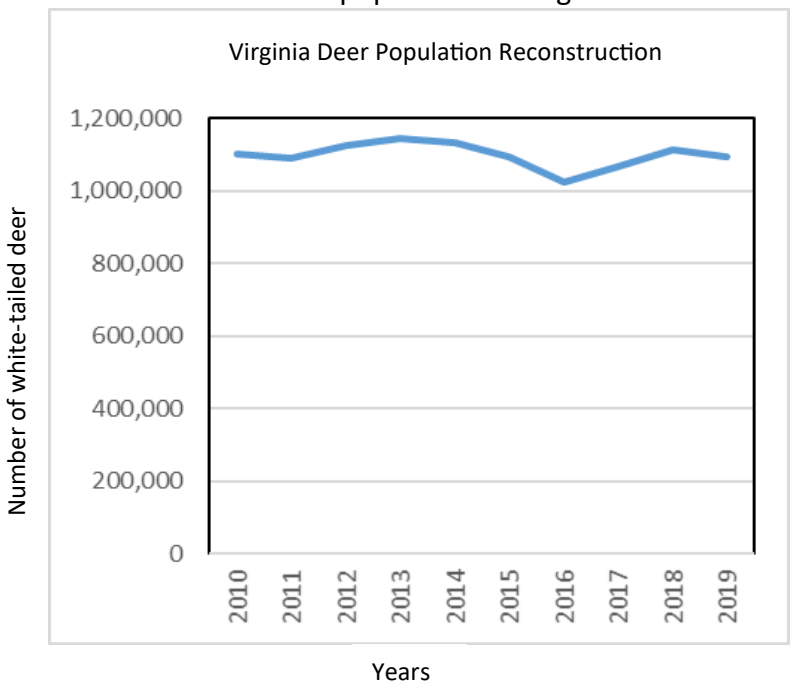
5) If a population is greater than its biological carrying capacity for a long time, what can that do to the available resources in the environment and what would most likely happen to the population?

If the population stays above its biological carrying capacity for too long, the resources in the environment will decrease. When those resources decrease so will the population as the environment can no longer sustain them.

6) What happens to the population of a species after it reaches its biological carrying capacity? Use the reading and the graphs in this activity to help you answer

The population often fluctuates above and below the carrying capacity over time. Some years it will be above the BCC, other years it will be below. These fluctuations are not large and are the population responding to the environment

7) The graph below shows a reconstruction of the population of white-tailed deer in Virginia from 2010-2019. The numbers represent DWR's working goal towards cultural carrying capacity of the white-tailed deer population in Virginia. What do you believe is the cultural carrying capacity DWR is working towards based on the data below for the white-tailed deer population in Virginia?



Based on the graph above, the cultural carrying capacity is likely between 1,000,000 and 1,100,000 deer in Virginia.

For more information about DWR's Deer Management Program please visit https://dwr.virginia.gov/wildlife/deer/

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