I will be collecting this assignment on the second day of classes. Please print this out and fill in your answers so that it can be collected on the second day of classes.





Illustration by Julia Zeman

Introduction

The American chestnut (*Castanea dentata*) was a keystone species in the ecology of the Appalachians. American chestnut trees once dominated the forests of the eastern United States, with an estimated 4 billion trees from Maine to Mississippi and Florida. It is estimated that 25% of the trees in the Appalachian Mountains were American chestnuts. They could grow up to 120 feet tall and 5 feet in diameter. They were awe-inspiring, the redwoods of the east coast, but with the bonus of edible nuts. Chestnuts were roasted, ground into flour for cakes and bread, and stewed into puddings. The leaves of the trees were boiled down into medicinal treatments by Native Americans. American chestnuts were nearly a perfect food source for both settlers and their livestock, as well as an array of wildlife from turkeys to bears. They are high in fiber, vitamin C, protein, and carbohydrates, and low in fat. Additionally, American Chestnut trees blossom relatively late, making their nut crop more reliable because it does not get harmed by the late frosts that often diminish the mast crops of oaks and hickories.

In the first 40 years of the 20th century, the pathogenic fungus chestnut blight (Cryphonectria parasitica) destroyed 3.5 billion American chestnut trees. What had been the most important tree in our Eastern forest was reduced to insignificance. No comparable devastation of a species exists in recorded history.

The first chestnut tree may have been infected as early as the 1890s, with chestnut blight first reported in 1904 when it was spotted on a tree in what was then the New York Zoological Park, now known as the Bronx Zoo, in the borough of The Bronx, New York City, by chief forester Hermann Merkel. The chestnut blight was accidentally introduced into North America on imported Asiatic chestnut trees. Merkel estimated that by 1906 blight had infected 98 percent of the chestnut trees in the borough. While Chinese chestnut trees evolved with the blight and developed a strong resistance, the American chestnut trees had little resistance, and most trees were killed by the chestnut blight before they reached 15 feet in height.

Panic over the chestnut blight was widespread by the 1910s. State commissions were created to study it and farmers were implored to chop down trees with any signs of blight. "Woodman, burn that tree; spare not a single bough," begged The Citizen, a paper from Honesdale, Pennsylvania. Even the Boy Scouts tried to save the American chestnut trees, scouring forests for blighted trees as part of an unsuccessful effort to create an infection-free zone. While all attempts to stop the chesnut blight ended in complete failure, the tree did not go extinct. The chestnut blight does not affect the root system, and American chestnut sprouts continue to rise again and again from the forest floor before succumbing to the blight, only to be followed by more sprouts.

Efforts to restore the American chestnut have been ongoing for over ninety years. Breeding programs that collect pollen from one of the few discovered mature pure-bred American chestnuts left in the forest and share it with other mature specimens have been attempted to promote natural resistance among existing American chestnut populations. Researchers with the American chestnut Cooperators Foundation oversee the crossing of surviving American chestnuts, and have yielded a number of progeny with low levels of blight resistance, but this process is painstakingly slow.

Another restoration effort is the development of blight-resistant hybrid American chestnut trees through the backcross breeding programs of the American Chestnut Foundation. The technique of using multiple backcrosses with the resistant parent started in 1981. The breeding program crosses American chestnut trees with Chinese chestnut or Japanese chestnut trees that are naturally resistant to the blight. After the initial hybridization, subsequent backcrossings with American chestnut trees progressively reduce the proportion of genetic material from the Asian parent, ultimately resulting in the third backcross hybrids (BC3 F1) that are 94 percent American chestnut but retain the genes for blight resistance.

Other scientists have discovered naturally occurring viruses in the forest that are, in effect, a blight of the chestnut blight, infecting it and weakening its destructive power. In Europe, such "hypovirulence" effectively stopped the blight from destroying that continent's chestnuts. Unfortunately, hypovirulence does not seem able to spread on its own in North America in the wild, which would be essential for it to bring back American chestnuts to the Eastern forest.

The newest effort is the development of a genetically modified version of the American chestnut that can survive the chestnut blight, by inserting a gene taken from wheat that protects against the fungus that causes the blight. Scientists at the State University of New York (SUNY) College of Environmental Science and Forestry hope to someday release it into the wild. If approved by federal agencies, it would be the first time a genetically modified organism would be intentionally set free into nature to reproduce.

'If America's beloved [American chestnut] tree can thrive again in the Appalachian canopy, it is because of those who neither accepted its demise, nor abandoned its story to legend." -Matt Collins

Watch: The Chestnut Tree: Bringing Back an American Icon at the following website: https://www.youtube.com/watch?v=-mhMdUryolU&feature=youtu.be

Figure 1. American Chestnut leaves, burs, and nuts



Source: Timothy Van Vliet, New Jersey



Figure 2. Historic range of the American Chestnut tree (Castanea dentata)

Source: American Chestnut Foundation

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Figure 3. Map depicting the spread of the chestnut blight

Source: American Chestnut Foundation

Questions

Describe how common American chestnut trees were in their native range prior to 1904 in terms of number, the percentage of trees that were American chestnuts, and geographic range.

How abundant are mature American chestnut trees now?

Describe what happened to the American chestnut tree.

Describe the ecological value of American chestnut trees.

Describe the economic value of American chestnut trees.

The airborne Chestnut blight spread up to 50 mi (80 km) per year in all directions after it was discovered at "ground zero" at the Bronx Zoo in New York City in 1904. If it traveled an average of 29.4 miles per year, estimate what year it reached one of the most distant areas of the American chestnut's former range 1,176 miles away in Kosciusko, Mississippi. Show all of your work and clearly label each step.

What efforts are currently underway to save the American chestnut tree?

Why are the remaining mature American chestnut trees so valuable?



Source: Denver Post

Go to <u>https://www.acf.org/resources/identification/</u> to find the information necessary to answer the following question:

The number of large surviving trees over 60 cm (24 in) in diameter within its former range is probably fewer than 100, but if you go hiking in the forest somewhere within the historic range of the American chestnut tree, there is a very small chance you might discover one. Let's assume you happen upon a tree in the forest that looks like it might be a mature American chestnut tree, and you are one of the few citizen scientists who is aware enough to take advantage of this once-in-a-lifetime opportunity. How can you distinguish an American chestnut tree from other closely related trees, such as Chinese, Japanese, and European chestnut trees?

Where do you think might be a good location to find mature, blight-resistant American chestnut trees? Justify your choice with evidence and reasoning.

Refer to the <u>Tree Locator Form</u> found at the end of the case study. What can you do if you find an American chestnut tree that will help ensure the future of the species? Ecologists use the term carrying capacity to define the maximum population of a particular species that a habitat can support over a given amount of time. American chestnuts are a favorite food for deer, as well as for squirrels, jays, quail, crows, woodpeckers, raccoons, rabbits, and foxes. If we collect 1,080,000 chestnuts per hectare and each chestnut weighs 2.65 g, how many kilograms of chestnuts are produced per hectare (2.47 acres)? Show all of your work and clearly label each step.

If each deer requires 3 kilograms of food per day, calculate how many deer each hectare of this forest could support for a year. Show all of your work and clearly label each step.

There are approximately 259 hectares per square mile. How many deer could a square mile of forest of mature American chestnut trees support for a year if they were the only organism consuming their nuts? Show all of your work and clearly label each step.

Let's assume that about 15% of the mast (tree nut) crop is eaten by other species that feed in the canopy of the trees. In other words, only 85% reaches the ground. Adjust your carrying capacity for a square mile of forest to reflect this assumption. Show all of your work and clearly label each step.

How would the presence of other animals that eat chestnuts from the ground further affect the number of deer the forest can support?

If you planted a chestnut orchard today, and in 20 years you were able to harvest 1,000 Kg/hectare each year, and you harvested and sold the chestnuts for \$12.50/Kg, how much money would you make each year per hectare from your chestnut trees? Show all of your work and clearly label each step.

American chestnut trees yielded lumber that was used to build homes, barns, furniture, cabinetry, and musical instruments. Historical accounts, and still existing wood products, provide solid evidence that its wood is light but strong, and resistant to rot. Let's assume you planted 60 American chestnut trees per hectare, and they would be harvested by your grandchildren at 75 years of age for lumber (after yielding chestnuts for many years), and each tree was valued at \$225 (in today's dollars). How much money would your grandchildren receive (in today's dollars) per hectare from the harvest?

Researchers at the State University of New York (SUNY) College of Environmental Science and Forestry have developed a genetically modified version of the American chestnut that can survive the chestnut blight. They inserted a gene that encodes an enzyme that essentially "detoxifies" the destructive acid emitted by the fungal infection. This wheat gene produces an enzyme called oxalate oxidase (OxO), which detoxifies the oxalate that the fungus uses to form deadly cankers on the stems. This common defense enzyme is found in all grain crops as well as in bananas, strawberries, peanuts and other familiar foods consumed daily by billions of humans and animals, and it's unrelated to gluten proteins. Scientists who advocate this approach argue that this is a minuscule alteration compared to the genetic alterations produced by traditional breeding methods. Genetic engineering allows us to produce a blight-resistant American chestnut that's genetically over 99.999 percent identical to wild-type American chestnuts. Scientists who oppose this approach argue that history has shown us that just because science can do something does not always mean it should. Our scientific and technological choices must be informed by broader ethical, health and environmental considerations, and in this case, there is some risk the first time a genetically modified organism would be intentionally set free into nature to reproduce. Genetic modification may offer modern solutions to modern ecological challenges; however, the technology may also pose ecological threats. Perhaps the threat that incites the most concern is gene flow from transgenic trees to sexually compatible wild trees. For example, if a transgenic poplar tree modified for increased insect resistance pollinated a compatible wild poplar tree, the transgene may be present in the resulting progeny. This would be particularly worrisome if the escaped gene gave its host a competitive advantage over other trees, which also raises concerns about the potential for genetically modified trees to become a new invasive species. In the case of chestnut, it will actually be the goal for the transgenic tree to reproduce with the wild American chestnut, to increase genetic diversity of the transgenic trees, while also disseminating the transgenes that confer blight resistance. Other potential risks of genetically modified trees include unintended impacts on other organisms. Do you support the release of a genetically modified version of the American Chestnut into the wild? Defend your position with evidence and reasoning.



Source: National Oceanic and Atmospheric Administration

The American chestnut tree could play a key role in the battle against rising atmospheric CO_2 levels by taking atmospheric carbon and turning it into a compound that is stored in the tree. In general, the faster a tree grows, the more carbon it is able to sequester, and even when trees are harvested and processed, the carbon can be stored in the hardwood products for centuries. The American chestnut grew much faster and larger and lives longer than the trees that have replaced it in the forest of the Eastern U.S. following the chestnut blight. Worldwide, trees store a sixth of the CO_2 emitted each year, but they could be managed to store much more. State whether you think restoring American chestnut trees to the Eastern deciduous forest is a viable carbon sequestration strategy and justify your position with evidence and reasoning.

Task Verb	Student-Friendly Definition
Calculate	Set up and complete a math problem. Include units and show step-by-step work.
Describe	To give a picture or offer characteristics of something in words. Usually 2-3 sentences.
Explain	Provide cause and effect relationships or a step-by-step explanation. Connect the dots and circle back to the prompt. Usually 3-5 sentences.
Identify	Name, list, and/or give an example. A simple response, usually 1 sentence maximum and with no elaboration.
Justify	Use evidence and explain how the evidence supports the claim. 3 - 5 sentences.
Make a Claim	Pose a 1 - 2 sentence statement that is open to challenge yet based upon scientific knowledge or provided information.
Propose a Solution	Explain how you could solve a problem and use evidence to support your proposal.

Free-Response Question Tips:

- 1. Circle the task verb.
- 2. Underline specific scientific vocabulary.
- 3. Carefully differentiate between the 3 E's (Ecological, Economic, and Environmental) and Human Health when answering a question.

Ecological	The effect that something has on living organisms and their nonliving environment. Ecology tends to focus on very specific populations of living things.
Economic	Related to finances, money, income, costs, subsidies, taxes, or jobs.
Environmental	A broad term that includes many areas of the earth and life sciences. Includes ecology but is more overarching than ecology.
Human Health	Related to human physical, mental, or social well-being, disease or injury.