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The Friends of Flight 93 National Memorial is the official 501(C)3 non-profit representing Flight 93 National Memorial in partnership with the National Park Service. The Friends created these lessons and activities for teachers and parents to teach children (or themselves!) about the role trees play in the world around them and how trees are essential at Flight 93 National Memorial and incorporated as part of the design.

For over a decade, the National Park Service, Friends of Flight 93 National Memorial, and National Park Foundation have partnered to continue a significant reforestation project that will soon result in 150,000 newly planted trees at Flight 93 National Memorial. This conservation project is part of the memorial's original design. The project's goal is to reclaim the former surface mine with native trees to re-establish wildlife habitats, create essential windbreaks and establish the healing of the memorial landscape.

The reforestation project has been a collaborative partnership that is shared by state and federal government agencies and both private and academic organizations. More than 5,000 volunteers over the past nine years have made this project possible. Since the beginning of the plantings in 2012, 193.2 acres have been reforested. The earliest planted trees have grown upwards of 8-feet tall to form a windbreak for the 40 Memorial Groves. Much of the land now part of the memorial is a former surface coal mine, and this effort has also re-established woodland wildlife habitats and cultivated a living memorial. Planting 38 native tree species has attracted 63 native bee species and 141 native bird species.

Several [passengers and crew members](#) on United Flight 93 were passionate about the environment, and a handful was traveling for personal trips that involved the outdoors. Alan Beaven was an ardent environmental litigator who prosecuted Clean Water Act violators. Richard Guadagno spent 17 years in environmental protection as a U.S. Fish & Wildlife Service member. Christine Snyder was an arborist and worked for The Outdoor Circle, Hawaii's oldest non-profit environmental group. Four passengers traveled to Yosemite National Park (William Cashman, Patrick Driscoll, Donald & Jean Peterman) to hike and enjoy the beauty. Donald Greene traveled to Lake Tahoe for the same reasons.

The living memorial landscape at Flight 93 National Memorial is restored; we honor all 40 passengers and crew members. The Friends of Flight 93 National Memorial website provides a wealth of additional information about 9/11, the story of Flight 93, and Flight 93 National Memorial. We encourage you to explore this online learning tool for further education resources at <https://www.flight93friends.org/>.

# What's Eating the Trees?

Students will explore the invasive insect Hemlock Woolly Adelgids and the threat they pose to forests in Pennsylvania. Students will explore the concept of invasive species via plant and animal adaptations, adaptation's role in ecosystems, and forest management practices. An extension lesson is included that focuses on forest-based careers. Each lesson should take approximately 30-40 minutes to complete.

**Unit goal:** Introduce students to the Woolly Adelgid Beetle and its role in the decreasing presence of Eastern Hemlock Trees in the United States.

## Lesson One

### Introduction

Students will be learning about an invasive species called a Hemlock Woolly Adelgid, which is threatening to kill the Eastern Hemlock Trees at the memorial. **Ask: Does anyone know what an invasive species is?** If students do not know, tell them that they'll find out shortly.

### Invasive Species Tag

**Goal:** Introduce students to the invasive species concept and the possible effects on native wildlife.

#### Next Gen Science Standards

- Middle School: MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS4-4
- Highschool: HS-LS2-6

#### PA SAS Standards

- 3.1.B.C2., 4.1.7.A., 4.1.10.A., 4.1.10.B., 4.5.6.D.

**Time:** 15 minutes

Game instructions:

1. Divide students evenly into three groups: grass, rabbits, wolves.
2. Wolves can tag rabbits, rabbits can tag grass, and grass can tag wolves.
3. When tagged, students must remain frozen (AKA eaten) for 30 seconds and then become the organism that tagged them. (Example: a wolf tags a rabbit. The rabbit is frozen for thirty seconds and then become a wolf who can tag rabbits).
4. Students will call out the name of their assigned group as they go, so it's easy to tell who is a wolf, a rabbit, or grass.
5. Remind students that this game is for fun, and you trust they will follow the directions and call out their organism and count to 30 before they start playing again.
6. The group with the most at the end of the round will be the winner. Let students play until their enthusiasm drops and then halt that round.

**Ask: How was your eco-system? Did it stay relatively balanced? Was it easy to tell who won that round?**

Tell students that you're going to see what happens when you introduce an invasive species to the ecosystem. Have students return to their original groupings. To alter the game, further **divide the rabbit group into two groups: rabbit and invasive**. Explain that a new animal that's like a rabbit has come into the park. It also likes to eat grass and the wolves don't like how it tastes, so it has no predators. You're not sure how they got here; maybe pet owners released them into the wild or a hunter brought them into the forest so they could hunt them. **Invasives can tag grass, but wolves cannot tag invasives**. The rest of the players roles remain unchanged. Play another round. Let the game continue until the invasives dominate the ecosystem.

**Ask: What happened this time? How did the ecosystem handle the introduction of the invasive species? Now that you've played this game, what do you think an invasive species is? How does introducing invasive species affect populations of other animals?**

Discuss with students that what makes invasive species so successful is their adaptations. Does anyone know what an adaptation is? It is a trait that an animal acquires over time that helps them survive.

- What might a rabbit's adaptation be? Its ears help them hear well and avoid predators.
- What might a wolf's adaptation be? Its nose helps it detect prey.
- What might grass' adaptation be? Some kinds of grass might taste bad so that some animals won't eat it.

In a healthy ecosystem, organisms' adaptations are in sync, so that the ecosystem stays relatively balanced, like in the first round of tag. When an invasive species arrives in the ecosystem, it has adaptations that are like an animal already present in that ecosystem, but its predators and prey aren't adapted to it. This means that it can be super successful - like the second round of tag - and take over the whole ecosystem.

Inform students that they will be learning more about the Woolly Adelgid (the invasive species) soon, but first must understand more about the Eastern Hemlock Tree and why it's important.

### **Hemlock Adaptations**

**Goal:** Students will explore adaptations, specifically those of the Eastern Hemlock Tree.

#### **Next Gen Science Standards**

- Middle School: MS-LS4-4, MS-LS2-5
- Highschool: HS-LS4-4

#### **PA SAS Standards**

- 3.1.7.A1, 4.1.12.A., 4.5.7.D.

**Time:** 20 minutes

**Materials**

- Photos of hemlock adaptations OR proximity to a hemlock tree

The Eastern Hemlock is a tree native to this area of Pennsylvania. This tree species can grow very tall (the tallest recorded was 174 feet tall, and very old). The oldest known tree is here in Pennsylvania and is over 500 years old, meaning this tree would have been a sapling when Columbus first came to America in 1492!

Hemlocks provide many ecosystem services including cooling the forest floor, providing shelter in the winter, and keeping stream banks from washing away. They also contribute to the forests' biodiversity.

**Ask: Does anyone know what biodiversity is? A forest with lots of biodiversity means that lots of different varieties of plants and animals in the forest. The greater number of different kinds of creatures, the healthier the forest because it can adapt to change.**

Show students photos of the Eastern Hemlock Tree and have them guess what adaptation is associated with that image. If you can be near an Eastern Hemlock Tree, point out adaptations on the tree instead. Tell them that the key is to remember that hemlocks are alpine, cold weather trees. Give hints as needed, but don't make it too easy.

- Photo of bark – thick bark to provide protection from winter cold
- Photo of tree shape – cone shape helps the cone shed snow
- Photo of cones – protect seeds during the winter
- Photos of needles – needles are waxy to prevent water loss and green to let them photosynthesize all year long
- Photo of roots – shallow roots because water is always close to the surface where they live

**Wrap Up:** Why do adaptations make invasive species so dangerous to native species and ecosystems?

Optional Closing Activity: How many other adaptations can you think of based on the other plants and animals that you've seen or heard about in the past? Make a list of all the adaptations. If time allows, you can put students in groups and have a race to see which group comes up with the most unique adaptations.

## Lesson Two

### Build an Adelgid

**Goal:** Students will explore how Woolly Adelgid adaptations make this insect a highly successful predator of the Eastern Hemlock Tree.

#### Next Gen Science Standards

- Middle School: MS-LS4-4
- Highschool: HS-LS4-4

#### PA SAS Standards

- 4.5.6.D.

**Time:** 30-40 minutes

#### Materials

- Scratch paper and writing implements, as needed
- Photo of Hemlock Woolly Adelgid

Students may work independently or in groups, depending on class numbers and characteristics of students. Now that students know Eastern Hemlock Tree adaptations, you have a challenge for them. First, students must decide what a Woolly Adelgid looks like individually, based on what they know about hemlocks. Students should spend some time thinking about what kinds of adaptations an Adelgid might need to feed and live off a hemlock. Where the tree could be vulnerable. Where and how might it eat the tree? How does it stay attached? How does it deal with a cooler climate? How might it lay its eggs?

When students seem like they're wrapping up their drawings, ask for a few volunteers to share their creations and explain why they chose to make their adelgids the way they did.

If there is extra time, or some students finish early, challenge students to create a completely new creature from scratch, based on an environment of their own choosing. They can consult the list from the last lesson if they need ideas.

Once students finish, share a photo of the adelgids and explain their adaptations. Woolly Adelgids arrived in Virginia in the 1950's from Japan. They likely came over on plants meant to go into people's gardens. They are a kind of aphid and are very, very tiny. When selecting a host site, they go for the base of the needle where they use their long mouth parts to steal the trees nutrients. They lay their eggs in woolly masses on needle tips. Once infested, the tree's health declines, and it will die anywhere from 4 to 10 years later.

**Wrap Up:** What did you think when you saw the real Hemlock Woolly Adelgid? What surprised you about the insect? Why is it important to stop the spread of this insect?

## Lesson Three

### Getting Rid of Adelgids

#### For Middle School Students

**Goal:** Students will compare and contrast solutions for managing the Woolly Adelgids and present findings of their preferred treatment method.

#### **Next Gen Science Standards**

- MS-ESS3-3, MS-ETS1-2

#### **PA SAS Standards**

- 4.5.7.B

#### **Materials**

- Scratch paper and writing implements, as needed
- Control Methods handout (1 per group)

**Time:** 25-30 minutes

Forest managers are working diligently to figure out how to stop the Woolly Adelgids and save the Eastern Hemlock Trees. For the rest of the class period, students will be the forest managers and decide on how to best protect the hemlocks here at the memorial.

#### **Instructions:**

1. Divide students into groups of 4-5 and give each group a handout.
2. Students must decide on the best treatment plan for the Eastern Hemlocks here at the memorial.
3. Students will analyze the pros and cons for each of the treatments and decide which treatment should be used and why.
4. Students will read through the handout and make a list of the pros and cons of each method. They are also allowed to research information outside of the handouts.
5. Encourage them to think of BOTH negatives and positives for each method that may not be directly stated on the handout.
6. Upon completion, students will report on which one treatment their team thinks best and why.
7. Have the class vote on the method they like the best.

#### For High School Students

**Goal:** Students will compare and contrast solutions for managing the woolly adelgids, create a plan for managing the insect in the park, and present their findings.

## Next Gen Science Standards

- HS-ESS3-4, HS-LS2-7

## PA SAS Standards

- 4.1.12.B, 4.1.12.C, 4.3.10.A, 4.5.12.B

## Materials

- Scratch paper and writing implements, as needed
- Control Methods handout (1 per group)

**Time:** 25 - 35 minutes

Forest managers are working diligently to figure out how to stop the Woolly Adelgids and save the Eastern Hemlock Trees. For the rest of the class period, students will be the forest managers and decide on how to best protect the hemlocks here at the memorial.

## Instructions:

1. Divide students into groups of 4-5 and give each group a handout.
2. Students need to come up with a treatment plan for the hemlocks here at the memorial.
3. Students will analyze the pros and cons for each of the treatments and decide on one method of control. (\*\*If you plan on utilizing the extension activity, it is recommended that you assign methods of control, so that each group has a different one.)
4. Students are permitted to research information addition to the handouts.
5. Each group's presentation must address why they chose their plan, any cost, safety, reliability and aesthetics constraints, and potential impacts on the environment and humans.
6. Groups will present their plan to the class.

**Wrap Up:** Wrap up the lesson by asking the following questions. If there's enough time, allow everyone to quickly answer. If not, choose a few students to answer.

- What is one new thing you learned today? What's something that you can do to help stop the spread of Hemlock Woolly Adelgid?

## Extension for 11-12<sup>th</sup> grade

Note: This extension activity will add 20 – 30 minutes to the activity, so it may need to take place over two class periods. Students can prepare in one class period and debate in the next.

Instead of having students only present information to the rest of the class, students will role play a landscape treatment representative attempting to sell their services to the National Park Service. The presentation should include how and why their method is better than other methods of control.

Round One: Each group will present their method of control as persuasively as possible. Students may nominate a group leader for their presentation or may share the speaking role among the group.

Round Two: Each group gets one minute to respond to points raised by other groups or add any additional points.

After each group has finished their second round, the class will vote as to which group was most persuasive.

**Wrap Up:** Wrap up the lesson by asking the following questions. If there's enough time, allow everyone to quickly answer. If not, choose a few students to answer.

- Do you agree with the group's decision on a Woolly Adelgid control method? Why or why not?





Photo by Nicholas A. Tonelli

Eastern Hemlock Tree: BARK



Photo by Nicholas A. Tonelli

Eastern Hemlock Tree: NEEDLES



Photo by Nicholas A. Tonelli

Eastern Hemlock Tree: CONES



Photo by John Chao (hemlock is on the right)

Eastern Hemlock Tree: ROOTS



Photo Credit: Dan Nydick

Eastern Hemlock Tree infested with Hemlock Woolly Adelgid Beetles & Egg Nests



Mark Whitmore, Dept. of Natural Resources, Cornell University

Woolly Adelgid

# Methods of Controlling Hemlock Woolly Adelgids

## Cultural Control

Cultural control means limiting people and animals that can spread the adelgids. These methods should be practiced from March through July because that is when the insect matures, and adults begin spreading out from where they were born. Because birds, squirrels and deer can all spread the insect, these animals should be kept away from hemlocks when possible. An example would be removing bird feeders from hemlock trees in the spring and summer. Care should also be taken when moving any wood or other objects from areas with adelgids into areas without them. Always clean vehicles, clothing, etc., after visiting forests, recreational areas, parks, or other properties with infested hemlocks. Trim hemlock branches, both with and without adelgids, that may touch hikers, campers, or delivery trucks. Never move live hemlock trees from infested areas.

## Mechanical Control

Mechanical control means that people use tools to get rid of adelgids. Trimming twigs from branches will reduce the number of insects. These branches should be put in plastic garbage bags, sealed tightly, and thrown away. Keep in mind that lots of trimming may make the tree not look as good and could make it weaker. Adelgids can fall off hemlock twigs in wind and rain, and most can't get back on the tree. Because of this, spraying a strong stream of water on branches April through July may help lower adelgids populations.

## Biological Control

Biological control means using another animal that eats adelgids to help control them. Several species of beetles can be used for this. Biological control can take time to help because predator insects must be released into an area and then be given time to increase their numbers. Once there are lots of the new insect, they can be very effective.

*Sasajiscymnus tsugae* are tiny, pinhead-sized, black lady beetles that were observed feeding on Hemlock Woolly Adelgids in Japan in 1992. These lady beetles only eat Hemlock Woolly Adelgid, Balsam Woolly Adelgid, and Pine Bark Adelgid. Each lady beetle larva eats approximately 500 eggs or 50 -100 immature adelgids, known as nymphs. The female lady beetles lay up to 300 eggs in March and April, during peak egg laying of Hemlock Woolly Adelgid. Adult ST beetles feed on dormant young adelgids during the summer. This lady beetle should not be viewed as a cure-all since its effectiveness is still in the testing stages. An additional problem with the lady beetles is that they love to eat Hemlock Woolly Adelgid eggs a little too much. If they cannot find enough eggs, they tend to not multiply as quickly and can fly off in search of more food.

## Chemical Control

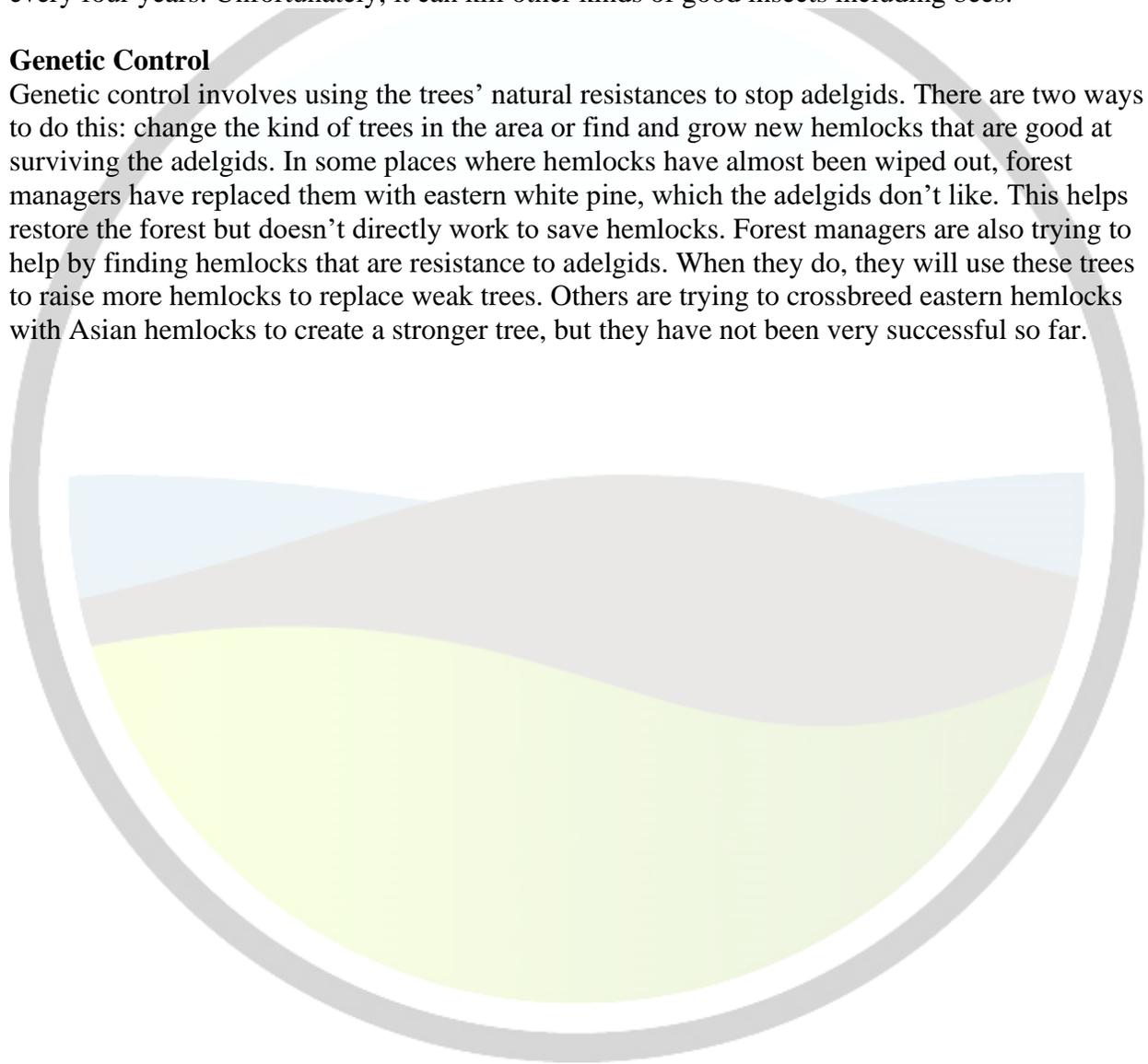
Chemical control means using pesticides to poison the adelgids. Other kinds of control can lower adelgid numbers on hemlock, but very sick trees usually get sicker and die without chemical

control. These treatments must be used continually, or the tree will be re-infested. It can be expensive to continue to use. Often, this method is only used for special or important trees, until biological control is established in an area.

There are several different kinds of pesticide available to treat adelgids. One method is to cover the trees in a special oil or soap. It is time consuming to cover a tree and must be applied once or twice a year but does not usually hurt other insects. The other option is a chemical insecticide that is injected into the tree or soil around it. It can be expensive but only needs to be repeated every four years. Unfortunately, it can kill other kinds of good insects including bees.

### **Genetic Control**

Genetic control involves using the trees' natural resistances to stop adelgids. There are two ways to do this: change the kind of trees in the area or find and grow new hemlocks that are good at surviving the adelgids. In some places where hemlocks have almost been wiped out, forest managers have replaced them with eastern white pine, which the adelgids don't like. This helps restore the forest but doesn't directly work to save hemlocks. Forest managers are also trying to help by finding hemlocks that are resistance to adelgids. When they do, they will use these trees to raise more hemlocks to replace weak trees. Others are trying to crossbreed eastern hemlocks with Asian hemlocks to create a stronger tree, but they have not been very successful so far.



## Classroom Extension Resources

Aquatic Invasive Species Education Project

<https://dnr.maryland.gov/wildlife/Pages/Education/Aquatic-Invasive-Species-Education-Program.aspx>

Hungry Pests

<https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/usda-efforts/educator-tools>

National Agriculture in the Classroom Invasive Species Curriculum

<https://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=151>

## References

Geography Revision – Coniferous Forests

<https://geography-revision.co.uk/gcse/ecosystems/coniferous-forests/>

PA DCNR – Hemlock Woolly Adelgid

<https://www.dcnr.pa.gov/Conservation/ForestsAndTrees/InsectsAndDiseases/HemlockWoollyAdelgid/Pages/default.aspx>

New York State – Hemlock Woolly Adelgid

<https://www.dec.ny.gov/animals/7250.html>

Forest Health Fact Sheet Hemlock Woolly Adelgid

[http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr\\_007179.pdf](http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_007179.pdf)

Maine Forest Service – Hemlock Woolly Adelgid

[https://www.maine.gov/dacf/mfs/forest\\_health/insects/hemlock\\_woolly\\_adelgid\\_fact\\_sheet.htm](https://www.maine.gov/dacf/mfs/forest_health/insects/hemlock_woolly_adelgid_fact_sheet.htm)

Hemlock Restoration Initiative – The Importance of Hemlocks

<https://savehemlocksnc.org/the-importance-of-hemlocks/>

# Who Works for the Trees?

**Goal:** Students will learn about careers based in forest management and will spend time exploring careers they may be interested in pursuing.

## PA SAS Standards

- 13.1.5.E, 13.1.5.F, 13.1.5.G, 13.1.5.H, 13.3.5.G

## Materials

- We are the Forest Service video (available here: <https://youtu.be/p1GDAN0M6u0> )
- Your Personality and Green Jobs Quiz
- Career Profile Sheets (1 of each sheet for each group) (available here: <https://pacificeducationinstitute.org/career-profile-cards/>)

**Time:** 30-40 minutes

Ask student how it felt when they were learning about Woolly Adelgid control methods and making decisions that could affect a whole forest. Let everyone in the group share a word or two.

Managing forests help keep them healthy, particularly when forests are close to where people like to live. Ask students why it is important to manage forests and make a list of their answers. Possible student responses such as: provide homes for plants and animals, keep wildfires from breaking out, forests provide places for recreation, humans use the wood for paper/homes/buildings, forests help keep air and water clean, etc.

Foresters are very important to managing forests but aren't the only ones who play a role in forest management. Many different jobs have a role in protecting our forests. Students will discuss careers in forestry and explore different careers in the field.

Play the short video. The US Forest Service helps to manage forests across the United States. This video introduces the many kinds of jobs and careers needed to support forest management: <https://youtu.be/p1GDAN0M6u0>

Ask students if they realized how many types of jobs were involved with forestry. Did they see any job that interested them? Students will explore forestry jobs that they might want to think about for the future. Distribute the "Your Personality and Green Jobs" sheets and instruct students to circle words in each column that they feel describes them and total up the number of words in each column. Upon completion, show students their quiz results.

Now that students have an idea of what kinds of jobs might suit their personalities, students will explore some jobs on their own. Break students up into groups of 3-4 people and pass out enough career profile sheets that everyone has 1-2 sheets. Students would spend some time looking through the sheets and selecting 1-2 careers they would be interested in pursuing. Students may conduct research on their phones or computers, focusing on jobs from the quiz results that may not be represented on the career profile sheets. Students will write down answers to the following

questions: 1) What makes this job interesting to me? 2) What do I like and dislike about it? 3) What skills, education, and training does this person require to be successful at this job?

**Wrap Up:** If there is time, allow each student to share the job they are interested in and why. If time is limited, choose a few willing students to share.

### **Classroom Extension Resources**

Work Wild – additional lesson plans  
<https://www.workwild.ca/>

Forestry Career Quiz  
<https://www.workwild.ca/career-profiles/>

Cool Jobs Video Series  
<https://www.worldsciencefestival.com/video/playlists/cool-jobs/>

### **References**

US Forest Service “We are the Forest Service” Video  
<https://youtu.be/p1GDAN0M6u0>

Project Learning Tree Green Jobs Unit  
<https://shop.plt.org/Shop/ProductDetails/green-jobs>

Career Profile Sheets  
<https://pacificeducationinstitute.org/career-profile-cards/>