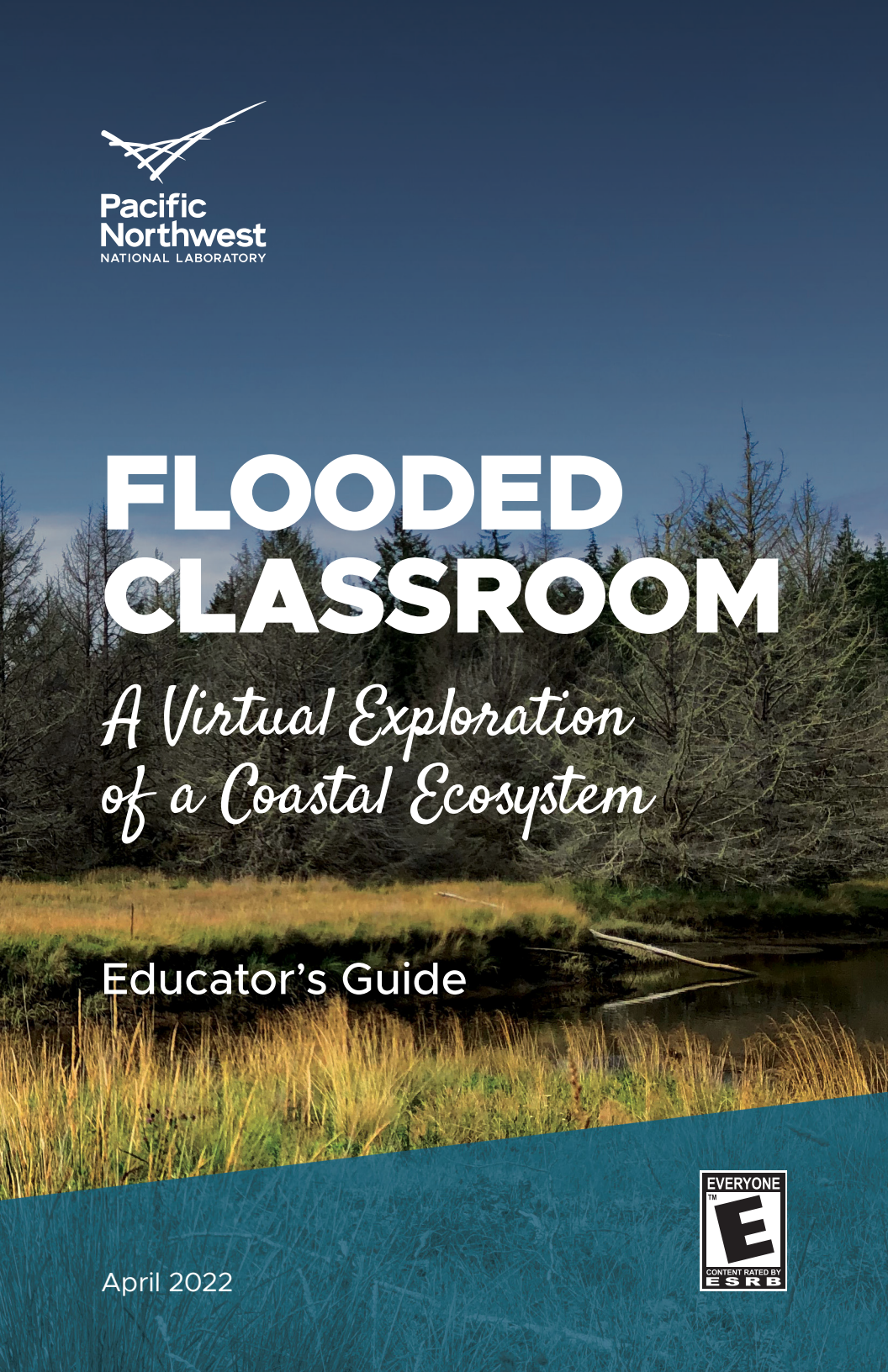
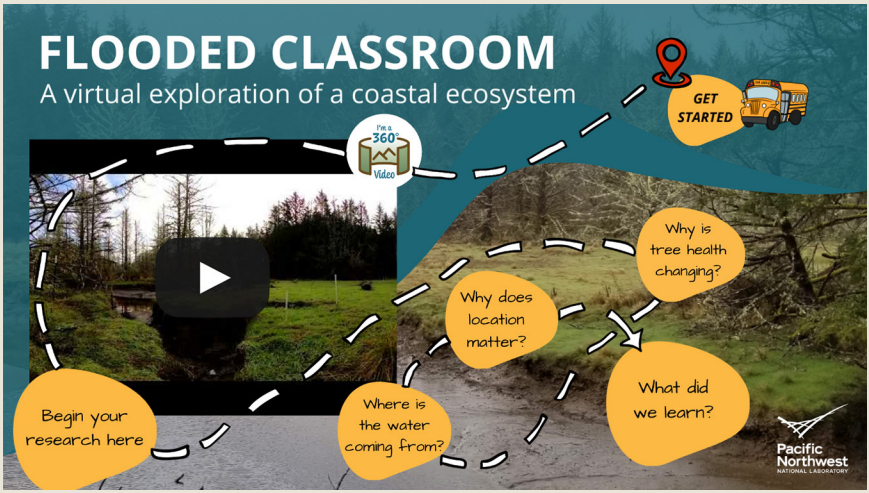

Pacific
Northwest
NATIONAL LABORATORY
FLOODED
CLASSROOM
A Virtual Exploration
of a Coastal Ecosystem
Educator's Guide
April 2022
EVERYONE
E
CONTENT RATED BY
ESRB

Contents

Introduction

The Flooded Classroom: A virtual exploration of a coastal ecosystem was designed by researchers and STEM educators at Pacific Northwest National Laboratory to provide a virtual field-based research experience using 360-degree videos. The videos were recorded while researchers were working in the field. The experience is optimized for viewing on a larger device, but tablets and smartphones enable additional 360-video functionality. A tutorial on using 360-degree videos at the beginning shares how to use a mouse or the navigation icon to explore the videos, but on a tablet or smartphone the viewer may also move the device around to see the video around them.



Link to Prezi: https://prezi.com/view/UwvDCSyHw6yCpKdsMn3K/

Related Standards
from the Next Generation Science Standards

How do people model and predict the effects of human activities on Earth's climate?

HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.

DCI - ESS3.D Global Climate Change – Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

From: https://www.nextgenscience.org/pe/hs-ess3-5-earth-and-human-activity

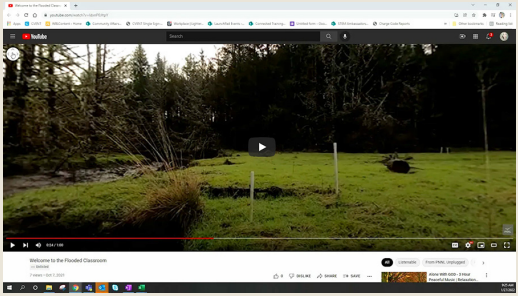
How to use the Prezi
in your classroom

Use the link to access the Prezi. The forward arrows will take the viewer through the entire presentation, including playing videos, as intended by the designers. Viewers may also choose to click on parts in another order to view contents for a specific topic out of sequence.

Integrate hands-on activities and discussions to aid student understanding of the content and the scientific practices illustrated in the Prezi. This guide provides some suggested activities and discussion questions.

Prezi Contents

Get started



https://youtu.be/s9MVbctsVtc

Flooded Classroom 360 Demo – Transcript

00:00 Before you get started today, let's take a quick moment to show you how to navigate the 360 videos.

00:05 If the video does not play automatically, simply push play to start.

00:09 While the video plays, you'll be able to explore your surroundings.

00:12 There are two options to navigate the 360 video.

00:16 You can move your cursor up to the left-hand corner of your screen and you'll notice a circle with arrows.

00:22 Click those arrows to move around.

00:24 Look up and down and turn around entirely.

00:28 You can also use your mouse to click and drag to explore the video.

00:33 Again, you have the option to look at the ground, the sky, and turn completely around.

00:39 Have fun exploring.

Record This!

Help researchers make observations about this environment. When you see this pencil icon be sure to grab your notebook and capture your ideas and findings.

Let's head to Beaver Creek, a field site under study in southwest Washington State.

I'm a 360° Video

https://youtu.be/ldxnP0JltpY

Welcome to the Flooded Classroom – Transcript

00:01 The environment is changing.

00:03 Can you tell?

00:05 Look up.

00:06 What do you notice about the trees?

00:10 Look down.

00:11 What do you notice about the ground?

00:14 Do you see water in the distance?

00:17 What do you notice about it?

00:20 Do you see people working?

00:22 Those are scientists trying to understand how and why this environment is changing.

00:28 Together, we will be learning about the trees, the landscape, and water dynamics to understand what's going on in this ecosystem and what that teaches scientists about the effects of climate change.

00:42 As you move through the module, click on the yellow bubbles to explore these topics and click the blue bubbles to dive deeper.

00:49 If you see a pencil, that means it's time to record your observations in your field notebooks.

00:55 Now grab your waders and let's go.

Pacific Northwest National Laboratory soil scientist, Aditi Sengupta, creating a soil pit to collect samples.

Begin your research here

Research Questions

Researchers generate specific questions based on observations. These are questions that may be answered through experimentation, observation, or modeling. The answers to these experimental questions help to answer bigger questions as researchers tackle grand challenges.

Meet Your Project Team

At Pacific Northwest National Laboratory (PNNL), team science is very dynamic and adapts to the needs of the research. While team members might change, each team often includes the following roles:

The Pacific Northwest National Laboratory project team on-site at Beaver Creek, the coastal ecosystem featured in the flooded classroom.

Principal Investigator(s)
Project management, budgeting, scope and vision

Subject Matter Expert(s)
Provides expertise in specific scientific areas such as: Biogeochemistry, Earth Science, Modeling, Soil Science, Ecology, Tree Physiology

Scientist(s)
Laboratory and Data Analysis, Fieldwork Design, Publications & Presentations

Technician(s)
Laboratory Analysis, Fieldwork & Data Analysis

Learn about careers at PNNL:
https://careers.pnnl.gov

Your Toolkit

Researchers use lots of tools in the field and lab to conduct their research. Here's a peek into a researcher's toolkit.


Field Backpack


Water + Snack


Notebook for Plant I.D.


Tree Cores


Water Samples


Soil Samples


Laboratory Analysis


Data Analyis + Modeling

Publications

Some observations can only be made in the field while others require samples to be collected on site and brought back to the lab.

Backpacks aren't just for school. Field researchers carry an array of personal and professional gear while collecting data in the field.

Data is gathered from the same field sites repeatedly to understand what is happening and validate the results.

EXPLORE MORE!

Watch researchers sift samples of soil to prepare them for analysis:

https://bit.ly/3i6LRjz

Laboratory instruments provide additional data that researchers analyze to better understand what is happening in the environment.

By taking measurements, collecting samples, and making observations, researchers can determine how an ecosystem functions.

The tiny molecules that make up soils, water, plants, and the atmosphere can provide information about the environment researchers are studying.

Researchers share their results and findings by publishing their work in scientific journals.

EXPLORE MORE!

Check out an example of a research publication:

https://go.nature.com/3zCJvPm

Browse Frontiers for Young Minds, written for budding scientists:

https://bit.ly/3CHlubl

Learn About the Project

The Project

Throughout history, humans have established structural barriers along coastlines for a variety of reasons. A causeway was built across Beaver Creek over 100 years ago creating a barrier that held back tides. This made the ecosystem under study a freshwater system.

Seven years ago, the barrier was removed, restoring tidal flow to this part of the ecosystem. Researchers are using collected data and existing models to study how the ecosystem at Beaver Creek is responding over time.

What researchers learn here may also help us understand the long-term effects of sea level rise due to climate change on coastal ecosystems.

The Big Question

What are the potential effects of sea level rise due to climate change on small coastal ecosystems?

Why is tree health changing?

I'm a 360° Video

https://www.youtube.com/watch?v=QfpWQk6kCHA

Trees – Transcript

00:02 Welcome to the forest.

00:03 Look around.

00:06 How many dead trees do you see?

00:09 Take a moment to count.

00:24 Now look up.

00:25 See all the trees with no leaves?

00:30 Those trees are actually dead.

00:33 What do you think could be causing those trees to die?

00:38 Use your observations of the ecosystem and your knowledge of what keeps trees healthy and jot down some ideas about why the trees might be dying.

00:47 I'll give you a few minutes.

[Nature Sounds]

02:50 Click on the blue bubbles to learn more.

Research Questions

1. How do we know if a tree is dead or unhealthy?
2. What could be causing some of the trees to die?
3. How might the water in this area impact tree health?

Record This!

Using your observations of the ecosystem and your knowledge of what keeps trees healthy, jot down some ideas about why the trees might be dying.

Your Glossary

Canopy
A tree canopy is the upper portion of the tree, including the leaves, branches, and stems. It shelters the ground from above.

Leaves vs. Needles
Tree needles are leaves. Pine trees have leaves shaped like needles. Needles capture sunlight, "inhale" carbon dioxide, and "exhale" oxygen.

Tree Ring and Tree Core
Each year, tree trunks grow and create new wood in a "ring." By collecting tree core samples, scientists can study the growth and conditions during each year of the tree's life.

Why is this Happening?

Water impacts tree health

Trees have small tubes inside them that move water, nutrients, and gases (such as oxygen and carbon dioxide) between their roots and leaves. When trees are exposed to seawater, the tube size changes. This may slow down how fast the tree can move water, nutrients, and gases, which can harm or kill the trees over time.

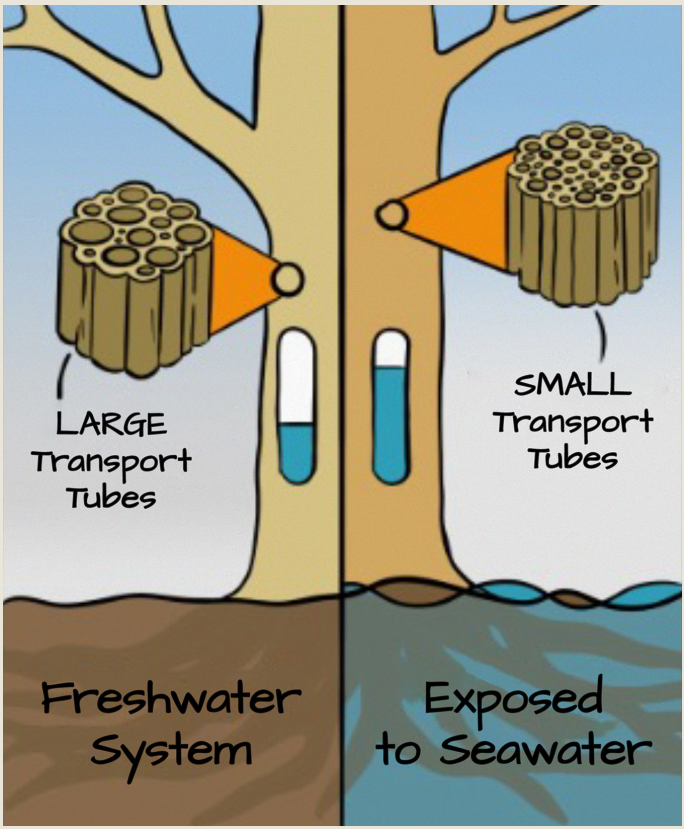


Image modified from *Norwood et al., 2000.* https://bit.ly/SeawaterTreePaper

EXPLORE MORE!

VIDEO: How do we measure tree health?

https://bit.ly/Video-TreeHealth

VIDEO: What is a ghost forest?

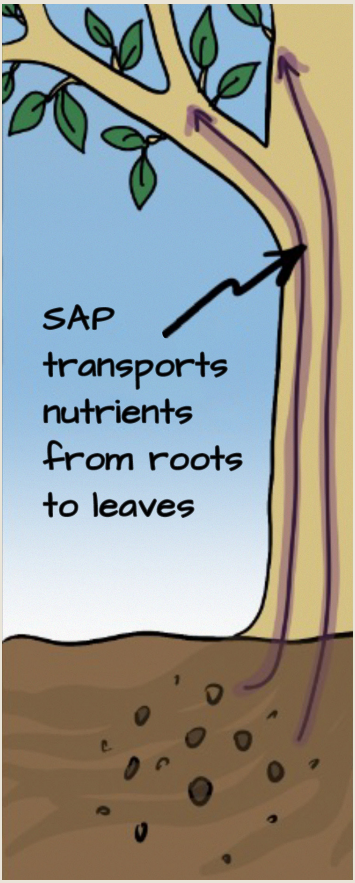
https://bit.ly/NOAA-GhostForests

Did you spot the **silver square** on a tree in the video?

↓ Learn why that's important!

The silver square is covering sensors in the tree. These sensors measure sap flow, which is the movement of water and nutrients through roots, stems and branches in plants. Sap flow measurements provide information on the health of a tree. Researchers at Pacific Northwest National Laboratory are studying how a tree's water consumption might change with increased seawater and/or freshwater flooding.

Learn more:
https://bit.ly/TreeHealthSalinityExposure



Where is the water coming from?

I'm a 360° Video

https://youtu.be/WkoJEvpwtYs

Water – Transcript

00:01 Hey.

00:02 Thanks for joining me in the river.

00:04 Take a moment to check out your surroundings.

00:14 You might be dry now, but in four hours the water will be over your head.

00:19 Why do you think that is?

00:26 It's because this is a tidal system, which means that the water level can change more than eight feet daily.

00:34 Where do you think this water is coming from?

00:37 I'll give you a hint:

00:39 If you tasted it, it might be a little salty.

00:49 If you guessed the ocean, you guessed right.

00:52 This floodplain is connected to the ocean.

00:55 When the tide comes in, it brings some diluted sea water with it, making it a bit salty.

01:02 But how does the ocean water make it all the way up here?

01:05 Do you think this affects the ecosystem at all?

01:09 Take a minute to write down your ideas in your field notebooks.

02:12 Want to learn more about tides? Check out the tide video in this module.

Research Questions

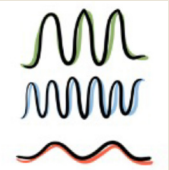
1. What is causing the repeated flooding of this area?
2. What are the impacts of seawater on this environment?
3. What types of changes do we expect to see in this ecosystem over time?

Record This!

Using your observations of the ecosystem and your knowledge of different ecosystems, jot down some ideas about how seawater may affect this freshwater ecosystem.

Your Glossary

Cycle
A series of events or actions that happen repeatedly in the same order.



Oscillation

A repetitive back and forth motion of something from one position to another.

Salinity
The amount of salt dissolved in a specific amount of water. Open ocean seawater has 30,000 parts per million (ppm) of salt. One part per million is like one minute in two years, or one car in bumper-to-bumper traffic from Cleveland to San Francisco.

Did You Know?

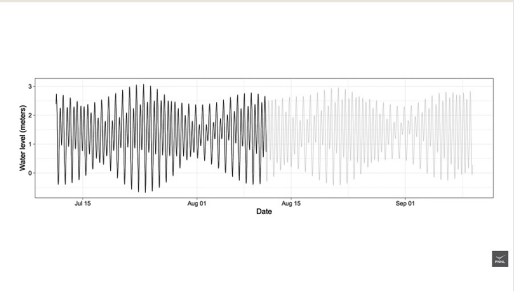
You can taste salt down to 300 ppm*. For comparison, the ocean has 30,000 ppm of salt in it!

*Richter and MacLean, 1939 American Journal of Psychology.

How is this Happening?

The impact of tidal cycles

The video on this page is an animation of water level data collected over three months at Beaver Creek. Time is shown along the horizontal or x-axis. The water level, as measured in meters, is shown on the vertical or y-axis. When graphed and viewed over time, the black line allows us to view the tidal cycle as experienced at Beaver Creek. We notice both daily and monthly variations in the water level. With two high and low tides of different heights each lunar day, this is referred to as a mixed semidiurnal tide. The change in the water level of the creek and the extent of flooding on the floodplain depend on what part of the tidal cycle is happening at a given time.



https://youtu.be/9uR8k_2wN4k

Tide Cycle — Transcript

00:01 What you're seeing is actual data from our creek.

00:04 On the horizontal axis, or x-axis, we have three months' worth of data.

00:10 On the vertical axis, or y-axis, we have the water level in meters.

00:15 The black line is following the tidal cycle.

00:19 This cycle has both monthly and daily changes or oscillations.

00:25 Our system has mixed semidiurnal tides, which means we have two highs and two lows each tidal cycle of different heights.

00:34 This means our creek water level changes and our floodplain floods at different amounts depending on where in the tidal cycle we are.

00:43 For more information on tides, check out these links.

Did You Know?

In this creek, the water level can change by more than 8 feet in less than 6 hours!

Watch the tide rise

Time-lapse video of Beaver Creek flooding
https://youtu.be/ZGYPBS11QAQ

More about tides

Are there different types of tides?
https://bit.ly/NOAATidalCycle

Do the tides change?
https://bit.ly/NOAATideTutorial1

How often do tides happen?
https://bit.ly/NOATideTutorial2

Why does location matter?

I'm a 360° Video

https://youtu.be/plUM4ylJzsc

Elevation — Transcript

00:01 Hey, team.

00:02 Now we're going to look more closely at the landscape.

00:06 Look forward and up.

00:09 Are the trees dead or alive?

00:21 Those trees look dead.

00:25 Now look behind you and up.

00:27 Are the trees dead or alive?

00:40 Those trees look alive.

00:44 How could it be that some of these trees are dead and some are alive?

00:48 What is different about where the trees are located?

00:53 Write down some of your predictions about what might be causing this difference.

02:20 Now look down; the answer is underneath your feet.

02:24 It's time to learn about elevation.

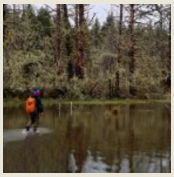
Research Questions

1. What is the difference between the locations of healthy and dead trees?
2. How can we predict what areas will flood?
3. How might repeated flooding change the landscape in this ecosystem?

Record This!

Using your observations of the location of the trees and your understanding of landscapes, jot down some ideas about how location influences the landscape.

Your Glossary



Elevation
The measure of how high above sea level the ground is.

Flood Plain
A low elevation area of land next to a river, creek, or stream, going from right next to the river to uplands. This area floods with water when the water level in the stream is really high!

Upland
An area of higher elevation that doesn't flood.

Watershed
An area of land where water drains into a stream or creek.

Why is this Happening?

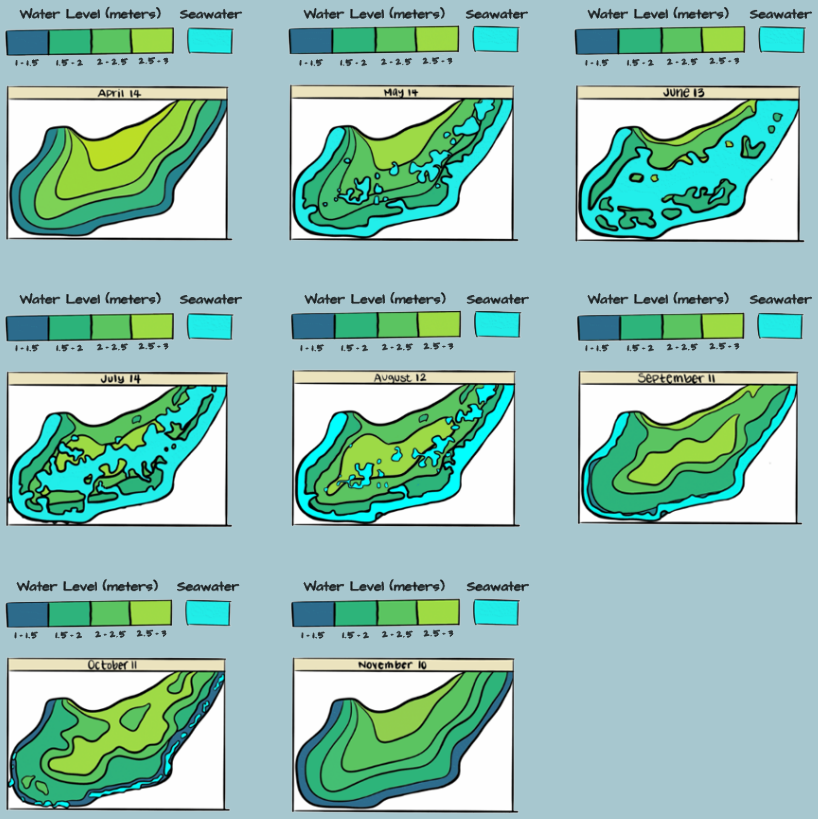
Elevation variation influences the ecosystem

The image to the right is a bird's eye view of a watershed, the land that drains into a stream or creek. This watershed has both a forest and a floodplain in it, you might remember seeing these parts of the watershed earlier on the main page video. A floodplain is a unique ecosystem, impacted by rising stream water. This rising can happen due to heavy rains or a stream's connection to the sea.

EXPLORE MORE!

How does a connection to the sea cause flooding?

This is a drawing of a computer simulation, or model, of a bird's eye view of a floodplain. In this system the water level changes monthly and daily. When the height of water during a tide is higher than the height of the floodplain, seawater floods this area.



Water level (meters), seawater. Modified from Yabusaki et al., 2020.

What did we learn?

Solving the Mystery

This ecosystem is in a floodplain with differing elevations of land. Where the elevation is lower, trees have died. The removal of a tidal barrier introduced saltwater tides into lower elevation areas of the floodplains where trees have grown without exposure to salt water. Trees in the lower elevation floodplains were then exposed to salt water due to twice daily tides, causing the trees to become stressed, then die.

As the climate changes coastal areas will be impacted by rising sea levels. Ecosystems at lower elevations that become exposed to seawater due to sea level rise are likely to experience similar impacts to those observed here. These impacts include the death of otherwise healthy trees and increased erosion due to tides.

Our findings

What We Know Now:

Trees are dying

Salinity is increasing

The creek is connected to the floodplain

What We Predict:

The types of vegetation will change

It will take 20 years for the salt in the floodplain to reach equilibrium

The tides will cause erosion

How are Scientists Helping?

Learn more about Pacific Northwest National Laboratory research in this area:

https://bit.ly/PNNL-ClimateChangeResearch

How you can help:

https://bit.ly/NRDC-ClimateSolutions

Pacific Northwest National Laboratory scientist in the field.

Additional vocabulary terms
with Definitions

Causeway
A raised path or road across wet ground or water.

Coastal Ecosystem
A unique habitat that includes plants and other organisms in an area where the land meets the sea.

Equilibrium
A state in which all parts of a system, including any opposing forces or influences, are in balance.

Erosion
The process that removes or transports soil, rock or other surface material by natural forces such as wind or water flow.

Grand Challenges
Ambitious yet achievable goals that use science, technology and innovation to solve important national or global problems.

Mixed Semidiurnal Tide
A tidal cycle with two unequal high and two unequal low tides in a lunar day.

Oscillation
Regular change or variation in position around a central point.

Sap Flow
The movement of fluid in the branches, stems, and roots of plants.

Sea Level Rise
The average long-term global increase in the level of the world's oceans.

Resources

to Extend or Enhance the Experience

Related to Science Tools

- https://courseware-www.ilc.org/sch3u_html/lessons/sch3u_u1la1.html
- https://investigatingsciencehsc.com/cause-and-effect/
- https://www.teachengineering.org/activities/view/cub_qandq_activity1

Related to Tree Health

- https://confluence.lightsource.ca/download/attachments/82051546/Module%201%20-%20Trees.pdf?version=1&modificationDate=1580240911620&api=v2
- https://kristinmoonscience.com/hands-on-activities-study-plant-vascular-system/
- https://stuy.enschool.org/pdf/bio_lab/second_semester//LAB%2016.doc
- https://www.khanacademy.org/science/in-in-class-10-biology/in-in-life-processes/in-in-transportation-in-plants/v/intro-to-vascular-tissues-xylem-phloem-life-processes-biology-khan-academy

MORE →

Related to Tides

- https://www.khanacademy.org/science/physics/mechanical-waves-and-sound
- https://www.nationalgeographic.org/encyclopedia/tide/
- https://homeschoolsciencegeek.wordpress.com/2018/01/22/sf-physics-15-oscillations/

Related to Salt Water

- https://www.abc.net.au/science/surfingscientist/pdf/lesson_plan12.pdf
- https://www.education.com/science-fair/article/saltwater-effect-grass-plants/
- https://coast.noaa.gov/data/estuaries/pdf/water-going-up-water-going-down-teacher-guide.pdf
- https://www.scienceprojects.org/what-is-the-effect-of-saltwater-in-plants-growth/

Related to Floodplains and Watersheds

- https://www.teachengineering.org/activities/view/cub_natdis_lesson07_activity1
- https://www.teachengineering.org/activities/view/cub_watershed_lesson01_activity1
- https://www.nationalgeographic.org/activity/in-your-watershed/

Example discussion questions

1. If you were on the Beaver Creek project team, what role would you want to fill and why?
2. What other questions would you want to investigate at Beaver Creek or other coastal ecosystems?
3. What is a local ecosystem that we could study and what questions do you have about it?
4. What impacts might sea level rise have on our local ecosystems, if any?
5. What impacts do you think our local ecosystems will experience as a result of climate change?
6. What changes are we seeing in our local ecosystems already that may be due to climate change?
7. Are there actions we can or should take to reduce or prepare for local impacts of climate change?
8. What Grand Challenges do you think are important for researchers to work on? Which ones would you like to help solve?

Pacific Northwest
National Laboratory

Pacific Northwest National Laboratory (PNNL) advances the frontiers of knowledge, taking on some of the world's greatest science and technology challenges. Distinctive strengths in chemistry, Earth sciences, biology, and data science are central to our scientific discovery mission. Our research lays a foundation for innovations that advance sustainable energy and enhance national security.

PNNL - Sequim

PNNL conducts marine research that supports coastal security, a resilient environment, and sustainable energy. Scientists at our marine research facility, PNNL-Sequim, develop efficient methods to translate

environmental data into actionable information and engineer new ways to detect and respond to threats along our coasts.

Coastal Ecosystems

PNNL researchers study coastal ecosystems that are critical to the health of aquatic organisms, plants, and human communities. This science informs decisions about protecting and restoring shorelines and aquatic habitats such as flood plains, marshes, and seagrass beds. By studying the impacts of climate change on our coasts, like sea level rise and flooding, PNNL scientists provide valuable information that helps us better understand our changing coasts and support resilient coastal ecosystems.

This Educator's Guide is provided as an instructional companion to the Flooded Classroom online Prezi presentation, developed by environmental research scientists at Pacific Northwest National Laboratory.

An interactive .PDF version of the Educator's Guide is needed to access the additional information available from the hyperlinks inside, and can be freely downloaded from:

http://www.pnnl.gov/STEM/

Pacific Northwest
NATIONAL LABORATORY

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ENERGY

PNNL-SA-172394