Expedition Northwest

Mystery of the Disappearing Cottonwoods

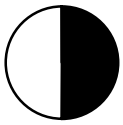
Description: Students will explore the scientific mystery behind a disappearing group of trees by examining data and attempting to explain the decline.

Learning Objectives: Students will learn that a complex set of factors can influence populations of organisms in their environment.

SCIENCE TOPICS	PROCESS SKILLS	GRADE LEVELS
Ecology Botany Land Management Populations	Modeling Hypothesizing Collecting and analyzing data Forming conclusions	7–8

TIME REQUIRED

The time required for this activity can vary from 1–2 class periods.

Advance Preparation	Set Up	Activity	Clean Up
			
30 minutes	**5 minutes**	**45 minutes**	**5 minutes**

SUPPLIES

- 3-hole punches or single hole punches (1 per group)
- Colored construction paper (one 8.5” x 11” sheet per group)
- Butcher paper (2, 2-meter long sections per group)
- Margarine tub or plastic cup (1 per group)
- Meter stick (1 per group)
- Pencils (1 per group)
- Blindfolds (1 per group)
- Scotch tape (1 roll per group)

- Index cards (3 inch by 5 inch) or post-it notes (10 per group)
- Broom
- Materials to photocopy: Science Background, Student Procedure, and Research Sheet

ADVANCE PREPARATION

- Gather and set aside the butcher paper, paper punch, meter stick, blindfold, pencil, and cup for each group.
- Copy Science Background, Student Procedure, and Research Sheet (one per student).
- Before doing the activity with the class, practice the activity procedure and familiarize yourself with the Science Background below.

SET UP

- Set out the butcher paper, paper punch, construction paper, meter stick, blindfold, pencil, and cup or tub for each group.
- After students have finished reading the Science Background article (or prior to the beginning of the class period if this has already been completed), the classroom will need to be arranged to make large open areas on the floor of the classroom. Each group of students will need enough space to lay out their sheets of butcher paper side-by-side, as well as room to kneel and walk around them.

INTRODUCING THE ACTIVITY

Let students speculate before offering answers to any questions. The answers at the right are provided primarily for the teacher's benefit.

Ask the students the following questions in **bold**. Possible student answers are shown in *italics*.

How many of you have visited a river?
Hopefully everyone.

How would you describe the land right next to the river? Did you notice anything about it?
Any appropriate answer is acceptable: it's muddy, sandy, people were fishing and swimming, trash, rocks, trees, lots of plants, birds or other animals walking around or swimming, bugs everywhere, the overall impression that the riverside is a busy place.

What about the types of living things? Does it seem like there are many plants and animals that live or spend time on the land beside a river?
Students may have noticed that there are trees or thick brush near their local rivers. They may have seen a variety of animals such as birds, insects, amphibians, or people, or animal signs, such as tracks and scats.

This would be an appropriate time to introduce or remind students of the term **riparian zone**. Tell students that a riparian area (or zone) is the land beside a river or other body of water.

Do you think that the area next to a river is an important place for wildlife? Why?
Many will guess that it is. Reasons could include it being a good place to hide or find food, the fact that there are lots of trees and plants providing food and cover, or that the river provides a good source for drinking water.

Riparian zones, the land directly adjacent to a river or other body of water, are very important places in nature. Most riparian areas provide a good habitat for plants because water is usually just below the ground. The dense vegetation that covers riparian zones provides cover, food, and habitat for many species of animals.

Has anyone ever noticed that there is usually only one place you can find trees in dry areas such as grasslands or deserts? *Trees and plants usually only grow along the rivers, creeks, or other places where water sometimes flows.*

The riparian zone in dry areas is especially important because it may provide some of the only local habitat for certain species and provides shelter for others.

Tell the students that in this activity, they will be investigating a scientific mystery: the disappearance of cottonwood trees, an extremely important riparian species, along the Missouri River in Montana. Lewis and Clark visited this area and found a huge number of animals living in very dense forests along the river. Today, those riparian forests are vanishing.

Just as a detective must carefully observe the clues when attempting to solve a mystery, students will first need to carefully consider all of the facts presented in the Science Background article. They will then construct a model and use it to collect more data to help them explain the disappearing cottonwoods.

SCIENCE BACKGROUND

Background information can be found at the end of the activity. Print on a separate page for students to read before doing the activity.

Vanishing Cottonwoods

One of the things that all rivers, lakes, and other bodies of water have in common is that they have **riparian** (ripe-air-ee-un) areas. When we talk about a riparian area (or riparian zone), we are just talking about the land that's next to water. For most rivers, the riparian area includes the riverbank as well as the **floodplain**, a flat area of land along a river that is covered with water when it floods.

In the Northwest, healthy riparian areas usually have a lot of vegetation. Trees often grow in riparian areas, as well as a large number of other plants. One of the places where riparian areas really stand out is in a dry **ecosystem**. If you live in a dry area, like a desert or grassland, you might have noticed that any place there's a river, there are often trees or shrubs next to it. This is the riparian zone! Large plants that can't get enough water in other areas often find enough water underground when they grow next to a river or a stream.

Riparian areas often provide important habitats for both animals and plants. Since a riparian area usually has dense vegetation, it provides cover, shelter, and food for many animals. All over the world, rivers and their floodplains are often some of the areas with the highest **biodiversity**.

TEACHER DEMONSTRATION

As part of the set-up for this activity, you may wish to review with students the steps of the scientific method. The activity asks students to hypothesize an explanation for the decline of cottonwood trees, then re-examine their initial hypotheses after collecting additional data on the subject. Points to emphasize prior to students attempting the activity include:

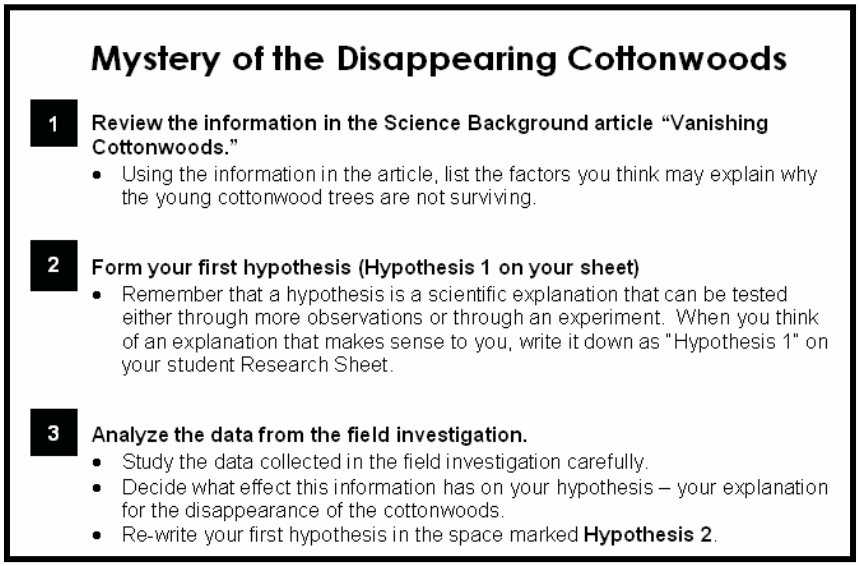
- Scientific hypotheses are explanations or ideas that can be tested and are based on available information or observations.
- A key part of the process of science is rethinking or even discarding a hypothesis when the scientific evidence does not support it.
- Even when evidence does seem to support a hypothesis, scientific explanations are always subject to modification as new evidence becomes available.

In addition, the teacher may wish to demonstrate how the students will use a model of the Missouri River riparian area to collect their data. Special emphasis should be placed on the need for a random scattering of the paper punch circles across the model, as well as careful recording of the resulting data.

Finally, students will be recording the data from their models as percentages. They will use 100 circles, so the counts they take will translate directly to a percent (e.g., 23 circles = 23 percent). Still, the teacher may wish to review the concept of percentages, reminding students that percentages express a certain fraction out of 100.

CLASSROOM ACTIVITY

Students should work in groups of 3–4. Each group follows the directions in the Student Procedure on the right.



Mystery of the Disappearing Cottonwoods

1 **Review the information in the Science Background article "Vanishing Cottonwoods."**

- Using the information in the article, list the factors you think may explain why the young cottonwood trees are not surviving.

2 **Form your first hypothesis (Hypothesis 1 on your sheet)**

- Remember that a hypothesis is a scientific explanation that can be tested either through more observations or through an experiment. When you think of an explanation that makes sense to you, write it down as "Hypothesis 1" on your student Research Sheet.

3 **Analyze the data from the field investigation.**

- Study the data collected in the field investigation carefully.
- Decide what effect this information has on your hypothesis – your explanation for the disappearance of the cottonwoods.
- Re-write your first hypothesis in the space marked **Hypothesis 2**.

Ask students to read the Science Background article about riparian zones and the problems faced by riparian forests on the Missouri River.

Afterwards, have them discuss the information with their group members and list factors they suspect could be responsible for this decline. These suspicions should be recorded on the appropriate part of their research sheets.

Based on the information presented so far, possible factors that could be listed include flood control by the use of dams, livestock grazing and trampling of riparian vegetation, recreational use of the river by humans, invasive species that have been introduced to the zone, drought, and the loss of predators important to the ecosystem.

The teacher may wish to discuss with the class the process of developing an initial hypothesis. Let students suggest ideas and discuss their possible explanations.

After individual students have formulated their first hypothesis, have them review the information found in the Field Data Set on Research Sheet. Assist with their interpretation of the information there and have them discuss it within their group. Have the students decide if their first hypothesis is supported by the data. Students should also attempt to revise their hypothesis in their small groups. Once students have made any revisions, the teacher could again facilitate a whole-class discussion of the new hypotheses, letting students discuss the factors they included in their thinking.

When students have completed their second hypothesis, they should gather their materials and begin following the directions for constructing their models found on the "Student Procedure" sheet. The teacher should ensure that students understand how to measure and lay out the grid lines and how to properly label the sections of their model riparian zones with the notecards.

As students begin using their models to collect data, the teacher should ensure that the paper circles are being scattered randomly, and that students are counting the numbers of circles and recording data carefully.

After the first trial, students should be encouraged to alter the conditions on their models to make them both more and less favorable for their cottonwood seeds. Students should record the resulting data in the two blank rows on their data sheets.

When students have completed their data collection, have them use the broom to collect the paper circles and put them in the garbage, recycling bin, or back into the plastic cup.

CLASS DISCUSSION

Ask for student observations. Let students guide the discussion and present their hypotheses before discussing explanations.

What do think has been causing the disappearance of the Missouri River cottonwood trees? What evidence do you see that this is the correct explanation?
Answers may include livestock grazing, dams and regulation of the river's flow, ice scours, and drought. Ask students to name some of the evidence that supports their favored hypothesis.

Do you think that there is only one thing that is killing the young cottonwood trees or are there many factors at work here?
Students may believe that one cause is more responsible for the decline than others, but most will suggest that multiple causes are at work in some combination.

After reviewing the data collected with their models, students should come to the realization that livestock, invasive species, changes to the river's flow patterns, and other factors are all creating difficulties for young cottonwood trees along the river.

Now that we understand this problem better, what do you think could be done to help prevent more cottonwood trees from disappearing?
Answers will vary.

Why do you think people are so concerned about the disappearance of these trees?
They are an important part of the riparian zone, provide an important place for birds to roost, habitat for other wildlife, and prevent erosion.

EXPLANATION

In-depth background information for teachers and interested students.

Riparian zones, the land adjacent to rivers and other bodies of water, are extremely important ecological areas. Regardless of the surrounding landscape, riparian areas usually have lush vegetation that provides food and cover for a wide variety of wildlife. Healthy riparian vegetation can provide a screen of filtration for some of the runoff that would otherwise enter the water. Riparian zones are also closely connected to the life in a river. Leaves and other dropped vegetation as well as insects that fall or are washed into the water provide a significant part of the base of the aquatic food chain. This is especially true in many smaller tributary rivers and streams.

While healthy riparian zones play an important role in maintaining biodiversity and water quality for any watershed, the riparian vegetation found in dry parts of the American West is of even greater ecological importance. In these arid areas, riparian vegetation provides crucial habitats. The lack of dense vegetation across much of the landscape means that many mammals, amphibians, and, in particular, migratory birds find essential cover and food in the trees and shrubs that border waterways. Much of the biodiversity in these areas hugs a narrow corridor of green that exists only along rivers and streams.

When Lewis and Clark traveled through the riparian forests of the Missouri River, they observed that they were populated with a tremendous amount of life. While they observed that buffalo and antelope were found in huge numbers on the surrounding grasslands, they saw a much broader array of plants, birds, and other animals in their travels along the riverside.

OPTIONAL EXTENSIONS

Extension A—Management Plan
In resource management, scientists often study or research a problem to help understand it. Using the data from their research, scientists create recommendations for how to manage wildlife populations, forests, or other areas based on their findings.

Have your students create a management plan that addresses the causes they feel are responsible for the death of the cottonwood seedlings on the river. Encourage them to be creative and not to limit themselves—changing the river's flow patterns, fencing off parts of the riverbank, and other large-scale projects should all be considered.

Extension B—A twist in the cottonwood mystery
Have your students investigate the ecology of wolves and decide if they think the lack of these predators could be a factor in the decline of cottonwoods in the Upper Missouri Breaks area.

Explanation:
Recent research has indicated that the restoration of wolves to the area around the Gallatin River in Montana may have brought about huge benefits to riparian vegetation. These changes have only occurred over the last ten years. Scientists now believe that by providing a constant threat that keeps elk and other browsing animals moving, wolves keep these herbivores from overgrazing any one spot. Wolves may even keep these animals out of riparian zones by frequently patrolling these areas for prey.

http://oregonstate.edu/dept/ncs/newsarch/2004/Dec04/fear.htm

http://fwcb.cfans.umn.edu/research/wolfgift.php

Extension C—Investigate why riparian forests are important to aquatic food webs
Conduct an experiment using light-colored tarps, butcher paper, sheets, or towels spread out beneath some bushes or small trees. Have students firmly shake (without injuring!) the trees or bushes for at least 60 seconds, then have them investigate what has fallen out. This activity will produce better results in a natural area or riparian zone but can also be done successfully with schoolyard bushes.

Extension D—Water temperature experiment
This activity tests one way in which riparian vegetation is important to water quality by providing shade. Students can set two identical tubs or buckets of water outside the school on a sunny day and take temperatures for both. Then provide shade for one container by suspending dead limbs, plastic plants, a tarp, etc., over it. Come back at the end of the day and take temperatures from both water containers. Compare the two measurements.

Extension E—Grow your own cottonwoods!
If the teacher or a parent volunteer has access to a Northwest river at the end of the school year, chances are good that cottonwood seeds can be gathered with almost no effort. Depending on the elevation, the trees may start spreading seeds anytime from early May through June. Look for the unmistakable white cotton fluff covering the ground or sometimes hanging out of large seed pods that have been dropped.

When fresh, the seeds are very easy to germinate, requiring only moisture and a thin bed of soil. The class could perform an experiment to see what types of water conditions or soil (sand, potting soil, gravel, etc.) the seeds grow best in. Results can be measured by the height or survival rates of the seedlings. When the experiment is completed, students can transplant their young trees to an appropriate location or take them home.

CROSS-CURRICULAR CONNECTIONS

SUBJECT	Activity
ART	**Sketch the Missouri River.** Have students create a sketch or mural of the river in modern times or as they imagine it might have looked two hundred years ago. Numerous model pictures to work from can be found at **http://infolink.cr.usgs.gov/Photos/index.html** .
SOCIAL STUDIES	Read the book ***Lewis and Clark: Explorers of the American West*** by Steven Kroll and Richard Williams. Read aloud from ***The Journals of Lewis and Clark*** edited by Bernard De Voto. Pages 132–146 describe the Corps of Discovery's first travel through the area of Upper Missouri Breaks National Monument and what they found in the cottonwood forests there.

RESOURCES

http://infolink.cr.usgs.gov/Science/
Information about the Missouri River from the USGS.

http://www.na.fs.fed.us/pubs/silvics_manual/volume_2/populus/deltoides.htm
Extensive information about cottonwood species from the U.S. Forest Service.

http://biology.usgs.gov/s+t/noframe/m6140.htm
Information about the decline of trees in Western riparian ecosystems.

http://water.montana.edu/newsletter/archives/newsletter_05_11.htm
Montana Water News.

http://www.fort.usgs.gov/products/publications/
Publications from the USGS, including an excellent 4-page article about the cottonwood forests in Upper Missouri Breaks National Monument.

GLOSSARY

Biodiversity: The natural variety of species in an ecosystem.

Channelization: The process of reconstructing the natural course of a stream in order to make it flow into a restricted path.

Cottonwood: The common name for a type of tree often found in riparian zones and wet areas throughout the United States.

Data: Information scientists have collected to answer a specific question.

Desiccate: To lose water and dry out.

Disturbance: In botany, something that exposes bare soil.

Ecosystem: A habitat and all of its native species.

Floodplain: An area next to a river that gets covered with water only when a river floods.

Germinate: To sprout from a seed.

Hypothesis: An idea that explains certain facts or observations.

Ice scours: Floods of large ice chunks that sometimes happen on partly frozen rivers in winter or early spring.

Invasive species: A non-native plant or animal that can out compete native species in habitats other than its own.

Mortality rate: The number of living things that die in a given amount of time.

Observation: Careful watching or noticing of something.

Pioneer species: In botany, a species of plant that is one of the first to grow on a disturbed or barren area.

Reservoir: A man-made lake for storing water.

Riparian: Having to do with the land that is directly beside water.

Seedling: A small, young tree.

Silt: Very small soil particles, usually deposited by a river.

USGS: The United States Geological Survey, a government service that studies the natural resources of the United States.

Vanishing Cottonwoods

One of the things that all rivers, lakes, and other bodies of water have in common is that they have **riparian** (ripe-air-ee-un) areas. When we talk about a riparian area (or riparian zone), we are just talking about the land that's next to water. For most rivers, the riparian area includes the riverbank as well as the **floodplain**, a flat area of land along a river that is covered with water when it floods.

In the Northwest, healthy riparian areas usually have a lot of vegetation. Trees often grow in riparian areas, as well as a large number of other plants. One of the places where riparian areas really stand out is in a dry **ecosystem**. If you live in a dry area, like a desert or grassland, you might have noticed that any place there's a river, there are often trees or shrubs next to it. This is the riparian zone! Large plants that can't get enough water in other areas often find enough water underground when they grow next to a river or a stream.

Riparian areas often provide important habitats for both animals and plants. Since a riparian area usually has dense vegetation, it provides cover, shelter, and food for many animals. All over the world, rivers and their floodplains are often some of the areas with the highest **biodiversity**.

Riparian areas also provide many important functions for the river itself. Dead leaves, insects, and other nutrients fall from riparian vegetation into the water and are eaten, providing part of the base of the river's food web. Riparian plants also play a vital role in preventing erosion by holding soil tightly in their roots.

The Cottonwoods of Lewis and Clark

The Missouri River begins its long flow east from the Rocky Mountains in Montana. When Lewis and Clark came up this river in 1805, they saw that the land all around was mostly covered with grass. At the same time, they found trees growing all along the banks of the river. Many of these trees were a type that people called **cottonwoods**. Cottonwood trees get their name from the huge amount of white fluff they produce in the spring, which looks much like cotton. This fluff is actually attached to the cottonwood trees' tiny seeds, which are so small they are barely noticeable.

The Missouri River in Montana
Source: U.S. Geological Survey

Lewis and Clark made an interesting scientific observation when they noticed that cottonwood trees grew along the Missouri River but not up on the plains

above it. In fact, cottonwood trees grow only in habitats where they can get plenty of water from the ground. As a result, they are mainly found near rivers and streams.

Cottonwood trees make many adaptations that make them successful at growing in riparian habitats. Once their seeds **germinate**, the **seedlings** grow fast, quickly sending down roots to help them get a tight hold on the loose soil along a river. While most trees produce their seeds late in the summer or fall (think of acorns from oak trees or apples), cottonwood trees have adapted to produce their seeds in the spring. This timing spreads the seeds at a time when rivers are often flooding.

The cotton fluff that almost explodes out of pods on a cottonwood tree's branches has huge numbers of tiny seeds attached to it. Much like a dandelion seed, the fluff on cottonwood seeds helps them float long distances in the wind and water. This helps the trees reproduce by scattering their seeds to as many areas as possible. One cottonwood tree can produce millions of seeds, so, not only do the seeds travel far, but there are a lot of them.

Even in dry ecosystems, cottonwood trees often grow in riparian areas. ***Source: NPS***

Cottonwood seeds have another thing in common with dandelion seeds. Both are **pioneer species** that grow best in a disturbed area. In nature, **disturbance** means that the native plant life has been destroyed, leaving an area of bare soil. Forest fires, floods, hurricanes, and logging are all examples of disturbance. In order to have the best chance of surviving to become a young tree, cottonwood seeds need to germinate in a sunny area of bare, wet **silt** or fine soil. In riparian habitats, this type of disturbed surface is usually created by high floods in the spring and early summer.

Changes to the Missouri River

The past two hundred years have brought many changes along the Missouri River where Lewis and Clark camped. In that time, many more people have moved into the Missouri River watershed and changed the landscape there. White settlers used many of the trees for firewood and building materials. They also brought cattle and other livestock, which often grazed and drank along the river. Wolves, grizzly bears, and some other predators have been mostly removed from the ecosystem. In the past, these animals hunted the deer that often eat riparian vegetation.

Increased human traffic has brought **invasive species** to the Missouri River. These plants are not native to the ecosystem but are good at competing with the native vegetation for water and space along the river. Human uses of the Missouri River for recreation have also increased. People have found that the river is a fun place to canoe, swim, fish, and camp.

Perhaps the biggest changes have been to the flow of the river water itself. Several dams have been constructed to prevent the river from flooding. The dams hold the water in large **reservoirs** so it can be used or released later. In addition, the Missouri River has been greatly **channelized**, removing many of the twists and turns that created side areas full of water. All of these changes have had impacts on the Missouri River ecosystem.

Great horned owlet perched in a cottonwood tree.
Source: NPS

People have begun to notice another type of change occurring along the river. The cottonwood trees that are such an important part of the river habitat have been disappearing. In many places, only older cottonwood trees are still standing. One of the reasons that cottonwood trees provide such excellent wildlife habitat is that they usually don't live more than 150 years. This means that the big, older trees are always dying as part of their natural life cycle. These dead trees have a very positive effect on the ecosystem by providing great nesting habitats for birds and other animals. But this also means that new, younger cottonwoods must keep sprouting up to replace the older trees when they die.

Young cottonwood trees face an uphill battle to survive. Many factors cause them to have a very high **mortality rate**. Many seeds land in spots with too much shade or poor soil and barely get started germinating before they die. Other young trees that are too high on the riverbank may dry out, or **desiccate**, and die. If the seedlings are low on the floodplain and close to the river, they may grow well for a few years but then be swept away by future floods or be destroyed by **ice scours**—giant piles of ice that sometimes flow down the Missouri River in winter. In addition, many species of wild animals or livestock eat the young trees. All together, these factors mean that less than one out of a million cottonwood seedlings survive to become an older tree!

For the past ten years, scientists who work for the **United States Geological Survey (USGS)** have been studying the Missouri River ecosystem and trying to understand why the cottonwood forests are disappearing. Michael Scott is one of the scientists investigating the vanishing vegetation. He collects **data** about the ages of the trees, what type of soil the older cottonwoods are found growing on, and the places where young seedlings have survived. The observations made by Michael and his fellow scientists may help to unravel the mystery of what is happening along the Missouri River.

Michael Scott, an ecologist for the USGS, studies cottonwood trees along the Missouri River.
Source: USGS

Student Procedure:
Mystery of the Disappearing Cottonwoods

1 **Review the information in the Science Background article "Vanishing Cottonwoods."**

- Using the information in the article, list the factors you think may explain why the young cottonwood trees are not surviving.

2 **Form your first hypothesis (Hypothesis 1 on your sheet).**

- Remember that a hypothesis is a scientific explanation that can be tested either through more observations or through an experiment. When you think of an explanation that makes sense to you, write it down as "Hypothesis 1" on your student Research Sheet.

3 **Analyze the data from the field investigation.**

- Study the data collected in the field investigation carefully.
- Decide what effect this information has on your hypothesis—your explanation for the disappearance of the cottonwoods.
- Rewrite your first hypothesis in the space marked **Hypothesis 2**.

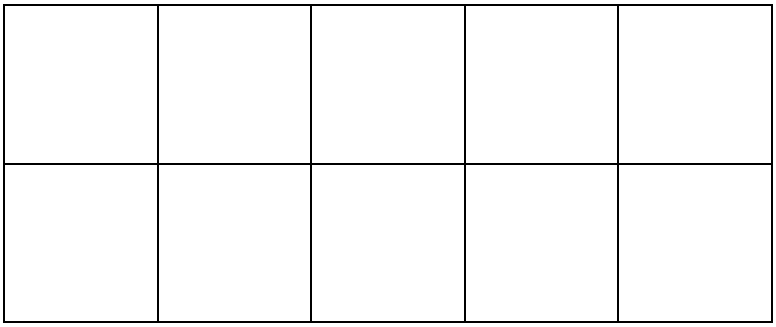
4 **Create your model of a Missouri River riparian zone.**

- Have one person punch out 100 paper circles from the colored construction paper. Each one of these circles will represent <u>ten thousand</u> tiny cottonwood seedlings in your model!
- The other students should use the scotch tape to tape your group's two butcher paper sheets together side by side. Put pieces of tape at both ends and a few pieces in the middle to hold them together. When you are done, it should look like this:

Butcher paper piece # 1
Butcher paper piece # 2

- Use a marker to trace the line down the middle between the two pieces of butcher paper.

- Now use your meter stick to measure and draw lines across both pieces of butcher paper every 40 cm. When you are finished, your butcher paper should look like this:



- Next, label your note cards with the following labels (be sure to write near the top of the note card):
  - Label two cards "Livestock grazing—seedlings consumed."
  - Label three cards "Too high on riverbank—seedlings desiccate and die"
  - Label two cards "Too low on riverbank—seedlings killed by floods or ice scour."
  - Label one card "Trampled by human canoeists or eaten by elk"
  - Label two cards "Favorable conditions—seedling survives"
- Place the cards, one per square, at random in the ten squares in the grid on your butcher paper.

5 **Collect your own data.**

- Choose one student to be blindfolded.
- Another student should place the paper circles in the hands of the blindfolded person.
- Walk the blindfolded student around the edge of the model riparian zone. As the student is carefully guided around the butcher paper, have him/her scatter the paper circles over it.
- When finished, remove the blindfold. Everyone in the group should help count the number of paper circles that landed in the squares that indicate the cottonwood seedlings survived (favorable conditions). Because you started with 100 circles, the number of circles you count in these squares is also the percentage of the cottonwood seedlings that survived.

6 **Record your data and repeat the process.**

- Choose one person to be the data recorder. This person should write the favorable conditions percentage down on his/her Data Sheet under "Percent of Cottonwood Seedlings Surviving After Year 1."
- Gather up the circles from the squares where seedlings survived due to favorable conditions. Put the rest of the circles, representing the seedlings that did not survive, in your group's cup.

- Blindfold another person and repeat the process, this time scattering only the circles from cottonwoods that survived the first year. Record the percentage of these that survive as "Percent of Cottonwood Seedlings Surviving After Year 2."
- Repeat the same process to get data for Year 3.

7 **Change the conditions for the cottonwood seedlings and collect more data.**

- The other two lines on your data sheets are provided for you to experiment with cottonwood survival under different conditions.
- To do this, cross out the conditions you marked on the notecards for the first trial, and create your own set of conditions. You can increase the mortality rate by making only one square represent favorable conditions for the cottonwoods. You can also increase their survival rates by creating more than two squares with favorable conditions.
- After you choose the new conditions and place the cards on the model riparian zone, scatter the circles and collect data just as you did in the first trial. Make sure you start with 100 circles again at the beginning of the second and third trials.

8 **Revise your hypothesis one more time.**

- After collecting three rounds of data, decide if your hypothesis is supported by your latest experimental evidence.
- Write it down as the **"Final Hypothesis"** on page 2 of your Research Sheet.

Research Sheet:
Mystery of the Disappearing Cottonwoods

You are a scientist trying to understand the disappearance of the cottonwood trees along the Missouri River. Based on the information you have already read in the Science Background article, come up with a hypothesis to explain why young cottonwood trees have not been able to grow successfully.

First, list what you believe are possible causes:

Now think of a possible explanation—this will be the hypothesis that you will test by conducting more observations.

Hypothesis 1: _____

_____

_____

Imagine that you have conducted a field investigation to gather data on what type of soils and other conditions helped older cottonwood trees grow when they were younger. You now need to examine your data and decide if it supports your hypothesis, if it has no effect, or if you need to rethink your explanation.

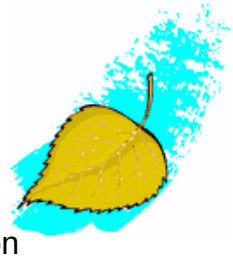
In this field investigation, you have dug around the trunks and roots of cottonwood trees that lived past the seedling stage. After doing this and examining historical records, you have been able to gather the following data:

Field Data Set

Site Number	Average Age of Trees	Soil Types Found Beneath Roots of Older Trees	Number of Years that Livestock Grazing Has Occurred in this Area	Other Notes
Site 1	87 years	70% silt, 20% sand, 10% gravel	Last 100 years	Large numbers of invasive plants
Site 2	53 years	85% silt, 15% sand	Last 70 years	High floods 53 years ago
Site 3	107 years	80% silt, 15% sand, 5% gravel	Never	Very few young trees

Name of Scientist:_____ Date:_____

Research Sheet:
Mystery of the Disappearing Cottonwoods



Think about ways you might want to change your original hypothesis based on the data from the field investigation on the last page. Write your revised hypothesis below.

Hypothesis 2: _____

_____

_____

Follow the instructions on the "Student Procedure" sheet to collect your own data and then record it on the Data Sheet. When finished, look at your data and determine if it supports your latest hypothesis. Revise your hypothesis again and write your final version below.

Final Hypothesis: _____

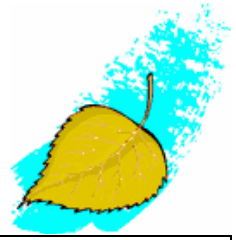
_____

_____

Name of Scientist:_____ Date:_____

Data Sheet

Mystery of the Disappearing Cottonwoods



Conditions	Number of Squares	Approximate Mortality Rate Each Year	Percent of Cottonwood Seedlings Surviving After Year 1	Percent of Cottonwood Seedlings Surviving After Year 2	Percent of Cottonwood Seedlings Surviving After Year 3
Livestock Grazing	2	20%			
Desiccation	3	30%			
Floods/ice scour	2	20%			
Human/animal traffic	1	10%			
Favorable conditions	2	0			