14. Cottonwood Creation

Description: Students learn about cottonwood seedling survival through two steps. In Part One students identify the conditions a cottonwood seed needs to germinate (start growing) by using cotton balls on the river model. In Part Two, students toss coins or dice to try to grow seedling roots fast enough to keep up with a lowering water table. Students realize that very few cottonwood seeds actually become trees and that altered river conditions are very limiting for cottonwood establishment. This activity delves into a specific example of a species and its survival—what allows a species to continue to exist in its location.

Materials:

- River model (see activity 13, "Changing River")
- Cotton balls (ideally 200 to 600, usually sold in bags of 200 or 300
- A copy of Root Race (page 205) for each student (laminate for repeated use)
- Writing tool for Root Race page (erasable markers for laminated sheets); use two colors, one for roots, the other for water depth.
- Pennies (or dice, spinner, or other device to randomly determine 1 or 2, or 1, 2, or 3), one per student or student pair
- Optional: gather real cottonwood seeds to share with the class

Phenomenon: When the cottonwood trees release their seeds, it looks like it is snowing.

Lesson Question:

- *What happens to cottonwood seeds in the bosque?*
- *What do they need to germinate and grow?*

14. Cottonwood Creation

Grades: 3–8

Time: two hours which can be divided into two or four sessions (two parts with old and new river models)

Subjects: science, math

Terms Términos:

germinate	*germinar*
groundwater	*agua subterránea*
hydrology	*hidrología*
overbank flooding	*inundación*
seedling	*plántula*
water table	*nivel freático*

New Mexico STEM Ready! / Next Generation Science Standards
NGSS DCIs and New Mexico State Performance Expectations
3.LS1.B Growth & Development of Organisms
3.LS2.C Ecosystem Dynamics, Functioning & Resilience
3.LS4.C Adaptation
3.LS4.D Biodiversity & Humans
4.LS1.A Structure & Function
5.ESS3.C Human Impacts on Earth Systems
MS.LS1.B Growth & Development of Organisms
MS.LS2.A Interdependent Relationships in Ecosystems
MS-LS2.C Ecosystem Dynamics, Functioning & Resilience
MS-LS4.B Natural Selection*
MS.ESS3.C (MS-ESS3-3 NM) Human Impacts on Earth Systems
NGSS CCCs
Patterns; Cause & Effect: Mechanism & Explanation; Scale, Proportion & Quantity; Systems & System Models*; Structure & Function
NGSS SEPs
Asking Questions & Defining Problems; Developing & Using Models; Analyzing & Interpreting Data
(* indicates extension activity)

Part One: Cottonwood Cotton Game—How Trees Get Started

Objective:

Students will explore how conditions impact the ability of cottonwood seeds to germinate (begin to grow).

Introduction:

Have students add to KWL charts—*What do they **Know**? What do they **Want** to know?* And then, *What have they **Learned**?* at the end of the activity. These questions will help drive the learning as they work through the lesson on the question:

What do you know about cottonwood trees? **(Asking Questions & Defining Problems)**

Students will model part of the life cycle of a plant—a cottonwood tree: Seeds need to land in the right conditions/locations, then the roots must grow fast enough to survive as the water level drops through the summer. **(Systems & System Models;** see Appendix K**)**

Procedure:

Section A: Río Bravo

- Set up the river model to represent the old river (Río Bravo). For guidelines, see activity, 13, "Changing River."
- Give each student a handful or two of cotton balls. Explain that each cotton ball represents a cottonwood seed.
- Ask students to describe the difference between true cotton and cottonwood seeds. (True cotton comes from an agricultural plant; cottonwood seeds are surrounded by a mass of fine threads that resemble cotton and allow the wind and water to transport the seeds away from the mother tree.)

- Have students stand around the sides of the river model. Standing with their backs to the center will have more random results. Tell the students that they will mimic the female cottonwood trees by tossing the cotton balls on the model at the same time. Since the seeds are transported by wind they will land at random locations. Ask students to toss their cotton balls into the air and onto the model on the count of three. Students may re-toss any that land off the model.

- Explain the conditions a cottonwood seed needs to germinate:
  - full sunlight (no shade)
  - bare soil
  - wet soil

In the old river these conditions occurred in areas that received overbank flooding, particularly where existing plants were scoured away by the spring floods.

- For this round, instruct students to collect all the cotton balls that:
  - landed on sandbars
  - are within one hand's length **(wrist to fingertips)** of the river edge
  - are not touching any other vegetation such as grass, shrubs, trees, or cattails (shade)
  - are not in the water (washed away)

  Place these in a "germinated" pile.

  Pick up all the other cotton balls and put those in a "did not germinate" pile.

- Have students count the number of cotton balls in each pile and write these numbers down (on the board or in their class journals). Discuss the difference in the size of the piles. The "germinate" pile should be smaller than the pile that did not germinate because there are fewer available sites for the seeds to start to grow. If the piles are equal or the "germinate" pile is larger, ask the students if they understood the directions and repeat these steps if necessary.

Río Bravo Discussion Questions

Ask the students:

¿Dónde sobreviven mejor los álamos? ¿Dónde sobreviven menos? ¿Dónde no sobreviven los álamos? **(3.LS4.C; Patterns)**

¿Cómo se reproducen los álamos? ¿Qué tipo de semillas tienen?

¿Por qué crees que los álamos producen tantas semillas?

¿Qué necesitan las plántulas para empezar a crecer (germinar)? **(3.LS1.B; MS.LS1.B)**

Considere las diferentes estructuras del álamo (hojas, semillas, raíces, etc.).

¿Qué adaptaciones/estructuras y funciones ayudan a un álamo a sobrevivir, crecer y reproducir?

¿Cómo cambia un álamo a lo largo de las estaciones del año y a lo largo de su vida para poder sobrevivir? **(4.LS1.A; 3.LS4.C; Structure & Function)**

¿Qué papel juega una inundación de primavera en la germinación del álamo? **(3.LS2.C; MS.LS2.C)**

- You may want to review the KWL charts to see what has been learned, and what students still want to know.

You may want to move to Part Two, **Root Race**, to determine the fate of the young seedlings before moving on to the Río Manso section of the Cottonwood Cotton Game.

Section B: Río Manso

- Change the river model to represent the altered river (Río Manso). For guidelines, see the activity 13, "Changing River."
- Repeat Río Bravo steps, handing out the same number of cotton balls.
- Explain to the students: *en este ecosistema fluvial modificado, hay muy pocas inundaciones sobre la ribera. Las únicas semillas que germinaron serán:*

  • *en bancos de arena desnudos.*

  • *en el borde del agua (ríos, acequias, desagües, etc.) hasta 1 pulgada (2.5 cm) (~ la anchura de 2 dedos) desde el borde del río.*

  • *no están tocando ninguna otra vegetación como césped, arbustos, árboles, o totora (plantas que producen una sombra).*

  • *no están en el agua (las semillas serán llevados por la corriente).*

  Ask students to once again pick up the cotton balls from the model and make two piles, one for successfully germinated seeds and one for seeds that did not germinate.
- Count the piles and compare the results with the old river activity. There should be a significant reduction in the number of seeds that germinated.

Río Manso Discussion Questions:

Ask the students, *¿Por qué germinaron menos semillas?* Some answers may include: lack of flooding left fewer wet sites, straightening the river left less river edge, growth of exotic species and filling-in of the forest left fewer bare/unshaded patches, etc.

¿Cómo han cambiado los humanos el río y el bosque? ¿Cómo han afectado estos cambios a los álamos?
(3.LS4.D; Scale, Proportion & Quantity)

The environment has changed.

¿Sobreviven bien los álamos, se mueven o mueren?
(3.LS2.C; Patterns; Cause & Effect)

- Move on to Part Two, Root Race, to determine the fate of the newly germinated seedlings.

Part Two: Root Race: How Seedlings' Roots Must Keep Up With the Lowering Water Table

Objective:

Students learn that a cottonwood seedling's roots must grow as fast or faster than the water table drops in order to survive by playing a game visually demonstrating water table levels and root growth.

Procedure:

Section A: Río Bravo

- Explain to the students that once a cottonwood seed germinates, its next hurdle is to grow roots fast enough to keep up with the water table as it drops after the flood. Students will play the Root Race game for each of the cotton balls in the pile of successfully germinating seeds from the Cottonwood Cotton Game. First review the *Teacher's Example Page: Root Race* to show how the sheet works, then hand out the blank *Root Race* sheets.

  ¿Cuál sería para un gran reto para una semilla en crecimiento? **(3.LS1.B)**

- Each student or student pair will roll for a piece of cotton from the pile that **did** germinate in the old river.

- To start, set the water level even with ground level at the top of the chart. Explain that this represents the seasonal flood that corresponds with the release of seeds from the cottonwood trees.

- Have each student or student pair flip a coin. If heads, move root one increment down; if tails, move root two increments (or roll the dice—odd move one increment, even move two). Each increment will represent approximately four inches of soil depth.

- To determine how the water level moves each round, have one student flip a coin or roll a dice for the whole class. Explain that the water table may lower faster in some areas than others, but, generally, within a small area, the water table lowers at the same rate. Therefore, only one flip per round for all activity sheets is needed for the water table. If the coin is heads, move the water table down one increment; if tails, move the water table down two increments (or if using dice, odd move one increment, even move two increments).

- Any time the water level drops below the root, that seedling dies. Mark it as dead. If the root of the seedling reaches the bottom of the chart before the water table, mark it as "alive." Explain that the bottom of the chart represents the lowest level of the water table for that area.

- Repeat this process for all of the cotton pieces that germinated in Step 1 for the Río Bravo. Count the number of seedlings that died and the number that lived, and record these on the board or in student journals.

- Discuss the difference between the number of seeds that reached the bottom of the chart and those that didn't. Based on this activity, *¿Que oportunidad tuvo una semilla de Álamo que germinó para poder sobrevivir? ¿Qué condiciones necesita para sobrevivir esta estación? ¿Cómo fueron afectados las semillas al cambiar el nivel freatico?* **(3.LS1.B; 3.LS2.C; Analyzing & Interpreting Data)**

Section B: Río Manso

- Have students play the Root Race game for each of the cotton balls in the pile of successfully germinating seeds from the Cottonwood Cotton Game. Explain that the "rules" have changed since the conditions along the river are different. Since the hydrology (the way water moves above and below ground) is different in the new river, explain that **the water table will drop by increments of one, two, or three,** but **seedling roots still grow in increments of one and two.**
- Now that the hydrology has been changed, the water table responds differently than it did with the old river. Humans have built dams, installed drains, drilled wells for homes and industry, and made other changes that have lowered groundwater levels, to the detriment of cottonwoods. When flipping for the water table, have students flip the coin twice. If they flip two heads, the water table drops one increment. If they flip one head and one tail, the water table drops two increments. If they flip two tails, the water table drops three increments. (With dice, a one or a two equals one increment, a three or a four equals two increments, and a five or six equals three increments.)
- Repeat the steps for all of the cotton pieces that germinated in the Río Manso round as before. Count the number of seedlings that died and the number that lived, and record these on the board or in student journals.
- Lead a discussion on this activity.

¿En qué ambiente crecen más álamos?

In Río Manso, young cottonwood trees are not being established in large enough numbers to replace older trees that die out.

Have students compare the results of established cottonwood seedlings between Río Bravo and Río Manso. How does this activity compare with the way cottonwood trees are really established? What other factors may affect cottonwood tree establishment? **(3.LS2.C; MS.LS2.A; Scale, Proportion & Quantity; Analyzing & Interpreting Data)**

Section C: Río Nuevo

- In the third river, Río Nuevo, new management strategies have goals of bringing as many of the characteristics of the Río Bravo as possible within the levees to today's river. This includes overbank flooding and creating conditions for cottonwoods to sprout and thrive (see Río Nuevo discussion in "Changing River" activity).

¿De qué manera han afectado los cambios hehos por los humanos a los álamos del bosque? ¿Cómo han impactado los diversos proyectos de restauración el establecimiento de los álamos? Haga una lista de los proyectos que ayudan a mejorar el establecimiento de los álamos y muestre esos proyectos en el modelos. ¿De qué manera podemos apoyar a los álamos hoy?

(3.LS4.D; 5.ESS3.C; MS.ESS3.C)

Assessments:

- Return to the KWL charts created at the beginning of this lesson. *What have students **Learned**? What more do they **Want** to know?*
- Students should be able to explain what conditions are needed for cottonwoods to germinate and grow. Without the correct conditions, cottonwoods—a key species in the bosque—will not successfully grow. Human-caused changes in the bosque have made it harder for cottonwood seedlings to grow and many mature trees are dying. **(Cause & Effect)**
- Have students demonstrate their own learning about cottonwood's life cycle through graphic, written or other means. **(Developing & Using Models)**

Extensions:

- For a variation, the teacher may choose to have a "heavy summer rainfall" so the groundwater does not drop during one round.
- Graph all the results to help understand the differences. Calculate the percent of cottonwood seeds that survived and did not survive. Create bar graphs or pie charts to compare the number of seeds produced by a tree and those that find the right conditions to grow. Compare those that start growing (germinate) with those that survive through the summer. **(Analyzing & Interpreting Data)**
- Use the lens of a System to think through the Structure and Function and/or Adaptations of cottonwoods—the system of a cottonwood tree itself. (See Appendix K) **(3.LS4.C; 4.LS1.A; Systems & System Models; Structure & Function)**
- What factors would lead to some seedlings surviving and some not? Explore concepts like the genetic diversity of any species and how natural selection might affect survival of seedlings. **(MS.LS4.B)**

NGSS Connections to Cottonwood Creation - Disciplinary Core Ideas

3.LS1.B Growth and Development of Organisms *Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.*

Cottonwood trees are very important to the bosque. In this activity, we focus on the conditions for germination and the needs of the growing cottonwood seedling.
How do cottonwoods reproduce? What type of seeds do they have?
What do they need to get started growing (germination)?
What is a big challenge for a growing seedling?
How does a cottonwood tree change through its lifetime?
How do cottonwoods change through the seasons? (flowers in spring, leaves only in warm months, turn yellow in fall—bringing nutrients back in for next year, no leaves in winter, buds in spring, etc…)

3.LS2.C Ecosystem Dynamics, Functioning and Resilience *When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.*

This activity delves into a specific example of a species and its survival—what allows a species to survive in its location.

Río Bravo: The river and bosque experienced annual and seasonal changes through spring runoff and the accompanying flood pulse.
What role does a spring flood play in cottonwood generation?
How does the river flow change during a year? (high water in spring, dropping through the summer)
How were the seedlings affected by the undergroundwater level?

Río Manso: Human-caused changes to the physical characteristics of the river and bosque influence the availability of resources and necessary physical conditions, which in turn affects a seedling's survival. Humans have altered the amount of water, when and where it is present and physical characteristics of sandbars and riverbanks, all of which affect the availability of germination sites.

The number of seeds that find the right conditions to germinate will differ between Río Bravo, Río Manso and Río Nuevo. *Have students predict what will happen in each time period—how and why have the conditions changed in each? and how does this affect the number of seeds that survive?*

3.LS4.C Adaptation *For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.*

The riparian ecosystem supports many more plant species than the arid uplands. Certain species are present only in one habitat or the other. Different plants are adapted to different environments.
What adaptations do cottonwoods have to help them survive in the bosque?
Where do cottonwoods survive well? Less well? Or not survive?

3.LS4.D Biodiversity and Humans *Populations live in a variety of habitats, and change in those habitats affects the organisms living there.*

Although floodplain ecosystems are very dynamic, with frequent changes to habitats occurring at a local scale, native organisms are less able to deal with the types of changes caused by humans. Prior to human changes, the diversity of species in New Mexican riparian habitats was very high. Changes in floodplain conditions have affected the number of cottonwoods able to germinate and survive in Río Manso.
How have humans changed the environment of the bosque?
How have these changes affected cottonwoods? (fewer seeds germinate; drought can kill mature cottonwoods)

4.LS1.A Structure and Function *Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.*

Plants have a variety of structures that allow them to survive in given habitats. Think about the cottonwoods and what structures help them to survive.
What structures do cottonwoods have to allow them to survive?
What helps them grow? What helps them reproduce?
Students can explore what cottonwood seeds look like, how they are dispersed, what parts of the tree get water and what parts get sunlight?

5.ESS3.C Human Impacts on Earth Systems *Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.*

Human activities have altered many features of the Río Grande and its floodplain. Consider how the hydrological changes have affected cottonwoods that live there. *In what ways have humans caused changes in the bosque that affect cottonwoods? In what ways can we help cottonwoods today?* (Do Río Nuevo section of Changing River model)

MS.LS1.B Growth, and Development of Organisms

-Animals engage in characteristic behaviors that increase the odds of reproduction.

-Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.

This activity focuses on a single species of plant—the cottonwood. *What specialized features do cottonwoods have for reproduction? With that knowledge, research and then compare to other plants. How do other plants reproduce? What other wind-pollinated plants are common? Do different trees have different methods of pollination?*

MS.LS2.A Interdependent Relationships in Ecosystems

-Organisms and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

-In any ecosystem, organisms and populations with similar requirements for food, water, oxygen or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

-Growth of organisms and population increases are limited by access to resources.

Cottonwood seedling establishment is limited by the availability of open spaces on moist soil, with ground water levels receding slowly. By completing the Cottonwood Cotton and Root Race games, students should be able to describe the limited resources available to seedlings; these resources limit the number of cottonwood trees that can get established.

MS.LS2.C Ecosystem Dynamics, Functioning & Resilience

--Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

--Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

How does the volume of spring flooding affect the number of cottonwood seeds that germinate?

How does the water table affect the survival of cottonwood seedlings?

MS. LS4.B Natural Selection*

Genetic variations among individuals in a population give some individuals an advantage in surviving and reproducing in their environment. This is known as natural selection. Natural Selection leads to the predominance of certain traits in a population, and the suppression of others.

What factors would lead to some seedlings surviving and some not? Explore concepts like the genetic diversity of any species and how natural selection might affect survival of seedlings.

MS.ESS3.C Human Impacts on Earth Systems

-Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

-Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

-The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

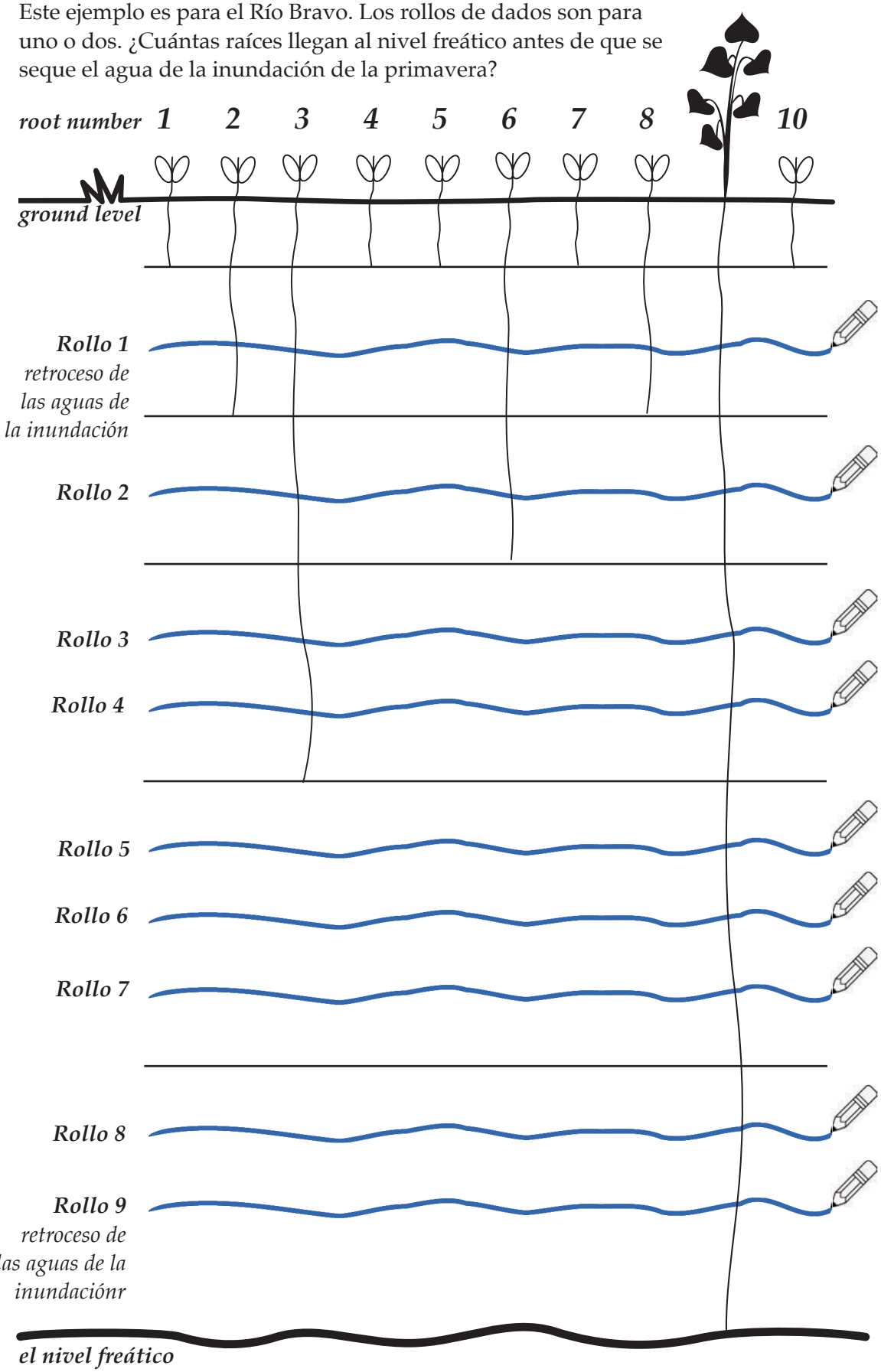
Human activities have altered many features of the Río Grande and its floodplain. Consider how the hydrological changes have affected cottonwoods that live there. Today, land managers are changing their tactics to improve the establishment of cottonwoods. Look at the Río Nuevo part of the Changing River model for ideas of management changes and how they may improve conditions for cottonwoods. *In what ways have humans caused changes in the bosque that affect cottonwoods? In what ways can we help cottonwoods today?*

Azulejo Garganta Azul refugiándose en una noche fría bajo la corteza de un árbol muerto de álamo.
Foto por Laurel Ladwig

Álamo del Río Grande
Foto por Mark Higgins

Teacher's Example: Root Race

Este ejemplo es para el Río Bravo. Los rollos de dados son para uno o dos. ¿Cuántas raíces llegan al nivel freático antes de que se seque el agua de la inundación de la primavera?



Root Race

¿Cuántas raíces alcanzarán el nivel freático antes de que se seque la inundación de la primavera?

Raíz número 1 2 3 4 5 6 7 8 9 10

Nivel de la tierra

el nivel freático