# *Appendix K: Standards Overview*

### *New Mexico STEM Ready! and Next Generation Science Standards*

The Rio Grande bosque is a dynamic and complex ecosystem, one that provides unique and essential habitats in this arid region. The primary focus of this *Guide* is to cultivate an understanding of how the bosque ecosystem functions. To that end, the main goal is to teach scientific concepts important to understanding this system and to support and promote the conservation and restoration of this valuable treasure. We hope you will use the *Guide* with this larger goal of understanding the bosque in mind, but in studying and learning about the bosque ecosystem your students can also address many of the New Mexico STEM Ready! Science Standards (NMSR!SS), as well as a number of New Mexico Common Core standards. The NMSR!SS include the Next Generation Science Standards (NGSS) adopted across the country plus six New Mexico-specific standards. Two of the New Mexico specific standards, those for grades 5 and middle school, are addressed with activities in the River of Change unit. Throughout this document, we generally refer to "NGSS" standards since the terms are used more widely, but note that NGSS in full is included in the New Mexico STEM Ready! Science Standards.

Your students will meet many of the performance expectations from the NGSS by engaging with Disciplinary Core Ideas (DCIs), Crosscutting Concepts (CCCs) and Science and Engineering Practices (SEPs) associated with each activity. To gain an understanding of how the bosque ecosystem works, we recommend that you do all of the core River of Change activities (Chapter 4) in the classroom, and also that you take your students out to the bosque at least once (see Chapter 3, "Going Out: Field Activities"). A field trip will help your students reflect on the real bosque compared to the model bosque they create in the classroom, and will help promote the multi-dimensional, phenomenon-based learning that is a goal of the NGSS. Additional classroom activities are provided that support the model-based, core activities of the program, and provide further opportunities to address the NGSS and the specific New Mexico standards. We encourage you to include as many of these in your lessons as you can.

In this overview, we will highlight those DCIs, CCCs and SEPs that apply to the multiple activities in the River of Change chapter that use the Changing River model. More detail, particularly for the DCIs, is included at the end of each activity, and references are provided in the body of each activity to show where the standards fit in. We encourage you to teach the full activity and not to focus only on a particular standard! By completing the full unit, including all of the river model activities, you will address a number of these standards from different perspectives, which will promote students meeting the performance expectations.

Enjoy the journey as you move through the *Bosque Education Guide* activities, and you will find that the many NGSS/NM STEM Ready! and Common Core standards can be met along the way!

| Lesson number & title | 13 Changing River | 14 Cottonwood Creation | 15 Who Lives Where? | 16 Who Grows Where? | 17 Working Water | 18 Bosque Chaos |
|---|---|---|---|---|---|---|
| **Disciplinary Core Ideas** | | | | | | |
| 3.LS1.B Growth & Development | X | X | | | | |
| 3.LS2.C Ecosystem Dynamics | X | X | X | X | | X |
| 3.LS2.D Social Interactions | | | X* | | | |
| 3.LS4.C Adaptation | X | X | X | X | | X |
| 3.LS4.D Biodiversity & Humans | X | X | X | X | | X |
| 3.ESS3.B Natural Hazards | X | | | | | X |
| | | | | | | |
| 4.LS1.A Structure & Function | | X | X | X | | X |
| 4.ESS2.A Earth Materials & Systems | X | | | | | X |
| 4.ESS3.B Natural Hazards | X | | | | | X |
| | | | | | | |
| 5.LS1.C Matter & Energy in Organisms | | | X* | | | |
| 5.LS2.A Interdependent Relationships | | | X* | X* | | |
| 5.ESS3.C Human Impacts | X | X | X | X | X | X |
| 5.PS2.B Types of Interactions | | | | | X | |
| 5.ETS2.A Science & Society | X | | X | | | |
| 5-SS-1 NM PE | X | | X | | | |
| | | | | | | |
| MS.LS1.B Growth & Development | | X | X | X | | |
| MS.LS2.A Interdependent Relationships | X | X | X | X | | |
| MS.LS2.C Ecosystem Dynamics | X | X | X | X | | X |
| MS.LS4.B Natural Selection | | X* | | | | |
| MS.LS4.D Biodiversity & Humans | X | | X | X | | |
| MS.ESS2.C Role of Water | X | | | | | X |
| MS.ESS3.A Natural Resources | X | | | | | |
| MS.ESS3.C Human Impacts | X | X | X | X | X | |
| MS.ETS2.B Influence of STEM | X | | | | X | |
| MS-ESS3-3 NM PE | X | X | X | X | X | |

| Lesson number & title | 13 Changing River | 14 Cottonwood Creation | 15 Who Lives Where? | 16 Who Grows Where? | 17 Working Water | 18 Bosque Chaos |
|---|---|---|---|---|---|---|
| **Crosscutting Concepts** | | | | | | |
| Patterns | X | X | X | X | | X |
| Cause & Effect | X | X | X | X | X | X |
| Scale, Proportion & Quantity | X | X | | | | X |
| Systems & System Models | X | X* | X* | X* | X | X |
| Energy & Matter: Flows, Cycles & Conservation | X | | X | X | | X |
| Structure & Function | | X | X | X | | X |
| Stability & Change | X | | X | X | | X |
| | | | | | | |
| **Science and Engineering Practices** | | | | | | |
| Asking Questions & Defining Problems | X | X | X | X | X | X |
| Developing & Using Models | X | X | X | X | X | X |
| Analyzing & Interpreting Data | | X | | | | |
| Constructing Explanations & Designing Solutions | X | | X | X | X* | X |
| Engaging in Argument from Evidence | X | | X | X | | X* |
| Obtaining, Evaluating & Communicating Information | X | | X* | X* | X* | X* |

* Indicates extension activity

*Bushtit collecting nesting material in an ABQ Backyard Refuge*
Photograph by Laurel Ladwig

**When We Say Standards...**

**NMSR!SS = New Mexico STEM Ready! Science Standards**
**STEM = Science Technology Engineering Mathematics**
**NGSS = Next Generation Science Standards**
**DCIs = Disciplinary Core Ideas**
**CCCs = Crosscutting Concepts**
**SEPs = Science and Engineering Practices**
**PEs = Performance Expectations**

## Performance Expectations (PEs)

The writers of this *Guide* made a conscious decision not to highlight the connections to NGSS Performance Expectations (PEs). According to the architects of the NGSS, PEs are a "set of expectations for what students should be able to do by the end of instruction (years or grade-bands)." PEs are not day-to-day standards, but are end-points or targets that all instruction should point towards. By completing all of the River of Change activities, your students will have multiple opportunities to address the DCIs, CCCs and SEPs that support the performance expectation goals. The New Mexico specific standard PEs are included below as they are part of the NMSR!SS.

## Disciplinary Core Ideas (DCIs)

Below is an overview of each of the DCIs that are addressed through the river model activities, along with a reference to which activities apply. Included in each activity description are suggested discussion questions and prompts to help students understand the connection to the DCI. More detailed information is provided for grades 3-5 at the end of each activity; details for Middle School, including discussion questions, are provided below. These prompts are suggestions and are not meant to be exclusive – encourage discussion and seek your own questions! Again, by encountering any given DCI in multiple activities, students will develop a broader understanding that will support meeting the performance expectations.

**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.*

Changing River Cottonwood Creation

**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.*

Changing River Cottonwood Creation Who Lives Where?
Who Grows Where? Bosque Chaos

**3.LS2.D Social Interactions and Group Behavior** *Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.*

Who Lives Where? (extension activity)

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

Changing River Cottonwood Creation Who Lives Where?
Who Grows Where? Bosque Chaos

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

Changing River | Cottonwood Creation | Who Lives Where? | Who Grows Where? | Bosque Chaos

**3.ESS3.B Natural Hazards** *A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.*

Changing River | Bosque Chaos

**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.*

Cottonwood Creation | Who Lives Where? | Who Grows Where? | Bosque Chaos

**4.ESS2.A Earth Materials and Systems** *Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.*

Changing River | Bosque Chaos

**4.ESS3.B Natural Hazards** *A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.*

Changing River | Bosque Chaos

**5.LS1.C Organization for Matter and Energy Flow in Organisms** *Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion.*

Who Lives Where? (extension activity)

**5.LS2.A Interdependent Relationships in Ecosystems** *The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.*

Who Lives Where? (extension activity) | Who Grows Where? (extension activity)

**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.*

Changing River | Cottonwood Creation | Who Lives Where? | Who Grows Where? | Working Water | Bosque Chaos

**5.PS2.B Motion and Stability; Forces and Interactions; Types of Interactions** *The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.*

Working Water

**5.ETS2.A Interdependence of Science, Engineering, and Technology**

*-Advances in science offer new capabilities, new materials or new understanding of processes that can be applied through engineering to produce advances in technology.*

*-Advances in technology, in turn provide scientists with new capabilities to probe the natural world at larger or smaller scales; to record, manage and analyze data; and to model ever more complex systems with greater precision.*

*-In addition, engineers' efforts to develop or improve technologies often raise new questions for scientists' investigation.*

Changing River Who Lives Where?

## Middle School DCI Connections

**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*

· *How do organisms grow and develop?*

**Cottonwood Creation**

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?*

**Who Lives Where?**

Use *Who Lives Where?* cards along with additional outside research to address how characteristic animal behaviors affect the probability of successful reproduction of animals.

**Who Grows Where?**

Use *Who Grows Where?* cards along with additional outside research to address how specialized plant structures affect the probability of successful reproduction.

**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.*

· *How do organisms interact with the living and nonliving environments to obtain matter and energy?*

**Changing River**

After building the Rio Bravo model, pose this question: *How are cottonwoods dependent on other living things as well as nonliving parts of the ecosystem?* Some of these are demonstrated in the model. (Cottonwoods need clear/unshaded, sandy, wet areas to germinate.)

After converting the model to Rio Manso, pose the question: *What plant species might be competing for resources?* (Compare cottonwood and saltcedar.) *What resources are now limited in the Rio Manso time?* (Flooding is rare, and wetlands are reduced.) *What species are affected by this limited resource?*

**Cottonwood Creation**

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.

**Who Lives Where?**

Pick one species of animal. *How are those animals dependent on interactions with other living creatures? (What do they consume? What eats them? What plants do they need—i.e. nest sites?) What nonliving factors does that species depend on? (What water does it need? Is it possible for too much or too little? Temperature? Soil type?* Brainstorm ideas.*) Are there other bosque species with similar needs? Do they compete? How do they differentiate their role in the ecosystem?* Both beavers and porcupines eat cambium—the inner bark of trees. *Do they eat the same way? Are they direct competitors? How does flooding, a resource for some animals, affect the population of some animals?* (Example-Rio Grande silvery minnow) Look at a native and non-native species like Northern leopard frog and bullfrog. *In what way do they directly compete for resources? How do introduced species affect native species when they are competing for the same resources?*

**Who Grows Where?**

Pick one species of plant. *How are those plants dependent on interactions with other living plants/creatures? What do they need?* (Cottonwoods need shade to germinate.) *What eats them? What nonliving factors does that species depend on? (What water does it need? Is it possible for too much or too little? Temperature? Soil type?* Brainstorm ideas.*)* Consider cottonwoods. *How does flooding, a resource for them, affect the population of cottonwoods?* Look at a native and non-native riparian species like cottonwood and saltcedar. *In what way do they directly compete for resources? How do introduced species affect native species when they are competing for the same resources?*

**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.*

· *What happens to ecosystems when the environment changes?*

**Changing River**

You can first look at seasonal changes to the river in Rio Bravo. *What is the impact of high spring runoff water in this ecosystem on different plant species?*

Then make the Rio Manso changes to the model. *What physical changes have humans made to the ecosystem?* (Consider the effects of physical changes on native species: amount of water in the river—water level changes through the year, wetland and side channel changes, change in sediment size, sandbars, etc.) There are now introduced species such as saltcedar. *What effects does saltcedar have on other populations?*

There are future concerns such as more frequent drought in the Southwest due to climate change. Land managers and engineers have to be creative in providing conditions for long-term survival of cottonwoods. Cottonwoods are susceptible to drought and resulting lower water table (Mature cottonwoods will die if water table drops below 3 meters/10 feet.)

*What do cottonwoods need to survive?*

**Cottonwood Creation**

*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?*

**Who Lives Where?**

Each year the flood pulse may make changes to the river channel and banks. Make lists of animals affected by changes in the river, sandbars, banks and floodplain. *How does a change in the physical river or its floodplain affect animals that live in the bosque?* Make the Rio Manso changes to the model. *How do introduced non-native species affect native animals in the bosque?*

**Who Grows Where?**

Each year the flood pulse may make changes to the river channel and banks. *What plants are affected by changes in the river, sandbars, banks and floodplain? In what ways are those plants affected?* Make the Rio Manso changes to the model. *What native species are affected by these human-caused changes? How do introduced non-native species affect native plants in the bosque?*

**Bosque Chaos**

Change is inherently part of floodplain ecosystems. This dynamic nature means that the exact conditions at a given location are often determined by chance. Students learn how these changes affect bosque organisms and habitats, and how human changes have further affected the system.

*What types of changes are naturally part of the floodplain ecosystems?*

*How do local, native plants deal with these changes?*

*How have humans altered this system?*

*What new changes are faced by these organisms, and how do they adjust?*

**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.*

· *How does genetic variation among organisms affect survival and reproduction?*

**Cottonwood Creation (Extension)**

*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.D Biodiversity & Humans**

*Changes in biodiversity can influence human's resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.*

· *What is biodiversity, how do humans affect it, and how does it affect humans?*

**Changing River**

*How do the human-caused changes to bosque habitats affect the organisms living there?*

*What value can people put on the bosque? What benefit does the bosque give to humans? (Monetary, spiritual, ecological, mental, etc….)*

**Who Lives Where?**

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 habitats have affected the types of animals living there.

*What types of changes in floodplain habitats have affected the animals that live there?*

*How do these changes in floodplain habitats affect the animals that currently are or used to be found in the bosque?*

**Who Grows Where?**

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 habitats have affected the types of plants living there.

*What types of changes in floodplain habitats have affected the plants that live there?*

*How do these changes in floodplain habitats affect which plants are present in the floodplain?*

**MS.ESS2.C The Roles of Water in Earth's Surface Processes**

*Water continually cycles among land, ocean, and atmosphere via transpiration, condensation, and crystallization, and precipitation, as well as downhill flows on land.*

*-Global movements of water and its changes in form are propelled by sunlight and gravity.*

*-Water's movement on land cause weathering and erosion, which change the land's surface features.*

· *How do the properties and movement of water shape the Earth's surface and affect its systems?*

**Changing River**

The high water flows in spring move sediment and change features of the river channel and floodplain. These changes create and destroy habitats within the floodplain ecosystem seasonally and over the years. Water is vital in creating riparian habitats. Focus on water moving sediment here. *How does the river change the features of the river ecosystem?*

**Bosque Chaos**

The annual flood pulse, created by high spring runoff, brings energy into the river system. With the energy from the increased flow, changes can occur. *What kinds of changes can the energy of the flooding river bring to the bosque ecosystem, and to the river channel?* Brainstorm the types of changes that might be expected.

*Along Rio Bravo, in what ways does water change habitats in the floodplain?*

*How do floodplain ecosystems change as a result of floods along the river?*

Consider the natural annual cycle of the river.

*How did habitats along the floodplain change naturally in Rio Bravo?*

*What caused these changes?*

**MS.ESS3.A Natural Resources**

*Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.*

· *How do humans depend on Earth's resources?*

**Changing River**

Water is a critical resource for people living in the arid Southwest. Look where cities and towns are located; the source of water is vital to their community's survival. The Rio Grande provides water for many communities in New Mexico. There are a variety of projects or water resource management. See the full list under the NM performance expectation.

**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.*

· *How do humans change the planet?*

**Changing River/Who Lives Where?/Who Grows Where?**

Humans have made many changes to the river valley and the river channel, and these human alterations have changed the dynamic nature of the Rio Grande floodplain and altered many aspects of natural habitats (changing from Rio Bravo to Rio Manso). In Rio Nuevo, students learn how humans are able to make new changes that help restore some of the natural floodplain ecosystems.

*What changes did humans make along the Rio Grande to promote agriculture and allow settlement along the floodplain?*

*How did those human alterations affect the bosque, and how could they be modified to allow a more natural, dynamic system?*

*What are the effects on native species from these human activities?*

*How can we decrease the number of individuals of species that are threatened or endangered?*

Land managers along the Rio Grande have made a definite shift in their priorities for how the river and floodplain are used, with a greater emphasis now on protecting natural biodiversity. Follow up any of the above activities by considering the following:

*How do you think the biodiversity of the bosque affects you, your family, your community?*

*Is it important to protect the bosque? If so, why?*

Design a conservation plan for the bosque that will protect native plants and animals while also contributing to the well-being of human communities living nearby.

**Cottonwood Creation**

Human activities have altered many features of the Rio 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 Rio 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?*

**Working Water**

Humans have made many changes to the Rio Grande Valley, some of them to help farmers get dependable water for their crops. Diversion dams direct water from the river into highline canals and irrigation ditches; deep trenches called drains ensure fields are not water-logged. Levees keep the river from flooding homes and agricultural fields. Water in ditches may help cottonwoods and other native plants grow in places away from the river. While flood irrigation is common in the valley, farmers typically have their field laser-leveled which reduces water use.

*How has agriculture affected the Rio Grande Valley?*
*How have farming practices changed over the last century?*
*What engineering projects have been built to provide water for irrigation for farmers?*
*What engineering projects protect our communities from flooding?*
*What engineering projects help farmers conserve water?*

What are positive and negative impacts from agriculture—brainstorm lists of each.

**MS.ETS2.B Influence of Engineering, Technology, and Science on Society and the Natural World**

*The uses of technologies and any limitations on their use are driven by individual or societal needs, desires and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.*

- *How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world?*

**Changing River/Working Water**

After years of building structures in the Rio Grande and its floodplain with the goals of reducing flooding, drying out waterlogged soils and delivering water for irrigation, biologists began to see impacts on the bosque ecosystem that were not intended or expected. The cottonwood forest corridor of the river was getting old, with few seedlings growing to replace them. Fish species like the Rio Grande silvery minnow were not finding the shallow, muddy, backwater areas needed to lay their eggs and produce successful fry. Use any of the following ideas after the "Changing River" activity to explore how New Mexicans have urged changes to the management of the river over time and how they are urging preservation of the bosque into the future.

*How does the public influence/impact the management of the bosque?*
*How has the management of the bosque changed from the early 1900s to today? Describe who has influenced changes in management over these decades?*

List long term impacts of major engineering projects concerning Rio Grande water, including original intent and unexpected results. Examples: dams, levees, sewage treatment plants, irrigation, agriculture, city water use, straightening the river, jetty jacks, San Juan-Chama diversion, growth of cities, pollution, industry, mining,

## Crosscutting Concepts (CCCs)

Crosscutting Concepts are intended to help students make connections and broaden their understanding across different areas of disciplinary study. By their very nature, they are meant to apply to a variety of activities and to be revisited often during the course of study. We provide suggestions for applying CCCs to the lessons in the *Guide*. We have included prompts in the descriptions of each activity that show where CCCs might apply. We encourage you to look for more connections as you explore these activities!

### Patterns

*Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.*

The Rio Grande once experienced temporal (time: seasonal or annual) patterns in flooding that structured floodplain ecosystems and determined the species that survived there. Flooding created spatial patterns in habitats, but random chance also influenced these patterns. For example, consider the shape of the river channel in Bravo, Manso, Nuevo. Look for patterns in the distribution of different plant species based on local conditions or similar adaptations of organisms depending on their habitat.

### Cause and Effect: Mechanism & Explanation

*Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.*

Prior to human alterations, flooding along the Rio Grande was caused by heavy snowfall or precipitation in the mountains. These events impacted the distribution of habitats along the floodplain, and determined which organisms could live there. Changes to the hydrology and increased use of the floodplain have increase the frequency and severity of fires.

Students can write a Claim, Evidence, Reasoning statement about a variety of topics, such as

- *The effect of flooding on the bosque.*
- *The effect of dams/levees/jettyjacks on the river and bosque.*
- *The effect of removing flooding or lowering the groundwater on the risk of fire.*

### Scale, Proportion, and Quantity

*In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion or quantity affect a system's structure or performance.*

The Rio Grande was once a dynamic system that changed greatly over time and space within the floodplain. Changes were much less predictable at a small spatial or temporal (time) scale, but habitats were predictable when considered over a longer time or larger area. Consider the natural annual cycle of the river, and variation that was present both temporally and spatially. Consider how the floodplain changed over time and space, and how this dynamic system was changed by human activity.

**Systems and System Models**

*Defining the system under study – specifying its boundaries and making explicit a model of that system – provides tools for understanding and testing ideas that are applicable throughout science and engineering.*

These activities model a system—the bosque ecosystem. Use the lens of systems to learn about this ecosystem through each of these Changing River activities. In this context, a system could be as big as the whole floodplain or as small as a single organism, like a cottonwood tree. Brainstorm with students: Boundaries, components, interactions, inputs and outputs, and properties.

Here are more tips for using a Systems lens:

1. Look for the bigger picture.
2. Study systems from multiple perspectives.
3. Consider the role of short and long time frames.
4. Search for complex cause and effect relationships.
5. Explore places where systems connect with other systems.

--WestEd / *Making Sense of Science*

**Energy & Matter: Flows, Cycles and Conservation**

*Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.*

Both animals, or plants, can provide an excellent path to understanding both matter and energy in ecosystems.

*How do animals get the energy and matter they need? What about plants?*

Consider the activity of animals / plants to observe how energy or matter might be transported into, out of, or within an ecosystem.

**Structure and Function**

*The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.*

Consider both plants and animals.

*How does an organism's shape affect the way it lives and operates, and in turn the way it survives?*
*How are different species similar or different in the way they are shaped and how they function?*
*Are any particular structures more suited to life along the river or in the bosque?*

**Stability and Change**

*For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.*

The Rio Grande floodplain is an inherently dynamic system, with both temporal (time) and spatial changes occurring regularly, but often in a random fashion. Stability is observed when one looks at a larger spatial and temporal scale. Seemingly simple changes such as removing flooding and lowering the groundwater have dramatically impacted the bosque. Consider the natural annual cycle and also changes after human alterations in the floodplain.

## Science and Engineering Practices (SEPs)

Science and Engineering Practices provide students with an opportunity to experience how scientists and engineers go about doing their jobs, including learning both the general skills required and also the basic knowledge needed to carry out their studies. Like the CCCs, SEPs apply across many of the activities in this *Guide*. Here we provide some general suggestions on how to fit these into your lesson plans.

### Asking Questions and Defining Problems

*A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and that can be empirically tested. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify the ideas of others.*

Science is not a collection of facts, but a process of exploration that is driven by questions and leads to more questions. Students need to learn to be comfortable with asking questions and exploring ideas without feeling that an answer is the endpoint of their learning. For any of these activities, you can begin with students creating KWL charts. You can start this chart with the Changing River activity, and then add new questions with each of the new activities. This can be started with a think, pair, share. Students have a few minutes to think about the topic and write a few ideas down; then discuss and continue to brainstorm with another student or small group, then share with the whole class.

For example, ask the question:

--*What do we **Know** about the bosque?*

-- *What do we **Want** to know about the bosque?*

Then after the lesson they answer,

--*What have we **Learned** about the bosque?*

Through this process, you prime your students for learning, and you can include activities that will help answer their questions. You probably want to come back to the chart frequently—to show what they have learned and to add their new questions!

### Developing and Using Models

*A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.*

The core activities of the *Guide* focus on the use of the river model to illustrate concepts related to the river and floodplain ecology. Students model the bosque ecosystem under the three different river conditions through time – Rio Bravo, Rio Manso and Rio Nuevo. The model illustrates how human alterations have changed the ecosystem, and how people can make further changes to keep as many aspects of Rio Bravo as possible into the future. Different activities include different components of the ecosystem, such as where plants and animals live or the changing role of chance or fire in the bosque. Students will model part of the life cycle of the cottonwood tree. Have students discuss the benefits and limitations of any model they use.

Assessment: After building the class model of the bosque ecosystem, students can make their own model illustrating the three rivers over time, or some particular aspect of the river as studied in these activities. They can draw on paper or white board, make 3-D model, video or photos, etc. This type of assessment can apply to any of the activities individually, or to the unit as whole.

### Analyzing and Interpreting Data

*Scientific investigations produce data that must be analyzed to derive meaning. Scientists use a range of tools to identify significant features and patterns in the data. Engineering investigations include analysis of data collected in tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria.*

Data analysis and interpretation is limited in the River of Change activities. "Cottonwood Creation" involves data collection and analysis.

### Constructing Explanations and Designing Solutions

*The goal of science is the construction of theories that provide explanatory accounts of the material world. The goal of engineering design is a systematic approach to solving engineering problems that is based on scientific knowledge and models of the material world.*

There are numerous opportunities for students to construct theories explaining phenomena related to the river and bosque, or to design solutions to engineering problems. This applies across all of the activities. For example, they can construct theories about how likely it is that the cottonwood bosque will survive as it is today, or to explain the effect of dams/levees/jettyjacks on the river. They can design solutions for how to solve the problem of restoring the natural hydrology or improving habitat or decreasing the impact of fire.

### Engaging in Argument from Evidence

*In science, reasoning and argument are essential for clarifying strengths and weaknesses of a line of evidence and for identifying the best explanation for a natural phenomenon. In engineering, reasoning and arguments are essential for finding the best solution to a problem. Engineers collaborate with their peers throughout the design process.*

This SEP can be addressed with any of the core activities. We suggest using a Claim, Evidence, Reasoning (CER) framework as an assessment tool. For example, consider the effect of flooding on the bosque, or the increase in fires due to lack of flooding, or the role that land managers can play in restoring the health of floodplain ecosystems.

### Obtaining, Evaluating, and Communicating Information

*Science advances when scientists are able to communicate their findings clearly and persuasively, and learn about the findings of others. Engineering produces new or improved technologies when the advantages of their designs are communicated clearly and persuasively.*

This SEP can be addressed as an extension or assessment to any of the core activities. Suggestions for topics are included for each activity. Share these ideas orally, or by writing letters, flyers, posters or books (connect to ELA/Common Core Standards).

## New Mexico Specific Standards

*Because these performance expectations are unique to New Mexico, we present the PEs as well as the supporting DCIs, CCCs and SEPs that can be addressed by the River of Change activities.*

**Performance Expectation 5-SS-1 NM**

*Communicate information gathered from books, reliable media, or outside sources, that describes how a variety of scientists and engineers across New Mexico have improved existing technologies, developed new ones, or improved society through applications of science.*

**DCI: 5.ETS2.A** *Interdependence of Science, Engineering, and Technology*

*-Advances in science offer new capabilities, new materials or new understanding of processes that can be applied through engineering to produce advances in technology.*

*-Advances in technology, in turn provide scientists with new capabilities to probe the natural world at larger or smaller scales; to record, manage and analyze data; and to model ever more complex systems with greater precision.*

*-In addition, engineers' efforts to develop or improve technologies often raise new questions for scientists' investigation.*

After years of building structures in the Rio Grande and its floodplain with the goals of reducing flooding and delivering irrigation water, biologists began to see impacts on the bosque ecosystem that were not intended or expected. The cottonwood forest corridor of the river was getting old, with few seedlings growing to replace them. Fish species like the Rio Grande silvery minnow were not finding the shallow, muddy, backwater areas needed to lay their eggs and produce successful fry. Use any of the following ideas after completing the "Changing River" or "Who Lives Where?" activities to explore New Mexico scientists and engineers and how they are helping preserve the bosque into the future. Any of these assignments will address ELA standards.

- *What engineering efforts could help the Rio Grande silvery minnow?* For a case study, look at the Los Lunas Rio Grande Silvery Minnow Refugium, that has received awards for its engineering design.
- *What other science-based engineering efforts are being used for bosque restoration?* Read the "Bulldozers in the Bosque" essay in the River of Change chapter introduction for one example.
- Miles of jetty jacks were installed in the 1950s. *Are/were they working? What did they help? What drawbacks do they present?*
- "Drains" were built throughout the valley. Many people see drains and think they are the Rio Grande, but they are not. *What are they? Why were they built and what do they do?*
- There are different dams on the Rio Grande. They are built for different reasons and purposes. Research any of them, but two to consider are Cochiti and Angostura. *How are they the same? How are they different?*
- Bosque Ecosystem Monitoring Program (BEMP) has been researching the Rio Grande bosque for many years. Go to their website and look at the monthly data they collect. Some of their results have been published or posted. *How has this research, with data collected by school students, helped resource managers along the Rio Grande?*

**CCC: Science is a Human Endeavor**

- *Men and women from all cultures and backgrounds choose careers as scientists and engineers.*
- *Most scientists and engineers work in teams.*
- *Science affects everyday life.*
- *Creativity and imagination are important to science.*

**CCC: Science is a Way of Knowing.**

· *Science is both a body of knowledge and process that add new knowledge.*

· *Science is a way of knowing that is used by many people.*

**SEPs: Obtaining, Evaluating & Communicating Information**

**Performance Expectation MS-ESS3-3 NM**

*Describe the advantages and disadvantages associated with technologies related to local industries and energy production.*

*[Clarification statement: Examples may include examining short and long term impacts of related technologies on water usage (such as withdrawal of water from streams and aquifers, the construction of dams and levees, or sewage treatment plants), land usage (such as urban development, agriculture, the removal of wetlands, or solar panel installation), pollution (such as of the air, water, or land), local employment, and economic stimulus.]*

**DCI: MS.ESS3.A Natural Resources** *Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.*

Water is a critical resource for people living in the arid Southwest. Look where cities and towns are located; the source of water is vital to their community's survival. The Rio Grande provides water for many communities in New Mexico. There are a variety of projects designed to help provide water to users along the Rio Grande. Use any of these prompts after the "Changing River" activity for further research:

· San Juan-Chama project

· Irrigation dams

· Flood control dams

· Irrigation systems—acequias, and irrigation districts

· If all the upstream users take as much water as they can, what is left downstream?

· Climate change is expected to reduce the snowpack in the mountains that feed the Rio Grande. What impact will that have on river flow in the future?

· Water quality. What is upstream of you that might affect the quality of water coming to you? What are ways to clean-up water coming from upstream?

· The Albuquerque Bernalillo County Water Utility Authority's 100-year plan for water resource management, called "Water 2021".

**DCI: MS.ESS3.C Human Impacts on Earth Systems**

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

Land managers along the Rio Grande have made a definite shift in their priorities for how the river and floodplain are used, with a greater emphasis now on protecting natural biodiversity. Follow up the "Changing River", "Who Lives Where?" and "Who Grows Where?" activities by considering the following:

*How do you think the biodiversity of the bosque affects you, your family, your community?*

*Is it important to protect the bosque? If so, why, or why not?*

Design a conservation plan for the bosque that will protect native plants and animals while also contributing to the well-being of human communities living nearby.

**DCI: MS.ETS2.B Influence of Engineering, Technology, and Science on Society and the Natural World**

*The uses of technologies and any limitations on their use are driven by individual or societal needs, desires and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.*

After years of building structures in the Rio Grande and its floodplain with the goals of reducing flooding, drying out waterlogged soils and delivering water for irrigation, biologists began to see impacts on the bosque ecosystem that were not intended or expected. The cottonwood forest corridor of the river was getting old, with few seedlings growing to replace them. Fish species like the Rio Grande silvery minnow were not finding the shallow, muddy, backwater areas needed to lay their eggs and produce successful fry. Use any of the following ideas after the "Changing River" activity to explore how New Mexicans have urged changes to the management of the river over time and how they are urging preservation of the bosque into the future.

*How does the public influence/impact the management of the bosque?*

*How has the management of the bosque changed from the early 1900s to today? Describe who has influenced changes in management over these decades?*

List long term impacts of major engineering projects concerning Rio Grande water, including original intent and unexpected results. Examples: dams, levees, sewage treatment plants, irrigation, agriculture, city water use, straightening the river, jetty jacks, San Juan-Chama diversion, growth of cities, pollution, industry, mining,

**CCCs: Cause & Effect; Systems & System Models**

**SEPs: Engaging in Argument from Evidence; Obtaining, Evaluating & Communicating Information**

# Common Core Connections

## English Language Arts Standards Grade 3

**Reading: Informational Text:**

CCSS.ELA-LITERACY.RI.3.1 Ask and answer questions

CCSS.ELA-LITERACY.RI.3.2 Determine the main idea

CCSS.ELA-LITERACY.RI.3.3 Describe the relationship between a series of events or ideas

**Writing:**

CCSS.ELA-LITERACY.W.3.2 Write informative/explanatory texts

CCSS.ELA-LITERACY.W.3.4 Produce writing appropriate to task and purpose

CCSS.ELA-LITERACY.W.3.5 Develop and strengthen writing as needed

CCSS.ELA-LITERACY.W.3.6 Use technology to produce and publish writing

CCSS.ELA-LITERACY.W.3.7 Conduct short research projects that build knowledge

CCSS.ELA-LITERACY.W.3.8 Recall information from experiences or gather information

**Speaking and Listening:**

CCSS.ELA-LITERACY.SL.3.1 Engage effectively in a range of collaborative discussions

## English Language Arts Standards Grade 4

**Reading: Informational Text:**

CCSS.ELA-LITERACY.RI.4.1 Refer to details and examples in a text

CCSS.ELA-LITERACY.RI.4.2 Determine the main idea of a text

CCSS.ELA-LITERACY.RI.4.3 Explain events, procedures, ideas, or concepts

CCSS.ELA-LITERACY.RI.4.7 Interpret information presented visually, orally, quantitatively

**Writing:**

CCSS.ELA-LITERACY.W.4.2 Write informative/explanatory texts

CCSS.ELA-LITERACY.W.4.7 Conduct short research projects that build knowledge

CCSS.ELA-LITERACY.W.4.8 Recall relevant information from experiences

**Speaking and Listening:**

CCSS.ELA-LITERACY.SL.4.1 Engage effectively in a range of collaborative discussions

CCSS.ELA-LITERACY.SL.4.4 Report on a topic or text, tell a story, or recount an experience

**Language:**

CCSS.ELA-LITERACY.L.4.6 Acquire and use accurately grade-appropriate words, phrases

## English Language Arts Standards Grade 5

**Reading: Informational Text:**

CCSS.ELA-LITERACY.RI.5.1 Quote accurately from a text when explaining the text

CCSS.ELA-LITERACY.RI.5.2 Determine two or more main ideas of a text, summarize text

CCSS.ELA-LITERACY.RI.5.3 Explain the relationships or interactions based on texts

CCSS.ELA-LITERACY.RI.5.9 Integrate information from several texts on the same topic

**Writing:**

CCSS.ELA-LITERACY.W.5.1 Write opinion pieces on topics or texts based on information

CCSS.ELA-LITERACY.W.5.2 Write informative/explanatory texts to examine a topic

CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources

## Math Standards Grades 3 to 5

Several activities provide opportunities to use graphs and charts to represent and interpret data as well as opportunities for measurement in various ways. Scientists use math all of the time.

*Woodhouse Toad*
Photograph by Letitia Morris