



24.

Invasive Species

Description: Students work in teams of two to research invasive species in the bosque to develop a management plan for a fictional wildlife refuge. Then, students develop recommendations for improving the situation at the refuge and produce a presentation of their recommendations.

Objectives: Students will:

- search for biological resource information;
- understand how invasive species affect an ecosystem; and
- prepare a basic species management plan.

Materials:

- Computers with internet access (one for each team of two students)
- Copies of student activity pages
- Supplies for making posters or software for creating computer presentations

Phenomena: There are species of plants and animals living in the bosque that have never been here before; invasive species are outcompeting native species for habitat.

Lesson Question:

- *How can a wildlife refuge manage invasive species to benefit native ones?*

24. Invasive Species



Grades: 6-12

Time: three hours for internet research; two hours for writing management plan; time for class presentations

Subjects: science

Terms: *alien species, exotic species, introduced species, invasive species, native species, non-native species, noxious species, webography/webliography*



New Mexico STEM Ready! / Next Generation Science Standards NGSS DCIs and New Mexico State Performance Expectations

MS.LS2.A Interdependent Relationships in Ecosystems
 MS.LS2.C Ecosystem Dynamics, Functioning & Resilience
 MS.ESS3.C Human Impacts on Earth Systems
 MS.ESS3.D Global Climate Change*
 HS.LS2.C (HS-LS2-7 NM) Ecosystem Dynamics, Functioning & Resilience
 HS.LS4.D (HS-LS2-7 NM) Biodiversity & Humans
 HS.ESS3.C Human Impacts on Earth Systems
 HS.ESS3.D Global Climate Change*
 HS.ETS1.A (HS-SS-2 NM) Defining & Delimiting Engineering Problems
 HS.ETS1.B (HS-LS2-7 NM & HS-SS-2 NM) Developing Possible Solutions

NGSS CCCs

Patterns; Cause & Effect; Structure & Function; Stability & Change

NGSS SEPs

Asking Questions & Defining Problems; Constructing Explanations & Designing Solutions;
 Engaging in Argument from Evidence; Obtaining, Evaluating & Communicating
 Information

(* indicates extension activity)

Terms

Native species: an organism indigenous to a particular area, occurring within its natural range or within the area in which it evolved.

Non-native/exotic/introduced/alien species: these are all terms used to describe an organism occurring outside its natural range. Such species are not necessarily invasive but may be neutral or even beneficial. Some introduced species become invasive.

Invasive species: a species not native to the ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species are able to establish, persist, and spread widely outside their natural range. They can be plants, animals, or other living organisms. Human actions are the primary means of invasive species introductions.

Noxious species: an organism that is likely to cause harm in an ecosystem or natural habitat, to agricultural or horticultural crops, to native species, humans or livestock. Noxious species may be native.

NOTE: Refer to the “Changing River” activity for more information on non-native species.

Background:

Exotic, or non-native species are widespread throughout the world. These include plants, animals and microbes that are established outside their native ranges, typically spread by the actions of humans. Many such species are benign, causing no significant problems in their new homes, while some are even beneficial, such as the honeybee. Others, however, cause extensive ecological or economic harm in their new environment. We call these invasive species, and they can reduce the biological diversity in an area, sometimes causing native species to go extinct or altering the habitat in such a way that native species are pushed away.



Land managers grapple with how to treat exotic species. In most cases, exotic species cannot be eliminated, and species that do not cause great harm are left to become part of the altered ecosystem. Attempts are often made to control invasive species that wreak havoc on native ecosystems, but in some cases, even invasive species that have caused environmental harm may be, if not welcomed, then at least accepted as part of the local ecosystem. For example, many exotic plants have become so widespread that removing them may be impossible. In this activity, students will wrestle with the challenges that land managers face in dealing with invasive species.

The local bosque ecosystem now supports numerous exotic species. Some do not cause great environmental harm and may even benefit native species, as in the case of mulberry benefitting fruit-loving birds and other animals. In contrast, saltcedar (or tamarisk) has completely replaced the native bosque trees in many areas, creating extensive monotypic (one species) stands that reduce available nesting habitat for birds and promote the spread of wildfire. Intentionally introduced as an ornamental in the early 1800s, saltcedar was soon also used to create windbreaks and to control erosion along river banks, including along the Rio Grande. It quickly spread throughout western riparian systems, causing lasting environmental changes. Millions of dollars have been spent as land managers have tried numerous methods to eradicate saltcedar, with limited success. The story became more complicated when it was discovered that, in some areas, the federally endangered Southwestern Willow Flycatcher (a Species of Greatest Conservation Need in New Mexico) was nesting in these monotypic stands. It turns out that these birds were not as picky as once thought and were successfully using saltcedar where no other trees were available. This created an unexpected complication for land managers once determined to remove this invasive species. [See “Introduced and Non-Native Species” and the “Tale of Two Exotics” sidebar in Activity #15 “Who Lives Where?” for one more unexpected twist in this exotic tale.]

In discussing exotic and invasive species, encourage students to consider why a species was introduced. In many cases, such as the invasive shrub saltcedar, the introduction made sense at the time, serving some ornamental or utilitarian purpose. It was only later that unforeseen effects were realized. In contrast, some species were introduced accidentally. That was the case for the small crustaceans called isopods (*Armadillidium vulgare* and *Porcellio laevis*), that were introduced from the Mediterranean region in soil used as ballast in ships sailing to North America. The ships dumped their ballast as they loaded cargo to return to Europe, and now these isopods occur across the United States. It’s important to understand that people have made mistakes, although they weren’t always intentional. Now, in many cases, we are dealing with the consequences.

Consider also how introduced species respond to disturbances in the landscape, particularly in comparison to native species. Do they recover quickly after a fire? After flooding? Have they become invasive because they can recover quickly after a disturbance, whether human-caused or natural? Tumbleweed and puncture vine grow well where soil has been disturbed, while saltcedar recovers quickly after fire and does well as the climate dries and warms. Disturbance is part of the bosque



ecosystem, so understanding how it affects both native and introduced species is important. See Activity #13 "Changing River" for more about disturbance in this ecosystem.

How are students affected by introduced species? In this activity they will develop management plans to deal with invasive species in fictional wildlife refuges. To relate to the need for such management, students should consider how they themselves are affected by invasive species. Saltcedar increases the risk of fires in the bosque. Do bosque fires put homes at risk? How do fires affect the impact of flooding? Have students ever stepped on a goat head, had one puncture a bike tire, or get stuck in their dog's paw? Students whose families enjoy recreational boating may have heard of invasive Zebra and Quagga mussels. Care must be taken by boaters to prevent the spread of these invasive aquatic species. Introduced species may affect us in many ways.

In this activity, you will challenge your students to understand the complexities of invasive species, the impacts on our local areas, and how those impacts might be reduced in our special nature reserves.

Overview of Activity:

1. Introduce invasive species and issues of concern regarding them in wildlife areas of New Mexico.
2. Practice internet research and documentation skills using Oryx as an example for class collaborative research.
3. Team Projects - Create and present management plans.
 - Step 1. Assign each team an invasive or noxious species to research. As a team, they will locate websites or webpages about their species, documenting their sources as they go.
(student handout)
 - Step 2. Using these sources, each team will prepare a species profile.
(student handout)
 - Step 3. Student teams write management plans based on research.
(student handout)
 - Step 4. Teams will present management plans to the class. They may do a computer presentation or a poster with appropriate drawings and illustrations.
 - Step 5. Evaluate teams' work. *(student handout)*

Make sure that computers are available and working with internet connection.

Procedure:

1. Introduce Exotic/Invasive Riparian Species in New Mexico

NOTE: Prior to this activity, we suggest doing the #13 "Changing River" model activity with the class. Make sure to do the Rio Bravo and Rio Manso sections. Add invasive animals and plants to the model with #15 "Who Lives Where?" and #16 "Who Grows Where?" activities. Discussing those non-native/invasive species through the included animal and plant cards will lay a strong foundation for this activity.

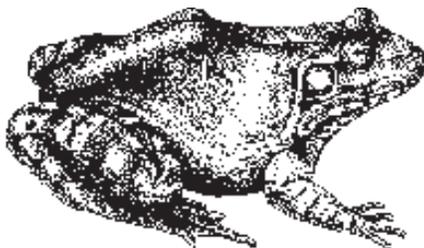


- ♣ Begin with a discussion of introduced plants. *What non-native plants have students seen around their neighborhoods? What about tumbleweed? Kochia? Anyone have a dog that gets stickers in their paws?* These are often goat heads or "toritos" (little bulls!) and are also known as puncture vine or caltrops; many names for this spiky-seeded plant. *How are students affected by non-native plants?*
- ♣ Developing a KWL chart can help organize student knowledge. **(Asking Questions & Defining Problems)**
- ♣ Now consider our wildlife refuges. Are there any threats to these protected areas? Let's brainstorm ideas about any threats to wildlife refuges and other natural spaces such as national forests, wilderness areas, public lands and non-government preserves. Encourage discussion of any problems, but be sure students recognize that invasive plants and animals pose significant threats in many areas.
- ♣ Teachers or students can look up the U.S. Department of Agriculture National Invasive Species Information Center (NISIC) for information on invasive species, including photos. <https://www.invasivespeciesinfo.gov/>

Refuges in New Mexico

There are many protected areas in New Mexico, managed by national, state, and local entities. These include National Wildlife Refuges, National Parks, National Forests, State Wildlife Management Areas, State Parks, BLM land, private conservation areas and more. Have students search for examples of protected areas near you.

The Rock Snot example (next page) can be shared with students as a brief introduction.





ROCK SNOT?!! What's that?

Didymosphenia geminata, commonly known as **didymo** or rock snot, is a freshwater diatom (a type of algae) native to cool, low-nutrient streams and lakes in northern parts of North America, Europe, and Asia. Since the 1980s, something in its physiology has changed that has allowed didymo to inhabit a wider range of temperature and nutrient conditions. Didymo now often forms large, nuisance blooms, and what's more, the species has spread throughout the world, including into the Southern Hemisphere. Its slimy appearance gives rise to the nickname, rock snot. Under certain conditions, it produces thick, branching stalks that join together to create large, carpet-like mats up to eight inches (20 cm) thick and capable of covering plants, rocks, and other hard surfaces. These tan mats look like clumps of wet toilet paper and can smother plants, insects, and mollusks along several miles of a stream or river, altering aquatic habitats and disrupting food chains. This affects humans directly by decreasing recreational opportunities, such as fishing and swimming. In fact, it is likely human activity has caused the spread of didymo, since it attaches to recreational equipment, especially felt-soled boots and waders. Anglers, boaters, or swimmers moving from one stream to another can unknowingly transport this tiny creature, with huge consequences.

As of 2021, didymo has been found in some upper headwater streams in New Mexico, but its range is currently limited. Please help prevent the spread of this potentially invasive species by checking gear and clothing for clumps of algae when you leave the river. Don't wash them down the drain! Throw clumps in the trash or away from water where they will dry out and die. Soak and scrub anything that has been in contact with the algae for at least one minute in either hot water (140°F/60°C), a 2% solution of household bleach, or a 5% solution of salt, antiseptic hand cleaner, or dishwashing detergent. Alternately, dry out gear for at least 48 hours before using it in a different waterway. Your help is needed to prevent the spread of rock snot!



2. Practice Using Strong Internet Research and Documentation Skills

Now work together as a class to develop students' research and documentation skills as you research the Oryx (*Oryx gazella*) in New Mexico. Oryx were introduced into the White Sands Missile Range in the late 1960s to provide exotic big-game hunting experiences, but they soon proved to be too successful in their new home. Students can learn more about this introduction and its ramifications, but the real emphasis here is to help students build strong internet research skills. Students will use these skills as they research their invasive species and develop their own management plan.

📌 Clarify Your Search and Define Your Question

First have students consider what information they are seeking. What are their questions? Brainstorm effective keywords, consider synonyms, alternative phrases, etc. It is good to start simple and then get more specific.

For the Oryx example, we suggest finding the following information:

- Physical description (including type of animal, size, physical characteristics)
- Where are Oryx native? Where do they occur in New Mexico?
- How did Oryx arrive in New Mexico?
- What are the consequences of being in New Mexico? Have they done any damage?
- Are there any benefits to Oryx being in New Mexico?

(The goal will be for the class to outline a plan for managing Oryx in New Mexico; see step d.)

📌 Evaluate Resources

It is usually easy to find many resources when using the internet, but how do students know if the resources are legitimate or useful for their research? Students can apply the CRAAP test, developed by librarians at California State University, Chico's Meriam Library (licensed under a Creative Commons Attribution 4.0 International License <https://creativecommons.org/licenses/by/4.0/>)

CRAAP Test acronym stands for:

Currency: The timeliness of the information.

Relevance: The importance of the information for your needs.

Authority: The source of the information.

Accuracy: The reliability, truthfulness, and correctness of the content.

Purpose: The reason the information exists.

Find the full version for questions to guide students in this evaluation here:

<https://library.csuchico.edu/sites/default/files/craap-test.pdf>

📌 Document Resources

Just as with books or other printed material, it is important to document any source of information that is not original when using material gathered via the Internet. A *webography* is a list of websites that pertain to a particular topic. The term *weblibliography*, adapted from the term *bibliography*, is similar and may also be used. Depending on your goals and your students' level, you may choose to require the full Council of Science Editors (CSE) style format or a simpler version. Examples of both are below. NOTE: frequently,



complete citation information is not available for internet sources, so tell students to just make their best effort in collecting this material. Gathering the information will help students assess the validity of the resource.

1) Simple Documentation of Research (suggested for younger students)

Documentation will include the following information:

URL (address):

Who sponsors or hosts this web page?

Who is the intended audience?

Information addressing your question

Oryx Simple Example:

URL (address): https://animaldiversity.org/accounts/Oryx_gazella/

Who sponsors or hosts this web page? University Michigan Museum of Zoology,

Who is the intended audience? General public

Information addressing your question (answers will vary)

2) Advanced Documentation of Research using the Council of Science Editors (CSE) style (suggested for older students)

The citation should include the following information:

Author's name (last name, first initials; if known)

Date of publication or last revision

Title of website (Online)

Place of publication (City [State initials]) and publisher name/organization

Title of web page/document

Update and/or access date

[updated year, abbreviated month day; cited year, abbreviated month day]

URL (address)

Information addressing your question

The Oryx citation could include the following information:

Author's name Sanders, S.

Date of publication or last revision 2005

Title of website Animal Diversity Web

Place of publication and publisher name Ann Arbor MI: University of Michigan

Title of web page/document Oryx gazella gemsbok

Update and/or access date 11-09-2021

URL https://animaldiversity.org/accounts/Oryx_gazella/

Information addressing your question (answers will vary)

Using the above information, the format for including a CSE style citation in a written document is as follows:

Author last name, first/middle initials. (year published). Title of website (Online). Publication city(state): Publisher/Organization. Title of web page [updated year abbreviated month day; cited year abbreviated month day]. Available from: URL

Oryx CSE style example for citation in a document:

Sanders, S. 2005. "Oryx gazella" (Online), Animal Diversity Web. Accessed November 09, 2021 at https://animaldiversity.org/accounts/Oryx_gazella/

- ♣ Outline a plan for managing Oryx in New Mexico.
 - List at least three methods for management, one being no action.



3. Team Projects

Step 1. Assign students to teams of two and assign each team a noxious /invasive plant species (invasive aquatic animals and additional plant options are listed in *Extensions*):

Cheatgrass, *Bromus tectorum*

Kochia, *Kochia scoparia*

Sweet clover, *Melilotus alba*

Russian olive, *Elaeagnus angustifolia*

Saltcedar, *Tamarix chinensis*

Siberian elm, *Ulmus pumila*

Tree of heaven, *Ailanthus altissima*

- Pass out the Invasive Species student pages; choose either the short version or CSE style version for documentation page. Teams will locate websites or webpages with information about their species, documenting sources as in the Oryx example. (*student handout*)
- Provide students with a timeline for completing their research.
- Facilitate student groups, helping to troubleshoot technology problems, asking questions, and helping them to organize their work.

Step 2. Students create species profiles.

During their research, considering questions like the following will help students address particular standards:

If a new organism is added to an ecosystem, how does it interact with species that were there already? If there are introduced predatory animals in an ecosystem, how might they affect native animals? (MS.LS2.A)

How do invasive species disrupt an ecosystem? What kinds of shifts in populations of other species can be seen? How would invasive species affect the biodiversity of an ecosystem? (MS.LS2.C)

How have human activities regarding invasive species impacted habitats or other species (positively and negatively)? (MS.ESS3.C)

When invasive species are introduced by humans, how are ecosystems disrupted? How is the survival of native species threatened? (HS.LS2.C)

How do humans depend on the biodiversity of natural ecosystems? (HS.LS4.D)

Invasive species often have negative impacts on ecosystems. How can scientists and/or engineers help prevent ecosystem degradation by invasive species?

What would be involved with restoring habitat in this location—in this example, managing invasive species to ensure native species can thrive in this area?

How can humans help to sustain the biodiversity of native ecosystems?

Think of examples where a reduction in invasive species can help the natural biodiversity in an area. (HS.ESS3.C)

(Above questions may address: Cause & Effect; Structure & Function; Stability & Change; Constructing Explanations & Designing Solutions; Engaging in Argument from Evidence)



Since your students will be learning about a specific species, they should be able to explain the adaptations and specific characteristics that allow its survival (i.e., their species' structures and functions). *How do the structures of your species help the function of that species?* **(Structure & Function)**

Step 3. Write a management plan. See student page for details.

This activity can specifically address **NM Specific State Performance Expectations**. 

By researching, writing and presenting a management plan for addressing invasive species in a nature reserve in New Mexico, your students can address:

HS-LS2-7 NM. Using a local issue in your solution, design and analyze the advantages and disadvantages of human activities that support the local population such as reclamation projects, building dams, and habitat restoration.

HS-SS-2 NM. Construct an argument using claims, scientific evidence, and reasoning that helps decision makers with a New Mexico challenge or opportunity as it relates to science.

See detailed explanations in the **NGSS Connections to Invasive Species – Disciplinary Core Ideas** section below.

(HS.LS2.C; HS.LS4.D; HS.ESS3.C ; ETS1.A; ETS1.B;)

Step 4. Student teams present their plans to reduce the impact of their invasive species to their fellow students. A typical management plan is a written report, with highlights given to agency staff and/or in a public meeting with a computer presentation. You may allow other formats such as posters. **(Obtaining, Evaluating & Communicating Information)**

Assessment:

Step 5. Use the rubric found at the end of this section to evaluate the students' work. The rubric can also be used by the students as a self-evaluation.

Extensions:

- Research additional non-native plant species in the bosque. Some examples are:
 - Camelthorn (*Alhagi maurorum*)
 - Common cocklebur (*Xanthium strumarium*)
 - Hoary cress (*Lepidium draba*)
 - Mulberry (*Morus alba*)
 - Musk thistle (*Carduus nutans*)
 - Perennial pepperweed (*Lepidium latifolium*)
 - Puncturevine (*Tribulus terrestris*) (aka goat heads)
 - Russian knapweed (*Rhaponticum repens*)
 - Silverleaf nightshade (*Solanum elaeagnifolium*)
 - Tumbleweed (*Salsola tragus*)
- Not all invasive species in New Mexico are plants. Aquatic ecosystems are particularly hard hit by invasive species of animals. For example, Red-eared sliders are often released into the river by well-intentioned



pet owners wanting to give their pet a better life (or just not wanting to care for it anymore). This species is not native to the Rio Grande drainage and poses a threat to the native Big Bend slider not only through direct competition for food and basking sites but also through potential interbreeding and associated impacts on the genetic integrity and adaptations of the native turtles. Similarly, though bullfrogs are native to the eastern US, they have been introduced into western river systems where they have negatively impacted many native species, primarily through predation. Zebra and Quagga mussels, originally from Europe, have also invaded western water systems. They pose a particular threat to New Mexico lakes and reservoirs since they are not yet present in the state but are found in neighboring states and are spread through the actions of humans (i.e., especially on boats brought into New Mexico from states where these species are found). Brown and Rainbow trout, though very popular with anglers, were also introduced to New Mexico and are originally from Europe, Asia, and the west coast of North America.

Research the impact of invasive and exotic animals in New Mexico. Examples include:

- Zebra and Quagga mussels
(*Dreissena polymorpha* and *Dreissena rostriformis*)
 - Northern and Red swamp crayfish
(*Faxonius virilis* and *Procambarus clarkii*)
 - Brown trout (*Salmo trutta*)
 - Rainbow trout (*Oncorhynchus mykiss*)
 - Bullfrog (*Lithobates catesbeianus*)
 - Red-eared slider (*Trachemys scripta elegans*)
- Bring in a civics discussion. Government agencies must wrestle with managing their lands. Generally, the public is invited to weigh-in on management plans. This is participatory government. Students can look at what the process would be to implement their management plan. Help students understand that it may take years to actually do the management changes that are proposed; the wheels of government may move slowly.
 - Challenge students to think about the Tamarisk leaf beetle, intentionally introduced to control saltcedar (tamarisk). Two exotic species, one is reducing the other. In some areas, the Southwestern Willow Flycatcher has been using saltcedar for its habitat where native riparian trees are absent. *What happens to the Southwestern Willow Flycatcher when saltcedar is reduced?* (MS.LS2.C; Cause & Effect)
 - --Research how invasive species complicate managing and modeling climate change effects. Look for how your assigned invasive species is expected to fare with climate change. Also consider how



invasive species fit into the mix of predicting climate change effects. *How do models of climate change include invasive species effects? Are there things we, as individuals and communities, can do to mitigate the impacts of invasive species on native ecosystems due to climate change?* (MS.ESS3.D; HS.ESS3.D)

NGSS Connections to Invasive Species – Disciplinary Core Ideas

MS.LS2.A Interdependent Relationships in Ecosystems

-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.

-Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Adding a new species to an ecosystem can create issues with the native species already present. Competition for limited resources can result in the native species not being able to survive as they have previously. New species may not have natural predators as the native species do, may be able to reproduce prolifically, or may have some other feature or behavior that gives them an edge against native species. A predatory species, like bullfrogs, may eat many native animals; bullfrogs have contributed to the decline of native amphibians. If a new organism is added to an ecosystem, how does it interact with species that were there already?

If there are exotic predatory animals in an ecosystem, how might they affect native animals?

MS.LS2.C Ecosystem Dynamics, Functioning and 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.

Invasive species, whether plants, animals, or even microbes or fungi, can disrupt an ecosystem, negatively affecting populations of native species. Although adding a new, non-native species might increase the species richness (number of species) present in an ecosystem, invasive species are not considered to increase local biodiversity. Their presence can disrupt the biological integrity at a site by competing with native species for limited resources, altering the habitat, directly preying on native species, and more.

How do invasive species disrupt an ecosystem? What kinds of shifts in other species can be seen?

How would invasive species affect the biodiversity of an ecosystem?

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.

Humans have introduced exotic species, whether intentionally or accidentally, to ecosystems worldwide, often with devastating effects to local habitats and to native species. Some native species are more susceptible to the effects of invasive species than are others, and thus, the effects on native species vary. Sometimes the negative impact of invasive species can be reversed with human intervention.

How have human activities regarding invasive species impacted habitats or other species (positively and negatively)?

MS.ESS3.D Global Climate Change *Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding human behavior and applying that knowledge wisely in decisions and activities.*

Riparian ecosystems are experiencing dramatic challenges in the face of climate change. Systems already stressed by a changing climate are often more susceptible to invasion by non-native species, which may be favored over native species by the new climatic conditions. Alternatively, the disruption of biological integrity in systems already affected by invasive species may make them more vulnerable to a changing climate. Understanding and addressing this interaction will be essential to managing natural ecosystems in the future. Research how invasive species complicate managing and modeling climate change effects. Look for how your assigned invasive species is expected to fare with climate change. Also consider how invasive species fit into the mix of predicting climate change effects.

How do models of climate change include invasive species effects? Are there things we, as individuals and communities, can do to mitigate the impacts of invasive species on native ecosystems due to climate change?

HS.LS2.C Ecosystem Dynamics, Functioning and Resilience

-A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

-Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

Invasive species can disrupt ecosystems by competing with native species over limited resources, by preying on native species, by altering the local habitat, and in other ways. Human-caused introductions of invasive species, whether intentional or accidents, may have devastating impacts on local ecosystems and native species.

When invasive species are introduced by humans, how are ecosystems disrupted? How are native species' survival threatened?



HS.LS4.D Biodiversity and Humans

Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

The introduction of invasive species, whether intentional or accidental, can adversely affect biodiversity and the functioning of ecosystems. Riparian ecosystems are particularly susceptible to these invasions. These changes in biodiversity can directly impact humans by decreasing the availability of natural resources and interrupting natural ecosystem functions upon which humans depend (e.g., flood control, water availability).

How do humans depend on the biodiversity of natural ecosystems?

HS.ESS3.C Human Impacts on Earth Systems

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

-Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Humans depend on a variety of natural resources for their survival. Land managers face many challenges in maintaining local biodiversity and thus in maintaining natural resources used by humans. Controlling invasive species is an important task of land managers and often requires creative strategies for success.

In this activity, students are challenged to work on the problem of invasive species at a wildlife refuge—a real issue for natural area managers in New Mexico. The preparation of a management plan for the invasive species the team investigates should address this standard. *What would be involved with restoring habitat in this location—in this example, managing invasive species to ensure native species can thrive in this area? How can scientists and/or engineers help prevent ecosystem degradation by invasive species? How can humans help to sustain the biodiversity of native ecosystems? Think of examples where a reduction in invasive species can help the natural biodiversity in an area.*

HS.ESS3.D Global Climate Change

-Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities.

Riparian ecosystems are particularly vulnerable to a changing climate and to the introduction of invasive species. Research how invasive species effects are included in models predicting climate change effects on ecosystems.

Look for how your assigned invasive species is expected to fare with climate change. Also consider how invasive species fit into the mix of predicting climate change effects. *How do models of climate change include invasive species effects? Are there things we, as individuals and communities, can do to mitigate the impacts of invasive species on native ecosystems due to climate change?*

New Mexico-Specific Science 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 Invasive Species activity.

New Mexico Performance Expectation

HS. Interdependent Relationships in Ecosystems

HS-LS2-7 NM. *Using a local issue in your solution, design and analyze the advantages and disadvantages of human activities that support the local population such as reclamation projects, building dams, and habitat restoration.*

HS.LS2.C Ecosystem Dynamics, Functioning and Resilience *A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.*

Invasive species can disrupt ecosystems by competing with native species over limited resources, by preying on native species, by altering the local habitat, and in other ways. Human-caused introductions, whether intentional or accidents, may have devastating impacts on local ecosystems and native species. *When invasive species are introduced by humans, how are ecosystems disrupted? How are native species' survival threatened?*

HS.LS4.D Biodiversity and Humans *Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.*

The introduction of invasive species, whether intentional or accidental, can adversely affect biodiversity and the functioning of ecosystems. Riparian ecosystems are particularly susceptible to these invasions. These changes in biodiversity can directly impact humans by decreasing the availability of natural resources and interrupting natural ecosystem functions upon which humans depend (e.g., flood control, water availability). In this activity, students are challenged to work on the problem of invasive species at a wildlife refuge—a real issue for natural area managers in New Mexico. *What would be involved with restoring habitat in this location—in this example, managing invasive species to ensure native species can thrive in this area? How do humans depend on the biodiversity of natural ecosystems? How can humans support the biodiversity of native ecosystems? Think of examples where a reduction in invasive species can help the natural biodiversity in an area.*



ETS1.B Developing Possible Solutions

-When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.

In writing a management plan for addressing invasive species at a wildlife refuge, students should consider a range of options and the effects of those options. This is what land managers need to do as they work through issues concerning threats to our public lands. Be sure to include consideration of social and cultural impacts; these are particularly meaningful here in New Mexico but may easily be overlooked when focusing on ecological and environmental impacts.

CCCs Stability and Change

SEPs Constructing Explanations and Designing Solutions

Connections to Nature of Science

Science is a Way of Knowing

-Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.

-Science is a unique way of knowing and there are other ways of knowing.

-Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical view.

-Science knowledge has a history that includes the refinement of, and changes to, theories, ideas and beliefs over time.

New Mexico Performance Expectation

HS.Science and Society

HS-SS-2 NM. *Construct an argument using claims, scientific evidence, and reasoning that helps decision makers with a New Mexico challenge or opportunity as it relates to science.*

ETS1.A Defining and Delimiting Engineering Problems

-Criteria and constraints also include satisfying any requirements set by society such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

-Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

In designing a management plan to address invasive species, engineering solutions may be part of the plan. In considering those solutions, students need to consider issues associated with maintaining a healthy society. For example, is one of the recommendations applying herbicides or pesticides? How would they be applied? What effects can be expected on target plants, non-target plants, and the ecosystem in the long-term or in downstream areas? Can the application procedure be improved and/or risks mitigated with proper training, timing, and/or hand preparation work? Students can construct an argument for their suggested alternatives.

How would management strategies affect global systems at the local level, such as the local water supply? Would application of herbicides/pesticides get into local water sources, with further, downstream effects? Would any of the proposed management strategies affect food supplies (such as alfalfa production)? Challenge students to consider effects beyond the immediate area of the refuge.

ETS1.B Developing Possible Solutions *When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.*

In writing a management plan for addressing invasive species at a wildlife refuge, students should consider a range of options and the effects of those options. This is what land managers need to do as they work through issues concerning threats to our public lands. Be sure to include consideration of social and cultural impacts, (e.g., input and/or advice from Native communities) as these are particularly meaningful here in New Mexico but may easily be overlooked when focusing on ecological and environmental impacts. Make an argument for your recommendation; state any risks and how those can be mitigated. Emphasize how your preferred approach is the best plan. Use arguments such as: the most cost effective, safe, aesthetically pleasing, socially and culturally sensitive, etc. Identify specific bosque species affected such as Species of Greatest Conservation Need (SGCN.)

CCCs: Cause and Effect

SEP: Engaging in Argument from Evidence

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

-Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.

-Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Science Addresses Questions about the Natural and Material World

-Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.

-Science knowledge indicates what can happen in natural systems— not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge



Invasive Species

Introduction

There are aliens in New Mexico! No, not UFOs, but alien, non-native plants. Non-native plants that cause environmental harm are often called “invasive species.” These species, like saltcedar (tamarisk), are threatening the health of the bosque ecosystem by taking over from the species that have lived there for thousands of years.

Here is the scenario: The state legislature of New Mexico has established a new wildlife refuge along a five-mile (8 kilometer) stretch of the Middle Rio Grande. According to the legislation, the mission of the refuge is to preserve the beauty of the bosque and to provide habitat for native bosque plants and animals, and for the enjoyment of all New Mexicans. What should be done about the invasive plants?

Task

You and a partner have been hired by the refuge manager as invasive plant consultants. You will work together as a team to become experts on a particular invasive or noxious species. Your team will then determine a management plan for this species and present it to the class during a “public hearing.” It will be your job to learn more about this species and about ways to manage it.

Process

- Step 1. Your teacher will assign your team an invasive or noxious species to research. As a team, you will locate websites or webpages about your species, documenting your sources as you go.
- Step 2. Using these sources, you will prepare a species profile.
- Step 3. Write a management plan.
- Step 4. Present your management plan to the class. You may do a computer presentation or a poster with appropriate drawings and illustrations.
- Step 5. Evaluate your team’s work.

Step 1: Website Identification - Documentation of Research

Find at least three websites that have descriptions of the invasive species you have been assigned. Fill out the information on the documentation handout for each website you find that contains information useful to your species profile and/or management plan. You may add additional websites if you find more than three that seem especially useful.

Begin by looking up the common name and/or the scientific name of the species. You will have to decide which sites best suit your needs. Sites with addresses that end in .gov (government) or .edu (education) tend to have more credible information than ones that end in .com or .net. Ultimately, it is up to you to decide which sites provide the best information for your purposes.

Step 1: Website Identification - Documentation of Research (short version)

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Website 1

URL (address):

Who sponsors or hosts this web page?

Who is the intended audience?

One thing you learned about your invasive species is:

Website 2

URL (address):

Who sponsors or hosts this web page?

Who is the intended audience?

One thing you learned about your invasive species is:

Website 3

URL (address):

Who sponsors or hosts this web page?

Who is the intended audience?

One thing you learned about your invasive species is:



Step 1: Website Identification - Documentation of Research using the Council of Science Editors (CSE) style

Website 1

Author's name (last name, first initials; if known)

Date of publication or last revision

Title of website

Place of publication (City [State initials]) and publisher name/organization

Title of web page/document; publication date

Update and/or access date

[updated year, abbreviated month day; cited year, abbreviated month day]

URL

Information addressing your questions:

Website 2

Author's name (last name, first initials; if known)

Date of publication or last revision

Title of website

Place of publication (City [State initials]) and publisher name/organization

Title of web page/document; publication date

Update and/or access date

[updated year, abbreviated month day; cited year, abbreviated month day]

URL

Information addressing your questions:

Website 3

Author's name (last name, first initials; if known)

Date of publication or last revision

Title of website

Place of publication (City [State initials]) and publisher name/organization

Title of web page/document; publication date

Update and/or access date

[updated year, abbreviated month day; cited year, abbreviated month day]

URL

Information addressing your questions:

Using the above information, the format for including a CSE style citation in a written document is as follows:

Author last name, first/middle initials. (year published). Title of website, [Internet].
Publication city(state): Publisher/Organization. Title of web page [updated year
abbreviated month day; cited year abbreviated month day]. Available from: URL

Step 2: Species Profile

Using the websites you have identified, complete a profile of your species. You should incorporate information from all of the websites you documented.

Common name:

Scientific name:

Physical description (including size, leaf description, flower description, color, etc.):

How does it propagate/reproduce?

Distribution (where is it found?):

Effect on natural areas and/or native species:

Three methods for management:

List three terms (words you didn't know) and definitions:





Step 3: Management Plan

Now that you have researched your non-native species, it is time to make your management recommendation to the refuge manager. Your management plan should be two to three typed pages in length.

Your management plan needs to include the following elements: statement of the problem, species profile, description of various alternative management strategies, final recommendation for species management, definition of terms, and a webography (full URL of websites used, plus sponsors, audience, and short notes on information gained there). Use this outline to help you prepare your management plan.

- I. Statement of the problem (two or three sentences about why this species is an invasive species).
- II. Species profile (one or two paragraphs describing where this species is found in the bosque, what it looks like, and how it affects the bosque ecosystem. Identify specific bosque species affected such as Species of Greatest Conservation Need [SGCN]).
- III. Description of various alternative management strategies and advantages and disadvantages of the alternatives (one paragraph for each alternative). One of the alternatives must be a do-nothing alternative.
 - A. Description; advantages and disadvantages
 - B. Description; advantages and disadvantages
 - C. Do nothing; advantages and disadvantages
- IV. Your recommendation for managing the invasive species. Use the format of Claim, Evidence, Reasoning. Make an argument for your recommendation; state any risks and how those can be mitigated. Emphasize how your preferred approach is the best plan. Use arguments such as: the most cost effective, safe, aesthetically pleasing, socially and culturally sensitive, etc.
- V. Unfamiliar terms and definitions.
- VI. Webography of web sites you accessed for the information included in your plan. Use CSE citation format, as appropriate for the student's level.

Step 4: Presentation.

Present your management plan to the class using a computer presentation or poster format.

Step 5: Evaluate this unit with the rubric

(see separate handout)

Invasive Species Evaluation Rubric

Name _____

Component	Beginning Level	Developing Level	Advanced Level	Student Score	Teacher Score
Oryx Research	0 points. Didn't follow directions. Answered fewer than half of the questions correctly.	3 points. Followed directions. Answered more than half of the questions correctly.	6 points. Followed directions. Answered eight or more questions correctly.		
Website Identification	0 points. Found fewer than three websites. Did not identify sponsor & audience for each site. Did not answer question about particular invasive species.	3 points. Found three websites. Identified some sponsors & audiences. Showed basic understanding of particular invasive species (answers were repetitive or simplistic).	6 points. Found three or more websites. Identified sponsor & audience for each. Showed strong understanding of particular invasive species.		
Species Profile	0 points. Completed fewer than half the components of the profile.	4 points. Completed three-fourths of the components of the profile.	8 points. Completed all components of the profile.		
Management Plan	0 points. Addressed fewer than half of the elements of the plan. Plan is messy, illegible, and/or less than one page with numerous grammatical and/or spelling errors.	6 points. Addressed most elements of the plan. Plan is neatly hand-written and/or less than one page, with few grammatical and/or spelling errors.	12 points. Addressed all elements of the plan. Plan is typed, one or two pages, with no grammatical or spelling errors.		
Presentation	0 points. Presentation is incomplete using paraphrased words and/or no pictures. Presentation shows little understanding about invasive species in general and/or particular species.	6 points. Presentation includes essential information with some elaboration. Presentation shows some understanding about invasive species in general and/or particular species.	12 points. Presentation is complete with original words and pictures. Presentation shows understanding about invasive species in general and about particular invasive species.		
Teamwork	0 points. Teammates often "did their own thing"; were not able to work together to accomplish task; had difficulty getting along with each other.	3 points. Teammates were mostly able to participate appropriately; usually came prepared and accomplished the task; avoided most conflicts and/or were able to resolve any that occurred.	6 points. Team members contributed fairly and squarely to all aspects of the project; always came prepared and accomplished the task; worked well cooperatively.		
Total Score				50	50



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