



Cream of the Crop:Assessing the Environmental Benefits of Prairie Strips

Produced by

Forest Service, an Agency of the Department of Agriculture (USDA)

FIND Outdoors

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Photo by Anna McDonald, Iowa State University.

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Join us in being green!



The following educator resources are now available exclusively on the *Natural Inquirer* website at http://www.naturalinquirer.org.

These resources can be found with the "Natural Inquirer Monograph Series—Forests and Agriculture" journal and on the "For Educators" pages.

- Note to Educators
- Lesson Plan
- Reflection Section
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- National Education Standards

Natural Inquirer

Ediforial Review Board Hard at Work

Distance Learning
Student Editorial
Review Board
April 2020















"I learned that agriculture is a bigger part of the world than I thought."

"This was
very interesting
to read. I also only
thought mercury
was just a planet! I
didn't know it was
a pollutant."

"Maybe add some more info on certain topics. For example, the scientists. I would like more info on who they are and what they do."

"I think it
would be helpful to
have some type of
game at the article.
It would cause me to
read more
carefully."

"I learned how the prairie strips help balance out the land used for farming." "Overall it was amazing. But I feel like you could add more scientist pictures."

About Natural Inquirer Monographs!

Scientists report their research in a variety of special books, called journals. Although journals have been produced in hard copy, they are increasingly also produced online. Journals usually contain between four and seven scientific papers. Journals enable scientists to share their research with one another. A monograph is a type of journal about research that focuses on a single scientific paper.

This monograph of a *Natural Inquirer* article was created to give scientists the opportunity to share their research with you and other students. The monograph presents scientific research conducted by Forest Service scientists and other scientists. If you want to learn more about the Forest Service, you can read about it on the inside back cover of this monograph, or you can visit the *Natural Inquirer* website at http://www.naturalinquirer.org.

All of the research in this *Natural Inquirer* monograph is concerned with the natural environment, such as trees, forests, soils, animals, insects, outdoor activities, and water. First, you will "meet the scientists" who conducted the research. Then you will read about one of the many interesting aspects of science and about the natural environment. You will also read about a specific research project. The research article is written in the format that scientists use when they publish research in scientific journals. Then YOU become the scientist as you go through the FACTivity associated

with the article. Don't forget to look at the glossary and the special sections highlighted in the article. These sections give you extra information that is educational and interesting.

At the end of each section of the article, you will find a few questions to help you think about what you have read.

These questions will help you think like a scientist. They will help you think about how research is conducted. Your teacher may use these questions in a class discussion, or you may discuss these questions in a small

Each Natural

group.

Inquirer monograph will help you explore the exciting world of science and prepare you to become a young scientist. You will learn about the scientific process, how to conduct scientific research, and how to share your own research with others.

Visit http://www.naturalinquirer.org for more information, articles, and resources.

Be sure to try the Cream of the Crop Create-A-Phrase Challenge on page 35 and eyeChallenge on pages 36-37!



WHO ARE SCIENTISTS?

Scientists collect and evaluate information about a wide range of topics. Some scientists study the natural environment.



To be a successful scientist, you must:

Be CUYIOUS:

Are you interested in learning?

Be enfhusiasfic: Are you excited about a particular topic?

Be Careful:

Are you accurate in everything you do?

Be open-minded:
Are you willing to listen to new ideas?

Question
everything:
Do you think about what you read and observe?



Photo courtesy of Jose Mercado, USDA Forest Service.



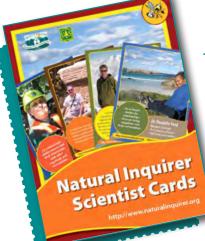
Photo courtesy of Leslie J. Boak, USDA Forest Service.



Photo courtesy of Randy Kolka, USDA Forest Service.



Photo courtesy of Rima Lucardi, USDA Forest Service



To learn more about scientists and their work, you can find *Natural Inquirer* scientist cards and posters online at http://www.naturalinquirer.org.

At this website, you can also view a series of scientist videos to help you plan, design, and conduct your science fair project.



Welcome to the *Natural Inquirer*Monographs – Forests & Agriculture
Series!

Agriculture is the science and practice of preparing the soil, producing crops, and raising livestock. Agriculture is the process through which humans get food and many other resources.

Societies have practiced agriculture for thousands of years. Experts have

difficulty pinpointing the exact start of agriculture, but estimates range from 10,000 to 25,000 year ago. Agriculture has taken many forms over its long history. Today, it is practiced on scales from very small, such as growing tomatoes in a pot, to very large, such as raising bison on ranches (figure 1). You may find a wide variety of agricultural techniques in both urban areas and rural areas (figure 2).

To learn more about monographs, read "About *Natural Inquirer* Monographs!" on page 5.



Figure 1. For people not living on a farm, plants can be grown in a pot, like this tomato plant.

Photo courtesy of coramueller, via http://www.istockphoto.com.



Figure 2. Agricultural areas include land used to raise animals, such as cows, horses, pigs, goats, sheep, and the bison pictured here. Animals can be used on the farm to complete tasks, and they can also be raised for products, such as meat or fiber.

Photo courtesy of Ryan Hagerty, United States Fish and Wildlife Service.

Historically, many people practiced agriculture on a small scale at their homes or in their communities. Over time, however, fewer and fewer people practiced agriculture at home. New techniques and technologies have become so efficient that agriculture has been able to support larger populations with fewer people farming (figure 3). Farmers can grow enough food for themselves and their communities, to sell food at grocery stores, and even trade with people across the globe.

Supporting the seven and a half billion people on Earth requires a large amount of land to be used in agriculture. According to the United Nations Food and Agriculture Organization, approximately 11 percent of land worldwide is used for agriculture. Scientists expect Earth's population to continue to grow. With population growth, scientists expect increased productivity on agriculture lands as a result of improved technologies and practices.



Figure 3. New technologies, like the modern tractor, have enabled farmers to produce more food and products.

Photo courtesy of Phyllis Cooper, United States Fish and Wildlife Service.

In the United States, large amounts of agricultural land are in the Midwest (figure 4). The scientists in this study found that 43 percent of midwestern land is used to grow corn and soybeans.

The scientists in this study were interested in determining the impact of harvesting wild plants on the long-term health of plant populations. As you read this article, take a moment to think about agriculture in your life. How are the items that you use daily connected to agriculture?

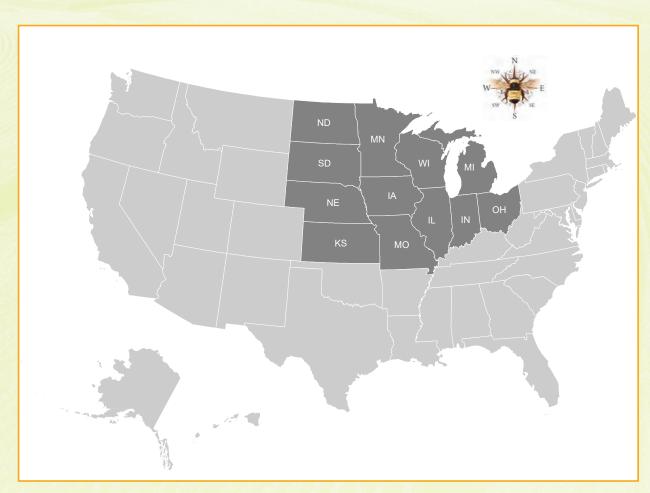


Figure 4. The Midwest is a region of the United States. Map by Carey Burda.



MEET THE SCIENTISTS!



Photo courtesy of Randy Kolka, USDA Forest Service.

■ RANDY KOLKA, Soil Scientist

My favorite experiences are working with students on research. Research topics range from the importance of putting native prairie strips in crop areas to studying the effect of climate change on wetlands in northern Minnesota, Indonesia, and Peru. Also, one of the topics I study is mercury cycling. Mercury is a pollutant that can affect our nervous system, brain functioning, and

reproduction. In one study, we looked at the effect of forest fires on mercury. We found that the amount of mercury deposited during and after a fire was a lot, about 40 percent of what is deposited annually from rain and snow. Wildfires and prescribed fires can be good for our environment, but they can also be sources of mercury in the food chain.



Photo courtesy of Lisa Schulte-Moore, Iowa State University.

■ LISA SCHULTE-MOORE, Ecologist

I love science – the whole process from conceiving an idea to publishing the results of a project. I think my favorite experience is feeling like, bit by bit, I'm helping to make our world a better place for current and future generations. I also like that I get to learn something new every single

day. In my photo, I'm standing in a prairie strip on a farm in north central lowa doing nest checks. We find and monitor bird nests to understand whether or not prairie strips are providing quality habitat for birds, especially birds of greatest conservation need.

What kind of Scientists Did This Research?

Ecologis†: This scientist studies the relationship of living things with each other and with the nonliving environment.

Soil Scientist: This scientist studies soil.

Glossary words are in **bold** and are defined on page 27.

Thinking About Science

One goal of scientific research is to discover solutions to problems affecting society. Scientists are interested in finding solutions which are both effective and **practical**. Together, the effectiveness and practicality of a solution gives scientists an idea of whether a solution will be widely used. For instance, one solution to a problem may be effective but expensive. If people cannot afford the solution, it may not be widely used. Similarly, if a solution is easy, but requires many hours to complete, people may be unwilling or unable to use it.

The scientists in this research tested prairie strips as a solution to the environmental damage occurring in some agricultural areas. Additionally, the scientists determined where the solution could be used and whether people desired a solution to the problem. This information enabled the scientists to determine whether the solution was also practical.

Thinking About the Environment

Many agricultural areas are designed to maximize growth of a desired product. To do so, land is changed from **native** ecosystems, such as forests, grasslands, and wetlands. Converting native ecosystems to agriculture can have negative impacts. Some negative impacts include soil loss and water and air pollution.

The loss of native plants and animals is another impact of creating agricultural lands. Native plants and animals can provide many **ecosystem services**, including carbon storage, healthy soil and water, pest control, and **pollination**. Not only are native plants and animals often lost on agricultural lands, but **nonnative** plants are sometimes introduced. Nonnative plants and animals can cause further problems by competing with remaining native species.

The Midwestern States contain large amounts of agricultural land where native plants and animals have been lost. The scientists in this study saw an opportunity to combine both native plants and agricultural lands. This strategy, they believe, could enable landowners to achieve multiple goals, like environmental health and crop production.

Introduction

Agriculture is a major part of the midwestern U.S. landscape. In Iowa, for instance, the scientists discovered that corn and soybean farms cover 69 percent of the landscape (figures 5-6b). Before being changed to agricultural land, the scientists knew that much of

Iowa's native ecosystems consisted of **prairies** (figure 7). As you read in "Thinking About the Environment," converting native ecosystems to agriculture can negatively impact the environment.

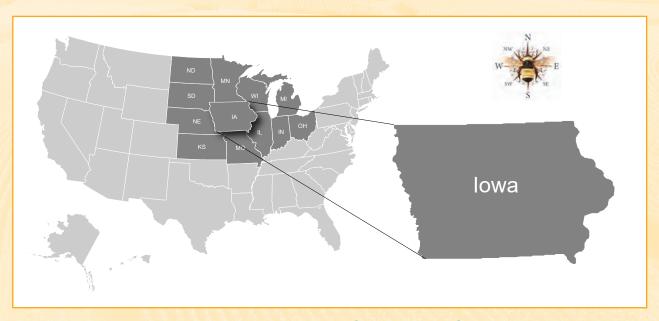


Figure 5. Iowa is in the Midwest region of the United States. Map by Carey Burda.



Figure 6a. Corn is a common agricultural plant in the Midwest. Corn is used for several products, and American farmers often trade with or sell it to people from around the world.

Photo courtesy of Stephen Kirkpatrick, USDA Natural Resources Conservation Service.



Figure 6b. The United States is one of the largest producers of soybeans, pictured here on this farm. Soybeans are often processed and used to feed farm animals. Soybeans are also eaten by humans in products like tofu.

Photo courtesy of Lynn Betts, USDA Natural Resources Conservation Service.



Figure 7. Prairies are ecosystems dominated by shorter plants, like grasses, instead of trees. Prairies, often called grasslands, can be found in many regions of the United States. The Midwest has the largest amount of prairie habitat in the United States.

Photo courtesy of Doug Mosser, U.S. Fish and Wildlife Service.

Where Did the Tallgrass Prairie Go?

Tallgrass prairie is an ecosystem that once covered 150 million acres of North America, including Iowa, its surrounding States, and even Texas and Canada (figure 8). Today, however, only 4 percent of the original area consists of tallgrass prairie.

As you might have guessed, the tallgrass prairie ecosystem contains tall grass species. Some species can reach an average height of 6 feet, with some stalks reaching over 9 feet high. Although the height of the grasses is impressive, their root systems are often even more impressive. Many prairie plants, including the tall grasses, have root systems that are longer than the grass is tall (figure 9).



Figure 8. Tallgrass prairie once covered many States. Map by Carey Burda.

6 Feet 7 Feet

Figure 9. Tallgrass prairie plants often have a large root system hidden in the soil below.

Illustration by Stephanie Pfeiffer.

The dense and deep root system of tallgrass prairies slows water runoff and traps nutrient-rich soil in place. As the United States grew and people settled the tallgrass prairie region, they started farming to take advantage of the nutrient rich soil. Farmers grew as much as they could on their farms, turning tallgrass prairie into agricultural land. The change from tallgrass prairie to agricultural lands has its benefits. Today, the area is a productive agricultural region. However, as tallgrass prairie has disappeared, so have the ecosystem services they provided.

Did You Know? In 1996, The Midewin (pronounced mi-DAY-win) National Tallgrass Prairie was established in Illinois. It encompasses approximately 19,000 acres and is home to a bison herd. You can even watch the herd on the BisonCam! https://www.fs.usda.gov/main/midewin/home

The scientists determined that reintroducing prairie plants in agricultural lands was one way to improve the environment. They started a large experiment in 2007 to test the use of "prairie strips" in agricultural lands (figure 10). Prairie strips are rows of native prairie plants that are grown alongside agricultural crops, like corn or soybeans.

Results of the experiment showed that prairie strips were an effective solution

to improve the environment. However, the scientists determined that they still needed to show that prairie strips were also a practical way to improve the environment. More specifically, the scientists wanted to understand the effects of prairie strips relative to the amount of land they occupy. They also wanted to know whether prairie strips could be used widely in Iowa and if the people of Iowa wanted the benefits provided by prairie strips.



Figure 10. Prairie strips are rows of prairie plants grown alongside crops, like this prairie strip located between rows of soybeans.

Photo by Omar de Kok-Mercado, Iowa State University.



State in your own words the questions the scientists were trying to answer with this research.

The scientists knew their previous research showed the benefits of prairie strips. Why did scientists need to show that prairie strips were a practical solution? (Hint: Think about what you read in "Thinking About Science.")

Methods

The scientists used data from their experiment which had been conducted at Neal Smith National Wildlife Refuge since 2007 (figure 11). The experimental area was divided into 12, approximately equal sized **catchments**. Each catchment received one of four treatments, with each treatment repeated three different times (figure 12):

- **1.** 100% crops (**control**)
- 2. 90% crops, 10% prairie strips planted only at the bottom of the slope

- **3.** 90% crops, 10% prairie strips planted throughout
- **4.** 80% crops, 20% prairie strips planted throughout

The prairie strips contained 32 plants native to the Iowa area. Each prairie strip was at least 4 meters wide and at least 36 meters from another prairie strip. The crops used were corn and soybeans, which are common in Iowa, and they were managed using common farming techniques.

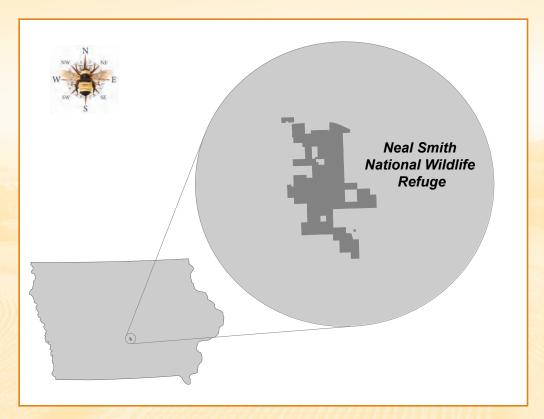


Figure 11. Neal Smith National Wildlife Refuge is located in central lowa. It was protected to preserve the prairie ecosystem.

Map by Carey Burda.

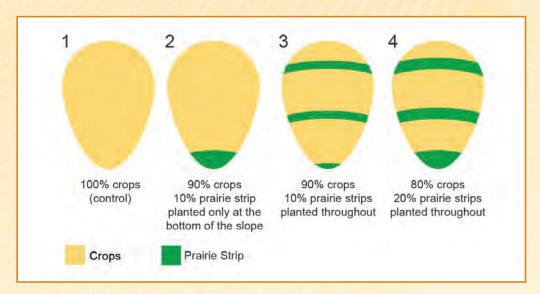


Figure 12. The scientists tested four different treatments, including the crop-only control treatment. Each treatment had a different combination of crops and prairie strips.

Illustration by Stephanie Pfeiffer.



Namber Grunch

Prairie strips were at least 4 meters wide.
There are 3.28 feet in one meter.

How many feet wide is a 4-meter-wide prairie strip?

Plants within prairie strips were inventoried each year for 4 years during the summer. Insects were inventoried in both prairie strips areas once per year for 3 years and in crop areas once.

Birds were inventoried each year for 5 years. Data about water flow and water chemistry were collected at each of the 12 catchments using an H flume and groundwater wells (figure 13a & 13b).

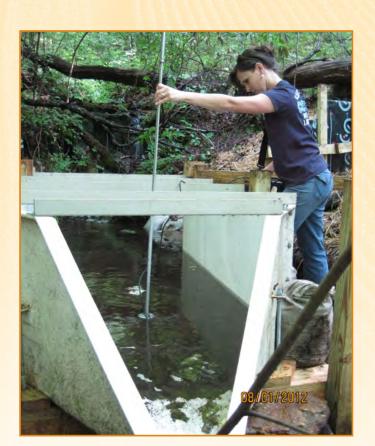


Figure 13a. An H flume is placed in a stream to calculate water flow. The H flume forces all water into one space so scientists can accurately measure how much water is flowing in a particular location.

Photo courtesy of Stephanie Laseter, USDA Forest Service.



Figure 13b. The scientists installed groundwater wells to measure groundwater on the high end of each catchment and the low end of each catchment. Groundwater wells are usually plastic pipes placed in the ground that can be opened at the surface.

Photo by Anna McDonald, Iowa State University.

As crops were **harvested** from each catchment, the scientists measured the crop production using a Case IH AFS Pro-600 monitor (figure 14). The scientists calculated **revenue** from crop production on each catchment.

Lastly, the scientists calculated the total amount of land in Iowa on which prairie strips could be used using a computer program, and they surveyed 2,400 Iowa residents regarding their opinions of agriculture and the environment.



Figure 14. A Case IH AFS PRO-600 is a computer mounted to the machinery which farmers use to harvest crops. The computer calculates the quantity of crops being harvested, among other things.

Photo by LivingImages, via http://www.istockphoto.com.

Alection Section

Think of a recent survey of which you are aware. Describe that survey.

The scientists tested 4 treatments, and each treatment was repeated 3 times.

Why did the scientists test each treatment multiple times?

Have you ever taken a survey? Do you think surveys are a good way to get people's opinions? Why or why not?

Findings

The scientists found that the control treatments, those catchments planted with 100 percent crops, had similar production and revenue as other Iowa farms. Catchments with prairie strip treatments resulted in lower crop production than the control treatments. Production in prairie strip treatments, however, decreased only by the amount of area taken out of production.

Despite lost production and revenue, catchments with prairie strip treatments resulted in many benefits. First, catchments with prairie strip treatments had greater native plant diversity than catchments with the control treatment. Water runoff was lower in the catchments containing prairie strip treatments, and as a result, soil and nutrient losses were lower.

The results, however, did not show many differences between the three treatment types containing prairie strips. Catchments with the 20 percent prairie strips treatment showed greater diversity of native plants and greater amounts of grassland bird species. Pollinating insect abundance was greater in catchments with treatments containing 10 percent or 20 percent prairie strips planted throughout.

Analysis of Iowa land showed that prairie strips were a suitable solution on 40 percent of agricultural lands with crops and 27 percent of total land in Iowa (figure 15).

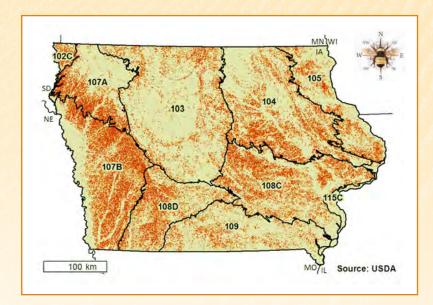


Figure 15. The red color on the map indicates the 40 percent of lowa land containing crop land that is suitable for using prairie strips.

Map courtesy of the USDA, National Agricultural Statistics Survey.

The survey of Iowa residents indicated that the benefits provided by prairie strips are priorities for Iowa residents (figure 16). Iowa residents indicated that water quality was their highest

priority. Survey respondents who lived on farms and those who did not live on farms differed, however, in some of their other priorities.

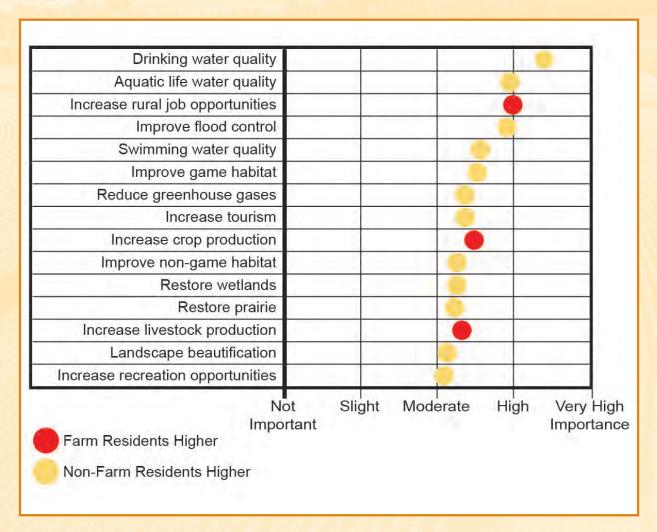


Figure 16. The scientists surveyed lowa residents living on farms and those that didn't live on farms. They wanted to see how the two groups compared on certain issues. The circles indicate the mean (average) answer from both groups of lowa residents. The color of the circle indicates which group (farm residents or non-farm residents) had a higher mean survey result for that issue.

Illustration by Stephanie Pfeiffer.



The scientists found little difference in benefits between the three prairie strip treatments. What does this tell you about how prairie strips should be arranged in agricultural areas?

Review the various priorities listed in figure 14. Think about the place where you live. What is your top priority from that list? Why?

Are you surprised that lowa residents shared the priority of improving water quality?

Why or why not?

Discussion

The experimental results confirmed the scientists' expectations about the differences between catchments with and without prairie strips. Prairie strips replace some crop land, therefore reducing crop production and revenue. However, many of the environmental benefits created by prairie strips outweigh the benefits lost from reduced crop land.

As discussed in "Thinking About the Environment," restoring native ecosystems provides environmental benefits. Planting native prairie plants was effective at slowing water runoff, therefore reducing soil and nutrient loss. Native prairie plants are also better for pollinating insects and may be less attractive to harmful pests.

The scientists found that prairie strips were a suitable solution for a large portion of Iowa. Compared to other farm conservation techniques, prairie strips are low cost and don't require much change to farm operations. Additionally, the benefits provided by prairie strips are of high priority to Iowa residents. Specifically, Iowa residents valued improved water quality.

The results of this study illustrate that prairie strips are both a beneficial and practical solution for improving the environment on agricultural lands. Despite these results, the scientists believe the government must provide policy, **incentives**, and education to encourage farmers to use prairie strips.

The scientists recognize that farmers may need encouragement to adopt prairie strips as a solution. What would you tell a farmer to convince them to adopt prairie strips in their agricultural lands?

crops with prairie plants is a good idea? Why or why not?

Do you think replacing

Adapted from Schulte, L. et al. 2017. Prairie strips improve biodiversity and the delivery of multiple ecosystem services from corn-soybean croplands. Proceedings of the National Academy of Sciences of the United States of America. 114: 11247-11252. https://www.fs.fed.us/nrs/pubs/jrnl/2017/nrs 2017 schulte 001.pdf.

Cream of the Crop GLOSSARY

agriculture (a gri kəl chər): The science or practice of preparing the soil, producing crops, and raising livestock.

annual (an yü əl): A plant living for a year or less, reproducing by seed.

biodiversity (**bī** ō dī **vər** sə tē): A measure of the differences between the types and numbers of living things in a natural area.

catchment (kach mont): (1) A small watershed; (2) Something that catches water.

control (kən **trōl**): A control is something used for comparison when checking the results of an experiment.

ecosystem services (ē kə sis təm sər vəs es): Environmental benefits provided by a community of plant and animal species.

harvest (här vəst): To gather, collect, or take a crop.

incentive (in sen tiv): Something that makes a person try or take an action.

inventory (**in** von tor ē): A complete list of goods, supplies, possessions, or items.

native (**nā** tiv): Naturally occurring in an area.

nonnative (nän **nā** tiv): Not naturally occurring in an area.

perennial (pə ren ē əl): Present at all seasons of the year.

pollination (pä lə nā shən): The transfer of pollen from a stamen to a pistil of a flower or from a male cone to a female cone.

practical (**prak** ti kəl): Likely to succeed and reasonable to do or use.

revenue (re və nü): The total incomes produced by a given source.

Accented syllables are in **bold**. Marks and definitions are from https://www.merriam-webster.com. Definitions are limited to the definition used in the article.

FACTivity

This FACTivity was adapted from the "Roots - Why So Fine?" lesson plan produced by the University of Northern Iowa Tallgrass Prairie Center. To learn more, visit https://tallgrassprairiecenter.org/sites/default/files/lesson_plans/why_so_fine.pdf.



Time Needed

One class period

Materials

- Electronic kitchen scale
- Clock or timer
- Sugar, finely ground coffee, cocoa powder, or similar item
- Measuring cup or tablespoon

Materials (per student or group of students)

- 3 6-inch pieces of ½ inch, twisted rope (hemp or cotton)
- 3 plastic cups with water
- 3 pencils
- 3 binder clips
- Plastic sandwich bag
- Permanent marker
- Why So Fine? Graphic Organizer

In this FACTivity, you will use every-day materials to explore how root size impacts the exchange of materials between roots and their surrounding environment.

FACTivity Background

As you read in the "Cream of the Crop" article, the tallgrass prairie ecosystem provides many ecosystem services. For instance, the deep and dense root system of native prairie plants slows water runoff and helps preserve soil and nutrients. The roots of these prairie plants provide structure for the soil. The roots also absorb water and exchange material with the soil.

Many of the tallgrass prairie plants are **perennial**. These root systems are working all year, even though you might only see the aboveground grasses growing during the warmer months. The life cycle of perennial plants is different than many crops grown in similar areas, which are **annuals**.

Much of the exchange between roots and soil occurs at the root tips where many very small roots are found, called "root hairs" (figure 17). The root hairs increase the surface area of root systems, enabling plants to exchange more water and nutrients.

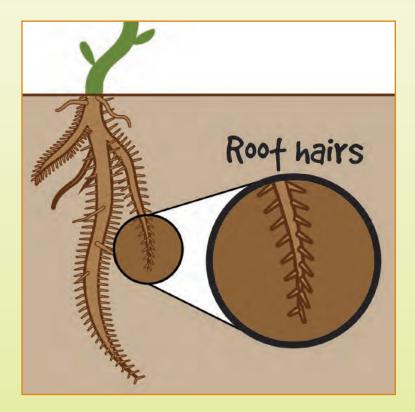


Figure 17. Root hairs are the very small, hair-like roots that grow on the larger roots. Root hairs increase the surface area through which plants can take up nutrients and water with the soil.

Illustration by Stephanie Pfeiffer.

FACTivity Methods

Begin by discussing the ecosystem services provided by the native tallgrass prairie ecosystem, like how roots slow water and soil runoff. Images of prairie root systems can be found at: https://www.tallgrassprairiecenter.org/curriculum images. What do you notice about these roots?

Your teacher will provide each student or group of students with the ropes, plastic cups, pencils, binder clips, plastic sandwich bag, permanent markers, and copies of the "Why So Fine? Graphic Organizer."

Using a permanent marker, label one cup "Thick," one "Medium," and one "Fine."

Fill each cup with the same amount of water. Cups should be filled at least halfway with water.

The three pieces of rope will be made into models of three types of roots or root structures (figure 18). One piece will stay completely twisted to represent a thick root. Another piece should be unraveled half of its length, leaving a few medium strands of rope. The last piece should be unraveled over half its length and separated into many fine strands.



Figure 18. Each of your three pieces of rope should be different. One should represent a thick root, one should represent a few medium-sized roots, and one should represent many fine roots.

Illustration by Stephanie Pfeiffer.

Using the scale provided by your teacher, weigh each of your ropes. Record the weight of each in the appropriate spot on your graphic organizer.

Which root structure will absorb more water? Why? Write your answers to these questions in the appropriate spots on your graphic organizer.

Start the experiment by first attaching the thick rope to the binder clip, then threading the pencil through the metal arms, then placing the rope and clip together next to the appropriate cup of water (figure 19). Repeat this step with each of the other root structure models.

Put each of the root structure models into the appropriate cups, allowing them to rest in the water. Let sit for 10 minutes.

Your teacher will come around after the 10 minutes to help you measure the weight of each model root structure using the electronic kitchen scale. Record the weights of each model root structure in the appropriate spot on your graphic organizer.

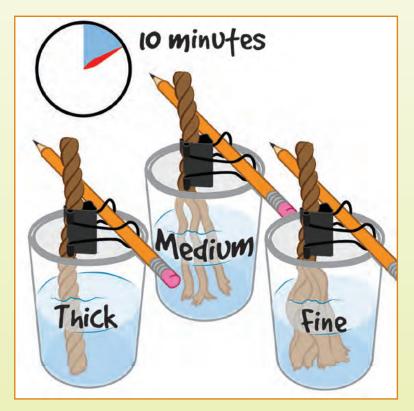


Figure 19. Each piece of rope should be clipped into a different binder clip, and a pencil should be slipped through the metal arms of binder clip.

Illustrations by Stephanie Pfeiffer.

Your teacher will also fill your plastic sandwich bag with sugar, finely ground coffee, cocoa powder, or a similar item. This material represents nutrients that can be exchanged with the roots.

One at a time, take each model root structure, place it in the bag. Close the bag and shake the bag for 10 seconds (figure 20).

Once all three have been individually shaken in the bags, look at the model root structures and rank them based on how much material is attached to the rope. Number one should be the root with the most nutrients and number three should be the root with the least nutrients. The more material attached, the more "nutrients" the model root structure could exchange with the soil.

Record these rankings on the appropriate spot on the graphic organizer.



Figure 20. Place each piece of rope individually into the bag and shake for 10 seconds. Remove the rope and place it on the table until each rope has been shaken and compared to one another.

Illustration by Stephanie Pfeiffer.

As a class, discuss the results of the experiment. Were your predictions accurate? Why or why not? What did you learn about roots and root structure from this experiment? Why is root structure so important to a plant?

Why So Fine? Graphic Organizer

Complete this graphic organizer as prompted in the Methods section of the FACTivity.

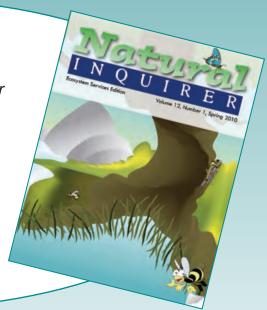
WEIGHT BEFORE				
Thick	Medium	Fine		
(2.1.1.		^		
Vhich root structure will	absorb more water? Why	/? 		
WEIGHT AFTED				
Thick	WEIGHT AFTER	Fino		
Thick	Medium	Fine		
ank the root structures	sorbed the most nutrients 1-3, with 1 being the best	t and 3 the worst.		
	· v	•		
-	curate? Why or why not?			
vnat did you learn about Vhy is root structure so i	roots and root structure moortant to a plant?	from this experiment?		

Natural Inquirer Connections

You may want to reference this *Natural Inquirer* article for additional information:

 For more information on ecosystem services, read the Natural Inquirer Ecosystem Services edition.

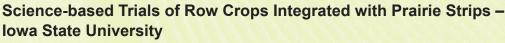
This article, along with others, can be found at: http://www.naturalinquirer.org/all-issues.html.





If you are a trained Project Learning Tree educator, you may use "Pass the Plants, Please" and "Field, Forest, Stream" as additional resources.

Web Resources



https://www.nrem.iastate.edu/research/STRIPS/

Tallgrass Prairie Center – University of Northern Iowa

https://tallgrassprairiecenter.org/

Midewin National Tallgrass Prairie

https://www.fs.usda.gov/main/midewin/home

National Forest Foundation Midewin Tallgrass Prairie Restoration Video https://youtu.be/YQ eF5zlhSU

Tallgrass Prairie National Preserve - National Park Service

https://www.nps.gov/tapr/index.htm

Welcome to Your National Grasslands - USDA Forest Service

https://www.fs.fed.us/grasslands/

GrasslandsLIVE

https://grasslandslive.org/

World Rangeland Learning Experience (WRANGLE) - University of Arizona https://wrangle.org/



Cream of the Crop **Create-A-Phrase Challenge**

Draw a line from a word in the left column to a word in the right column to create a phrase from this article. Explain or write at least three sentences to describe what each phrase means.

Prairie	Prairie
Ecosystem	Benefits
Multiple	Strips
Practical	Solution
Control	Lands
Environmental	Treatment
Agricultural	Benefits
Tallgrass	Services

Cream of the Crop eyeChallenge

Each of the following images represents something from the article. Explain what each of these images represents. You may write your explanation or hold a class discussion. If you write your explanation, use complete sentences, proper spelling and grammar, and appropriate punctuation.

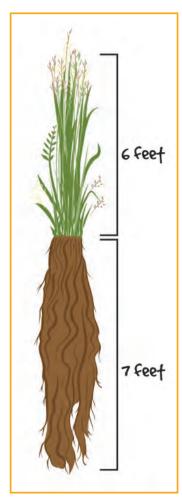
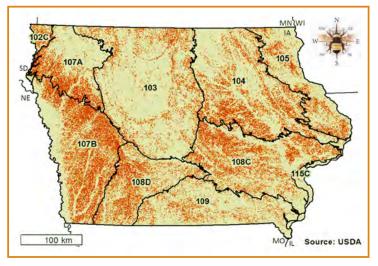


Illustration by Stephanie Pfeiffer.



Photo courtesy of Stephanie Laseter, USDA Forest Service.



Map courtesy of the USDA, National Agricultural Statistics Survey.

Photo by LivingImages, via http://www.istockphoto.com.



Photo by Omar de Kok-Mercado, Iowa State University.





National Education Standards

For more detailed correlations of this *Natural Inquirer* Monograph to National Education Standards, visit the *Natural Inquirer* website (http://www.naturalinquirer.org).

National Science Education Standards Addressed In This Article

- Abilities necessary to do scientific inquiry
- · Understandings about scientific inquiry
- · Structure and function in living systems
- · Populations and Ecosystems
- · Diversity and adaptations of organisms
- Understandings about science and technology
- Populations, Resources, and Environments
- Natural Hazards
- · Science and technology in society
- Science as a human endeavor
- Nature of Science
- History of Science
- Social Studies Education Standards Addressed In This Article
- Culture
- · Time, Continuity, and Change
- · People, Places, and Environments
- · Individuals, Groups, and Institutions
- Science, Technology, and Society
- Production, Distribution, and Consumption
- Science, Technology, and Society

Common Core Education Standards Addressed in This Article

Key Ideas and Details

CCSS.ELA-Literacy.RST.6-8.1

CCSS.ELA-Literacy.RST.6-8.2

CCSS.ELA-Literacy.RST.6-8.3

Craft and Structure

CCSS.ELA-Literacy.RST.6-8.4

CCSS.ELA-Literacy.RST.6-8.5

CCSS.ELA-Literacy.RST.6-8.6

Integration of Knowledge and Ideas

CCSS.ELA-Literacy.RST.6-8.7

CCSS.ELA-Literacy.RST.6-8.8

CCSS.ELA-Literacy.RST.6-8.9

Next Generation Science Standards Addressed In This Article

Science and Engineering Practices

Asking Questions and Defining Problems

Planning and Carrying Out Investigations

Analyzing and Interpreting Data

Developing and Using Models

Constructing Explanations and Designing Solutions

Engaging in Argument From Evidence

Using Mathematics and Computational Thinking

Obtaining, Evaluating, and Communicating Information

· Disciplinary Core Ideas

Life Science: LS1.A Structure and Function; LS1.B Growth and Development of Organisms; LS2.A Interdependent Relationships in Ecosystems; LS2.B Cycle of Matter and Energy Transfer in Ecosystems; LS2.C Ecosystem Dynamics, Functioning, and Resilience; LS4.B Natural Selection; LS4.C Adaptation; LS4.D Biodiversity and Humans

Earth and Space Science: ESS2.C The Roles of Water in Earth's Surface Processes; ESS2.D Weather and Climate; ESS3.A Natural Resources; ESS3.B Natural Hazards; ESS3.C Human Impacts on Earth Systems

Crosscutting Concepts

Patterns

Cause and Effect: Mechanism and Prediction

Structure and Function

Stability and Change

Connections to Nature of Science

Connection to Engineering, Technology, and Applications of Science







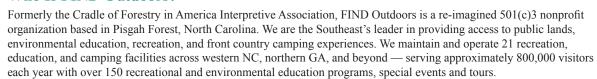
What Is the Forest Service?

The Forest Service is part of the United States Department of Agriculture (USDA). The Forest Service is made up of thousands of people who care for the Nation's forest lands and grasslands. The Forest Service manages 154 National Forests and 20 National Grasslands. These are large areas of trees, streams, and grasslands. National Forests are similar in some ways to National Parks.

Both are public lands, meaning they are owned by the public and managed for the public's use and benefit. Both National Forests and National Parks provide clean water, homes for the animals that live in the wild, and places for people to do fun things in the outdoors. National Forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the Forest Service are scientists whose work is presented in the journal. Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our natural environment is healthy, now and into the future.

For more information, visit https://www.fs.fed.us.

Who Is FIND Outdoors?





Our story is rooted in education about the **forest**.

Our passion is to help people become inspired.

Our goal is to help people connect with nature.

Our drive is to help people learn through discovery.

We help people...FIND Outdoors

We are...FIND Outdoors

For more information, visit http://www.goFINDoutdoors.org.

What is 4-H?

The 4-H Youth Development Program is the youth outreach program from the land-grant institutions' cooperative extension services and the U.S. Department of Agriculture. 4-H serves as a model program for the practice of positive youth development by creating positive learning experiences; positive relationships for and between youth and adults; positive, safe environments; and opportunities for positive risk taking.



For more information, visit https://4-h.org/

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Distance Learning Student Editorial Review Board April 2020



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Forest Service Conservation Education https://www.fs.usda.gov/conservationeducation

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FS-1167 March 2021

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