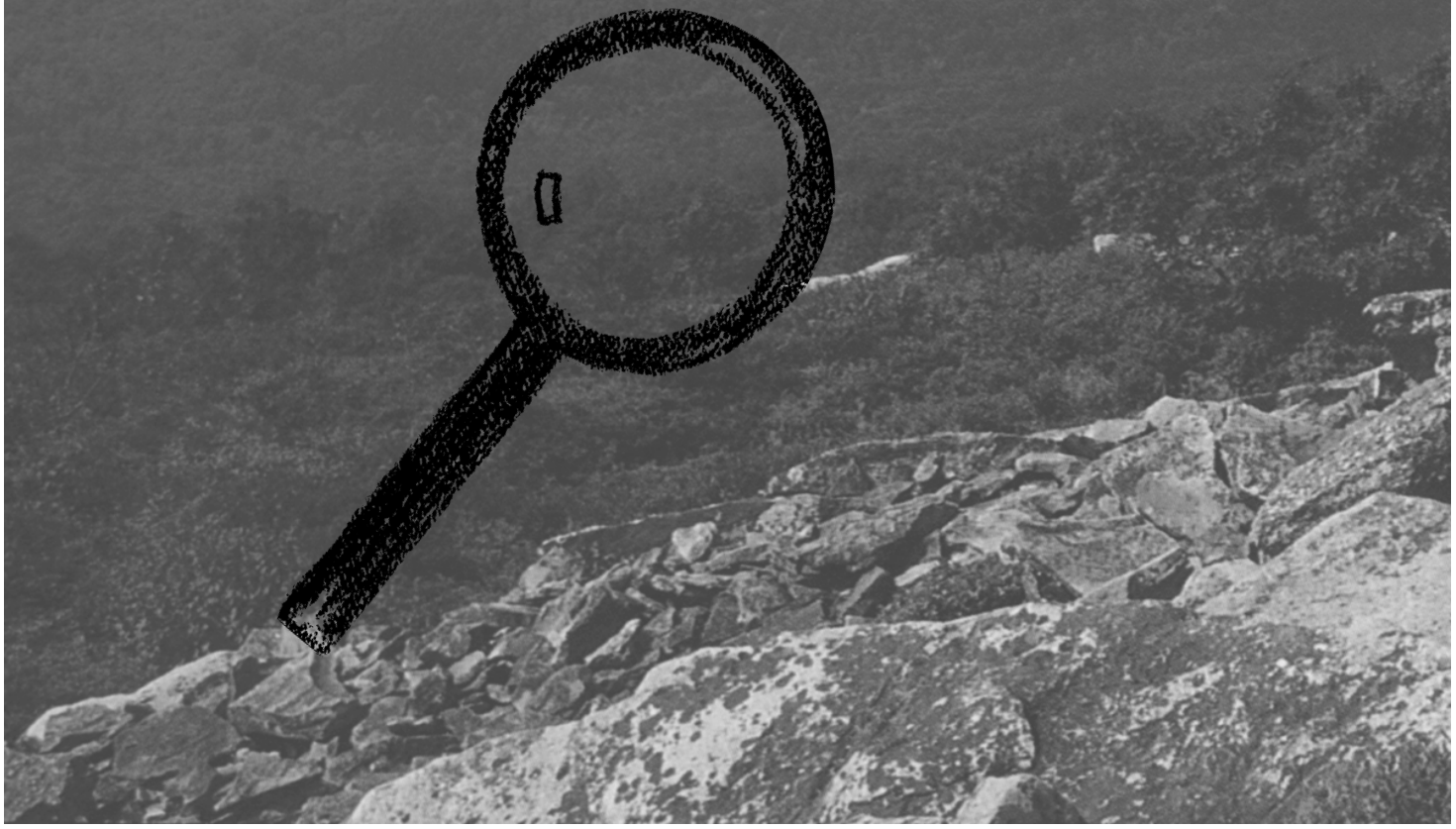
Spring 1999, Volume 1, Number 2

The Natural Inquirer

A Research and Science Education Journal



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SRS 4104 - Management & Properties of SE Species
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SRS 4901 - Outdoor Recreation and Wilderness Assessment
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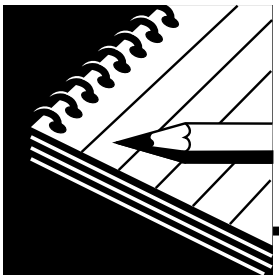

TEACHER'S NOTE

Although students will learn about natural resources by reading these articles, one of the main purposes of the journal is to introduce the work of scientists to middle school science students. Our goal is to stimulate an interest in natural resource and life sciences by presenting the research activities of a variety of scientists. In the articles, reflection questions are placed at the end of each section. These reflection questions are oriented toward helping the teacher conduct a class discussion about the problems, methods, and findings associated with each research article. These questions should stimulate critical thinking about the research. Critical thinking and discussion may be encouraged by using small groups, although entire class discussions may also be helpful. Note that the answers to the questions should not be considered right or wrong. They are only intended to stimulate critical thinking.

The articles themselves, as well as the journal's overall format, are designed to imitate the format of a professional research journal. Prior to publication, this journal's articles were reviewed by the primary scientist and by a young reviewer between the ages 9 and 16. When introducing the journal, the teacher may want to bring the students' attention to the list of youth editors. A discussion of the advantages and disadvantages of peer review is suggested. Again, there are no right or wrong answers. The purpose of this discussion would be to consider one of the many activities and procedures of science—In this case using other scientists to review the completed research.

On first page of each article, we have included three additional sections. The first section highlights an item having to do with scientific methods or concerns. The second section presents a Discovery activity, which provides the teacher with a hands-on activity related in some way to the article. A list of vocabulary words follow the Discovery activity. Understanding these words will be crucial to the student's comprehension of the article.

This journal was created by the Urban Tree House, an education program of the USDA Forest Service. It was produced as a summer project for college interns, sponsored by the Forest Service and the Hispanic Association of Colleges and Universities. We want your comments and suggestions. Also, if you are interested in having your class participate in research to understand the effectiveness of this journal, please contact

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ABOUT THE NATURAL INQUIRER

Scientists report their research in journals, which are special booklets that enable scientists to share information with one another. This journal, The Natural Inquirer, was created so that scientists can share their information with you and with other middle school science students. Each article tells you about scientific research conducted by scientists in the USDA Forest Service. All of the research in this journal is concerned with natural resources, such as trees, forests, wildlife, and outdoor activities. First, the article will tell you about a scientific principle, technique, or special concern of scientists. Then, YOU are the scientist as you do the Discovery activity. The vocabulary section will help you understand the article.

At the end of each section of the article, there are Reflection boxes, questions to help you think about the research. These questions are not a test! They are intended to help you think more about what the scientists did. Your teacher may also use the questions in a class discussion.

The research in this journal is just a small part of what scientists study in natural resources. Other things that are studied are water, soils, wildlife, and insects. Scientists also study how the various parts of the forest interact and depend on one another. In the Forest Service, scientists study natural resources throughout the United States. They try to solve problems and advance our understanding of how to take better care of our natural resources.

What are Scientists?

Scientists are people who collect and evaluate information about a wide range of topics. Scientists have some qualities that you may have also. To be a successful natural resource scientist, you must:

Be curious
— You must want to know something, and be interested in learning.

Be enthusiastic
— You must be very interested in a particular subject.

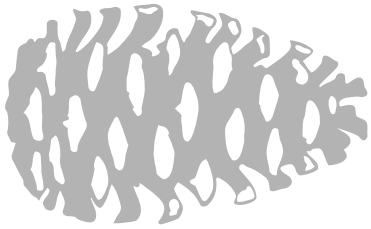
Be careful
— You must be accurate in everything you do.

Be open-minded
— You must be willing to listen to new ideas.

Question everything
— You must think about ideas and what you read. You must not be willing to accept what you read without thinking about it yourself. You must be a reflective person!

Care about the environment
— You must have interest in and respect for the natural world. You must want to protect the environment.

Why? What if...? Is that true?



The Sick Seeds
Black Seed Rot and Slash Pines

Vocabulary
Vocabulary in article indicated in italics

Colonize
To establish or form a colony

Fertile
Capable of producing offspring

Fungus
Organisms which contain no chlorophyll and are parasitic

Germination
Beginning of growth; sprouting

Infestation
A large amount of parasites swarmed in one area

Moisture content
The amount of moisture an object contains

Organic matter
Substance which breaks down naturally and which comes from either plants or animals

Seed orchards
A place where trees are planted to harvest seeds

Specimen
An individual or part considered representative of group as a whole

Adapted from:
Fraedrich, S. W., T. Miller, and S. J. Zarnoch. 1994. Factors affecting the incidence of black seed rot in slash pine. *Canadian Journal of Forest Resources,* 24:1717-1725

Scientists often study things using a particular ***research design***. That means that they plan in advance what they will do, and they follow their plans carefully. In this study, the scientists wanted to be able to compare the *germination* of seeds that were collected at three different times and in two different ways. Therefore, they carefully planned how and when the seeds would be collected. When scientists carefully follow their plans, they can have more confidence in their results.

Discovery

You are a scientist trying to discover what conditions are most favorable for seed germination. Obtain lima beans from a seed store. Get five clear plastic cups, five pieces of dark blotter paper, and a bag of cotton balls. Soak the lima beans in water overnight. Line the cups with the blotter paper and stuff the centers with the cottonballs. Place ten lima beans in each tumbler between the blotter paper and the plastic so that you can see the beans throught the plastic. Moisten the cotton balls in four of the cups, so that the blotter paper becomes moist. Put the dry cup on a table in the classroom, along with two other cups. Cover one of these two "wet" cups tightly with plastic wrap. Put the fourth "wet" cup in the dark and the fifth in a refrigerator. Make sure the blotter paper stays moist (except for the dry cup and the plastic covered "wet" cup) by adding water to the cotton every few days. Observe and record the germination that occurs in each cup. Which conditions are favorable and not favorable for seed germination?

Introduction

Just like you and me, trees can get sick. This can happen in many different ways. One way trees become ill is through an *infestation* of insects or fungi. This is what happens to a certain type of tree called slash pine. In this case though, it is not the actual tree which is affected, but the seeds. When seeds are infected with black seed rot, a type of *fungus*, they become damaged. What happens is that the black seed rot

does exactly what the name says--it rots the seeds and gives them black spots! Sometimes they are damaged so badly that the seeds will never be able to grow into a tree. The reason this happens is that the rot affects the seed's ability to germinate. This is especially bad news to *seed orchards* where they grow trees specifically for selling the seeds. For people who manage seed orchards, losing seeds to black seed rot means losing money. And for us, that means fewer trees. Three scientists, S.W. Fraedrich, T. Miller, and S.J. Zarnoch, decided to investigate why black seed rot occurs and what its effects are. This is what they did and what they found out....


A loblolly pine seed orchard.

Reflection

1 Why is it important that the scientists study black seed rot?

2 Who will benefit from the results of this study?

Methods

First, the scientists traveled to a slash pine seed orchard in Florida. They then began to collect cones, which contain the pine seeds, for their experiment. Three cones were taken directly from the tree and put into storage bags. Three more cones were hand-picked off the trees and dropped to the ground. Three days later, these cones were gathered off the ground and put into bags. The scientists repeated this procedure at three different times of the month.

After the scientists collected all the cones, they stored them as normally done by seed orchard managers. After storage, the scientists opened the cones and took out the seeds.

Three tests were performed on the seeds:

Fungus test

First, the seeds were examined for any *fungus specimen*s. The fungus test would show the scientists exactly which seeds were diseased.

Moisture test

Cones were weighed and tested for *moisture content*. Because unopened (or younger) cones have more moisture, they are heavier. This test determined the cone's maturity.

Germination test

The purpose of this test was to find out what percentage of the seeds would *germinate.*


Cones in storage at a seed orchard

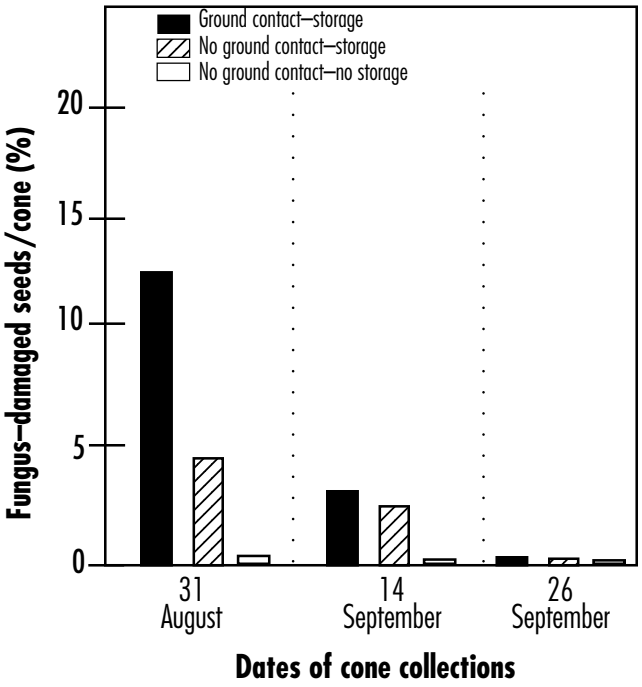


Fig. 1 Can you tell which month was more favorable for germinations? What kind of effects did ground contact or storage have?

Results

After the seeds went through all the tests, the scientists studied the information they obtained. The scientists concluded that the cones that were picked later were the healthiest. If the cones are removed from the tree too early, and they have contact with the ground, the seeds have a greater chance of becomming sick. This is because more *fungus* can get on them when this happens. Collecting cones later greatly decreases the chances that the seeds will get sick. They found that the cones that were collected later have less moisture in them than those collected earlier, and, therefore, are less likely to have fungi develop in them.

The scientists believe that the reasons fungi were growing on the seeds include:
1.*Organic matter* on the ground, such as twigs and fallen branches, help fungi *colonize* cones. Because *fungus* already existed on the *organic matter* on the ground, the cones that had fallen may have been an easy target.
2. Picking the cones off the trees sometimes made little wounds on the surface of the cones. Some of these wounds were caused as the cones were falling from the tree. On their way down, most cones bump against branches. When they hit the ground they almost always become damaged. These openings can become infected with fungi.
3. *Fungus* needs a moist environment to grow. At the beginning of the harvest season the cones have more moisture than at the end.

Further Discovery

Reflection

1 When do you think would be the best time to harvest the seeds?

2 If you were a scientist doing this experiment, what would you tell the seed orchard owners to do to increase the amount of healthy seeds?

In the activity that you did at the beginning of this article, you carried out an experiment by following plans. You tested seed germination: 1) at room temperature with no water, 2) at room temperature with no air and with moisture, 3) at room temperature with no light and with moisture, 4) at a cold temperature

with moisture, and 5) at room temperature with light, with air, and with moisture. Because you followed these plans, you can report, with some confidence, which conditions are more and less favorable for lima bean seed germination. When you report your findings, do you think you should explain how you did your experiment? Why or why not?

Reflection

1 Why do you think the scientists picked cones at different times and under different conditions?

2 Which cones do you think had the most fungus? Why?

Whitewater Rafting Measures Up!

The Value of Guided Rafting on Southern Rivers

VOCABULARY
Vocabulary in article indicated in italics

Consumer surplus
The extra price people are willing to pay for something, above its actual cost

Guided rafting trip
A whitewater rafting trip that is led by a professional guide

Monetary value
How much money something is worth

Non-commodity value
A monetary value (see above) placed on something, although it is something that cannot be bought or sold

Quantify
To measure something and assign a number to it

The scientists in this study wanted to ***quantify*** the value of people's vacations. For most scientists, numbers are necessary to evaluate and compare the results of their research. For some things, discovering the correct number is easy. For example, it is easy to measure how tall a tree is, or how many insects you find in a particular area. For social scientists, measuring things like people's attitudes or values is much harder. In this study, you will learn how the scientists put numbers on the value of a whitewater rafting trip.

Discovery

Bring a special toy, stuffed animal, or book to school. Share it with your classmates. Pretend that you are auctioning it off. Ask for prices until you reach the highest bidder. Is the price higher or lower than what you think it is worth? Why do you think that the value is higher or lower than you think it is worth?

Introduction

People have many different kinds of values. They might value their family, home, and country, as well as their favorite t-shirt or place to play. Almost everything has some kind of value, from an old teddy bear to your parents' car.

Adapted from:
Bowker, Mike J., D. B. K. English, J. A. Donovan. 1996. Toward a value forguided rafting on southern rivers. *Journal of Agricultural and Applied Economics,* 28:423-432.

Some values are easy to *quantify*, such as the value of a new car. This is because the car can be bought or sold for a price. Other values, such as the value of your old teddy bear, cannot be easily quantified. That is because you probably would not sell your teddy bear, and no one else might not want to buy it anyway. Nevertheless, that teddy bear has a value, which would be called its *non-commodity value*.

Many kinds of activities are done outside, such as hiking, birdwatching, and canoeing. You may not pay to do these activities, but they still have a value to you. If forest managers have to decide between two options, they want to know how much people value the two options, even if one of the options has a *non-commodity value*. For example, if a river is dammed for electric power, the electricity has value to some people. However, the river can then no longer be used for canoeing and rafting, which also has a value to some people.

Economists are social scientists who try to identify the *monetary value* of non-commodity resources, as well as commodity resources. For example, they try to compare the value of things that are not bought and sold, but are nevertheless important to people. Economists call the value of something, especially the value that people are willing to pay for something over its actual cost, *consumer surplus*. They try to estimate *consumer surplus* so that decisions can be made according to the best understanding of what people value.

Scientists Mike Bowker, D. B. K. English, and J. A. Donovan, wanted to understand the value of whitewater rafting. They felt that if they could identify a *consumer surplus* value for whitewater rafting, decision-makers could make better decisions in the future about how to manage free flowing rivers.

Reflection

1 Why do you think it is important (or not important) to understand non-commodity and consumer surplus values?

2 What are things that have a non-commodity value in your life?

Methods

Dr. Bowker and his colleagues studied people who rafted on two rivers, the Chattooga River in Georgia, and the Nantahala river in North Carolina. They created a questionnaire, and mailed it to people who had taken a *guided rafting trip* on either of the two rivers. The scientists asked people how far they traveled to get to the river, how much money they spent to go rafting, and how often they went rafting. They also asked people what their income was. They calculated the value of the rafting trip by adding up actual costs and estimating other costs and values. For example, they multiplied the number of miles each person said they traveled by $.09, and added that to the actual cost of going rafting. Economists believe that people's time is worth something, so the scientists added an estimate for the amount of time spent traveling and rafting. This estimate was based on the amount of their income, or how much they are paid to work. Because economists do not agree on how best to estimate the value of a person's time, Dr. Bowker and his colleagues used a range of values. They, therefore, ended up with a range of values for guided rafting on the two rivers.

Reflection

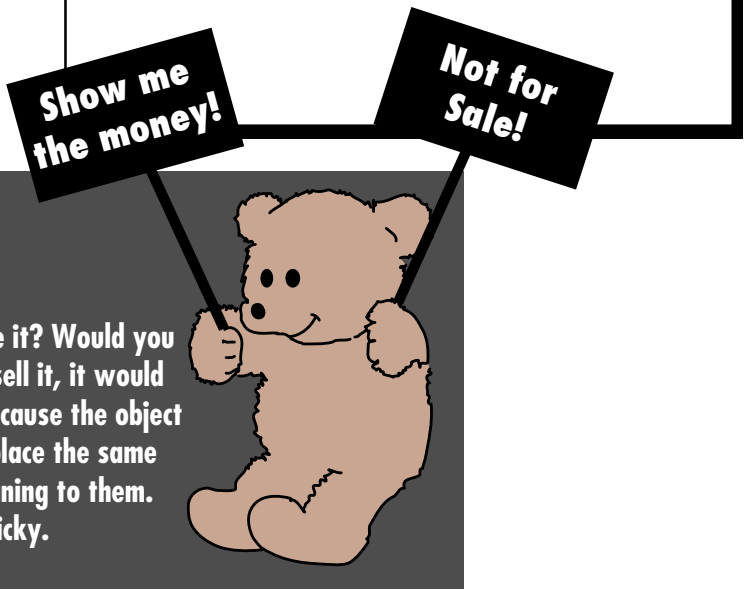
1 Think about taking a day trip with your family to go boating on a nearby lake. Would you be willing to give up playing with your friends to do that?

2 Now think about taking a day trip with your mom or dad so they can visit the dentist. Would you want to give up playing with your friends to do that? What is the difference between the two day trips?

3 Do you think that using a person's income is a good way to estimate the value of his/her time? Why or why not?

What would you do?

Think about your favorite thing in the world, for example, a toy or a book. How much do you value it? Would you sell it if given the chance? Chances are if you did sell it, it would be for a lot more than the original price. This is because the object is special to you. Perhaps other people wouldn't place the same price on it, because it probably has a different meaning to them. As you can see, placing a price on things can get tricky.



Results

Dr. Bowker and his colleagues found that guided rafting on the Chattooga River had a *consumer surplus* of between $119 and $286, depending on how the value of people's time was computed. They found that the Nantahala River's *consumer surplus* value was between $89 and $191. Why do you think the Chattooga River's rafting value was higher? The scientists believe it is because the rapids on the Chattooga River are more exciting to raft than the Nantahala River, and people are willing to pay more for the experience. With information like this, decision-makers can better compare the value of different management options on free flowing rivers. Then, when they make decisions, even experiences that cannot be bought or sold can be considered.

Reflection

1 Has your mother or father ever told you that you could not go outside to play until a household chore or your homework was done? In what way is your mother or father putting a value on your after-school time?

2 Do you think you could put a monetary value on your afterschool free time? Why or why not?

Spores Galore!
A Look into the World of Fungi & How they Reproduce

VOCABULARY
Vocabulary in article indicated in italics

Asexual reproduction
Act of reproducing without a mate

Agar (aw' gur)
Jelly-like substance made from seaweed; used as a thickener in foods

Basidiospores
(bah sid' ee oh spors) *Spores* associated with spreading plant disease

Chlorophyll (klor' oh fil)
substance which helps produce food (carbohydrates) for plants; this is what gives plants their green color

Direct germination
To germinate (sprout) under favorable conditions

Dormant
An inactive, yet live state

Exudation (ex oo day' shun)
The process of the oozing out of matter

Germination (jer min ay' shun)
To sprout; development

Hydrate
To combine with water

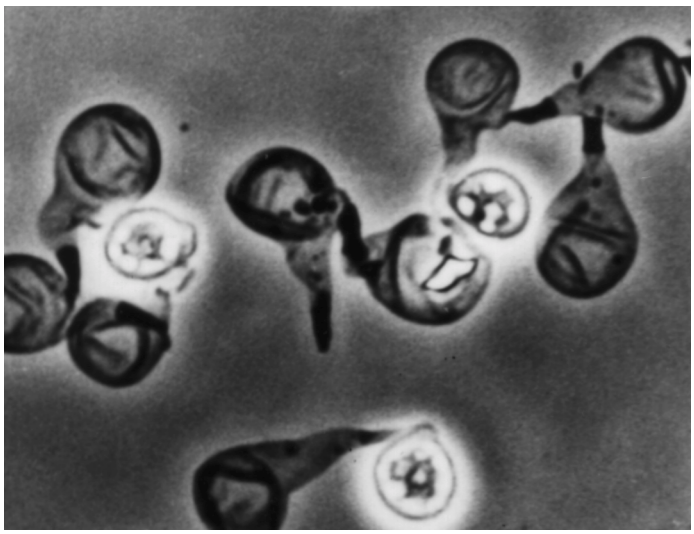
Spores
Microscopic bodies which alter germination and develop into fungi

Adapted from:
Spaine, Paula C., and S. Kaneko. 1993. Spore exudates and other factors affecting germination type of Cronartium quercuum f. sp.fusiform basidiospores. *Mycologia. 85:51-61.*

The scientists in this study conducted **basic research** to understand the reproduction of *spores*. Basic research is research that is not aimed at solving a particular problem. Instead, the scientist designs a study that advances knowledge in a particular area of interest, with the hope that the information can be useful to other scientists in the future.

Discovery

This paper is about fungi. You might be wondering what fungi are. The following paper will describe fungi, but first let's see what a fungus looks like. Bring a fresh, watery fruit such as grapes or strawberries and a plastic bag from home. Put the fruit in the bag with a few drops of water and place in a warm area. Observe the fruit every day, and notice the changes that occur as mold begins to form. Why do you think the mold appeared?



The spore is forming a seconday case where it will remain for a certain period of time to ensure that the spore germinates when the environment is most favorable.

Introduction

Fungi are very distinct among the plant and animal kingdoms. They are neither plant nor animal. Since they do not contain *chlorophyll*, they cannot be considered plants. And because they lack certain animal characteristics, like mobility, they cannot be considered a part of the animal

kingdom. Because fungi are immobile, they cannot hunt or gather food. Therefore, in order for a fungus to survive, it must feed off a host.

Not only are their eating habits different, but they reproduce in a very strange and fascinating way. As you may already know, there are many types of fungi. While some can reproduce sexually, they are all asexual reproducers. In other words, they do not need a partner to produce offspring. *Asexual reproduction* is carried out by cell division. Fungi do this by forming *spores*, a microscopic body which is somewhat like an egg because it contains DNA and nutrients. However, they are unlike eggs because they do not need to be fertilized by sperm. What is inside the spore's protective wall is all it needs to become a fungus!

How many *spores* do you think a fungus can produce? The answer is millions! When the environment is favorable, the fungus releases its *spores*. Since *spores* need a lot of moisture, the most favorable environment would be one that is humid or rainy. After the *spores* are released they are carried either by wind or rain. When they land they do something very curious. You see, the *spores* can only *germinate* under certain conditions. These conditions are: plenty of water, humidity, and food in the environment. Also, the surface onto which they land has to be just right in order for the spore to continue its *germination* process. So, the *spores* "sense" the environment and "make a decision" as to whether or not they should continue to germinate. If they "decide" it is favorable, they begin cell division. This is called *direct germination*.

If the *spores* do not find the conditions favorable, they stop the *germination* process. They do this by going into a *dormant* state. They are considered *dormant* because the *spores* do not need to obtain nutrients externally. The *spores* contain fats and carbohydrates that nourish them while they are *dormant*. If the environment becomes favorable in a short period of time, the spore can begin *germination* again.

Studies have shown that the primary reason for this *dormant* state is that in this way a spore can continue to live while waiting until the time is right to germinate. You might be asking yourself how the spore "knows" when to directly germinate and when to go *dormant*. That is a very good question. In fact, it is a question that scientists Paula Spaine and S. Kaneko asked themselves. This question, in turn, led to a research study on *germination* factors that affect *spores*.

Reflection

1 Some animals, such as bears, are also able to live in a dormant state. This dormant state is called:

2 Why do you think the spores might "decide" to go dormant?

Methods

The spores were put in different conditions to see which conditions are most favorable for *germination.* The experiment conducted involved the following tests:

Agar Concentration

This test used *agar*, a jelly-like substance made from seaweed, to simulate leaf hardness. In other words, Drs. Spaine and Kaneko wanted to find out what level of leaf hardness is more favorable for spore *germination*.

Agar pH

This test determined which pH level, or acidity level, is ideal for both *direct* and indirect *germination*. Drs. Spaine and Kaneko used agar with different concentrations of acidity to see which concentration is most favorable for *germination*.

Washing Time

In this test, *spores* were washed with water for different amounts of time. The purpose of this test was to find how much washing had to occur before the *spores* lost their ability to germinate after being *dormant*.

Results

Agar hardness did not affect the *spores* significantly. As for pH level, Drs. Spaine and Kaneko found that higher acidity produced higher *direct germination* rates. The washing time test concluded that all washing treatments resulted in more *direct germination*. Almost all (99%) of the *spores* that had been washed germinated directly. But, only 4-11% of unwashed *spores* germinated directly.

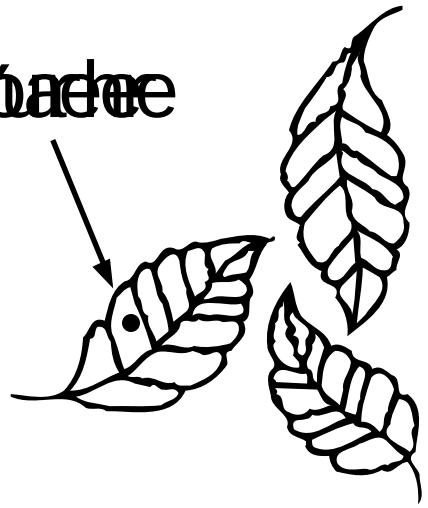
Reflection

1 On the basis of the three tests, which factor is least important for spore reproduction?

2 What do you think is the most important factor? Why?

Further Discovery

For fun: Imagine you are a spore... After being released from a fungus you are swept away by the wind. It carries you about a mile away. You land on a dead leaf. This leaf hardly has any moisture in it. The air around you is dry and cold. What will you do?



There's a Fungus Among Us!
Developing Fusiform Rust-Resistant Loblolly & Slash Pines

VOCABULARY
Vocabulary in article indicated in italics

Basidiospore(bah sid e o spor)
A spore responsible for causing Fusiform Rust Disease by infecting pines

Fungus
Organism which contains no chlorophyll and is parasitic

Galls
A swelling of plant tissue caused by fungi, parasites, or insects

Genes
Small sections of DNA containing hereditary information

Susceptible
Can easily be affected by a disease

Inoculation
The introduction of a harmful disease agent into a host

Mortality
Death of an organism or organisms

Orchards
Places where many tree selections are planted for the harvesting of their seeds

Resistance
Able to withstand the infections by a disease agent

Seedlings
Small, young trees

Adapted from:
Powers, H.R., Jr., and J. F. Kraus. 1983. Developing fusiform rust-resistant loblolly and slash pines. *Plant Disease.* 67:187-189.

Sometimes a study is done that completely changes how scientists study or understand a problem. This is called **seminal research**. That is what happened with this research. Prior to this research, scientists looked for the causes of tree disease. This research was different—it looked at how some trees are naturally resistant to disease. Following this research, other scientists began looking at how to encourage the growth of trees that are resistant to disease, rather than at the cause of the disease

Discovery

Your job is to gather spores that cause tree disease. First gather 2-3 red oak leaves and put them aside. Then, find a tree with a gall, which is a swelling in the trunk or limb. Lay a piece of newspaper under the gall. Brush the gall with a broom. Although you will not see them, spores from the gall will fall onto the paper. The spores are so small that you cannot see them without a microscope. Carefully brush the spores into a plastic bottle (pick one that has a large lid). Put some talc in with the spores, and shake the bottle up to mix the talc and the spores. Dust the underside of the red oak leaves. Keep the leaves moist for 24 hours by wrapping them in moist paper towels. Removed the moist paper towels in 24 hours. Within two weeks, the Fusiform Rust Disease will appear as spots on the red oak leaves

A fusiform rust gall on a branch.

Introduction

We need trees for many important activities. Trees reduce soil erosion, reduce noise, lower temperatures, and provide habitat for animals. Trees also provide wood and paper products, such as lumber, furniture, writing paper, and baseball bats. Trees may be found in orchards and in natural forests. Natural forests contain trees that grow naturally while orchards contain trees that are raised and cared for by humans.

Trees get diseases just like humans do. That is why scientists Harry R. Powers and J. F. Kraus study trees. They hope to prevent diseases to maintain a healthy supply of trees. One of these diseases is Fusiform (fusé a form)Rust Disease. This disease is considered one of the most deadly diseases of forest trees and affects loblolly and slash pines throughout the southeastern United States.

This disease is caused by a *fungus* that forms *galls*, which are growths on the stems of trees. These growths cause early *mortality* in the tree and an increase in the chances of storm breakage. That is, the tree becomes so weak that it may break in half when severe winds or storms occur. Stem *galls* can also cause *seedlings*, or small trees, to die at a very early age. *Resistance*, the ability to avoid the disease, is the most practical means of controlling the disease.

Reflection

1 What problem are the scientists trying to solve?

2 Why do you think that resistance is the most practical means of controlling the disease?

Methods

The procedure Drs. Powers and Kraus used involved *inoculation*, or spraying trees with *basidiospore* spray, to determine if the trees were *resistant* to the disease. *Basidiospore* spray is an agent that contains *basidiospores*, or the spores responsible for spreading Fusiform Rust Disease to pine trees. The scientist sprayed *seedlings* from trees that had never showed symptoms of developing the disease. They inoculated the *seedlings* and picked out those that survived the spray. These trees were then planted in 60-acre *orchards* where seeds were to be produced. Trees showing symptoms of the disease were removed from the orchard.

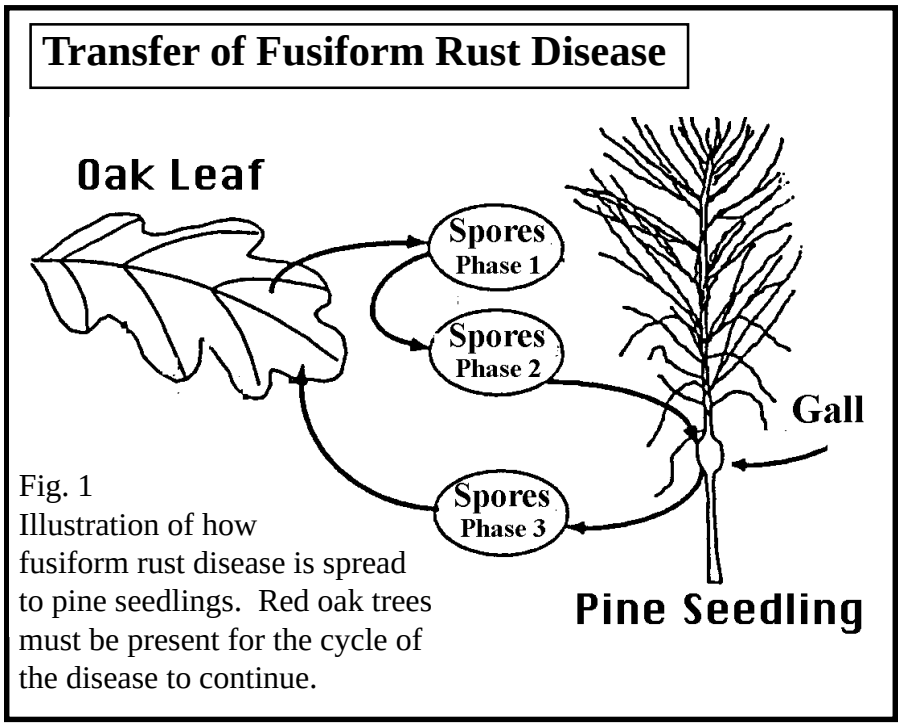
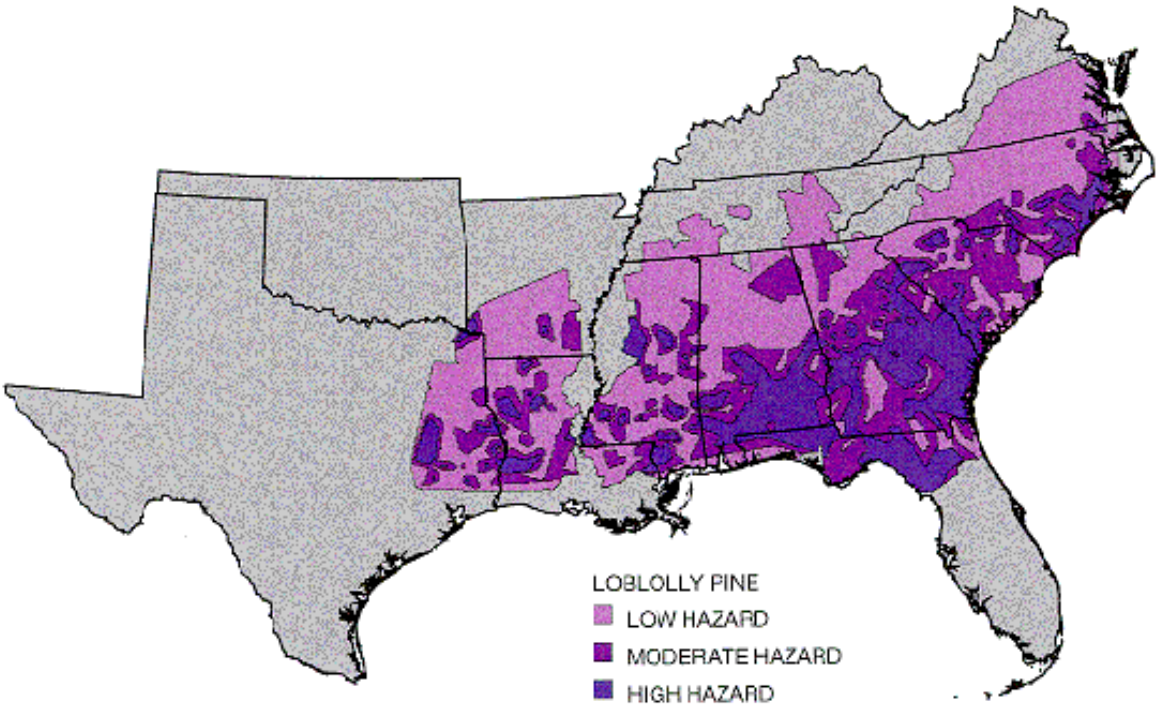


Fig. 1
Illustration of how fusiform rust disease is spread to pine seedlings. Red oak trees must be present for the cycle of the disease to continue.

The *basidiospore* spray is used to determine if trees are *resistant* to Fusiform Rust disease. Trees that are *resistant* will not get the disease. Some trees are more *susceptible* to the disease than others, and those trees will get the disease after being sprayed with basidiospores.



Fusiform rust hazard for loblobby pine

Reflection

1 Why do you think the scientists chose to inoculate *seedlings* from suspected healthy trees?

2 Why do you think we need to plant disease resistant *seedlings*?

Results

As a result of Dr. Powers' and Dr. Kraus' research, there has been a great increase in the number of healthy *seedlings* raised in nurseries and *orchards*. Since beginning this project, millions of healthy tree *seedlings* have been produced. The seeds which produced these *seedlings* were harvested in an 85-acre orchard which is now estimated to produce at least 12 million *seedlings* per year. Any trees showing symptoms of developing the disease are removed form the orchard to eliminate any *susceptible* trees. Most trees are then sold to small forest landowners who have never before had trees that are *resistant* to Fusiform Rust Disease. The results from this research have led to other studies. Some studies involve finding the *genes* responsible for resisting the disease.

Reflection

1 Why should trees showing symptoms of developing the disease be removed from an orchard?

2 Do you think trees in an orchard are more susceptible to Fusiform Rust Disease than trees in a natural forest? Why or why not?

Controlling the Rust is a Must!

Detection of a Major Gene for Rust Resistance to Fusiform Rust Disease

VOCABULARY
Vocabulary marked in article in italics

Genes
Small sections of DNA which contain hereditary information

Genetic Code
Specific genes that are the same for forms of life

Offspring
The product or result of something or someone; like a child

Pathogen (path' oh jen)
An organism or other agent that causes disease

Pollen
Particles containing genetic material for reproduction of plants

Resistance
Able to withstand an effect

Spores
Microscopic bodies which alter germination and develop into fungi

Susceptible
Can easily be affected by something, such as disease

Technology
Mechanical improvements intended to aid human activities

Adapted from:
Kuhlman, George E., H. V. Amerson, and W. D. Pepper. 1997. Inoculum densityand expression of major genes resistant to fusiform rust disease in loblolly pines. *Plant Disease,* 81:1-4.

Some scientists conduct **longitudinal** (lon' ja tude in ul) **research**. This is research that occurs over a long period of time. Some research may even take years to complete. The scientists in this study were interested in breeding trees that are resistant to disease. In order to understand how successful the research is, the scientist will have to do this study with successive generations of trees.

Discovery

In this experiment, you will purposely germinate pollen from a flower. Fill 3 cups with boiling water (BE CAREFUL!!). Add 1 teaspoon of sugar to the first cup, 2 teaspoons of sugar to the second cup, and 3 teaspoons to the third cup. Mix well to dissolve the sugar. Now pour a small amount from each solution into three seperate saucers. With the help of your teacher, shake the pollen from different kinds of flowers onto the surfaces of the sugar solutions. Pollen comes from the stamens, which grow in a ring around the flower's center. Cover each saucer with a piece of glass and let them stand at room temperature for at least three hours. Examine the pollen grains with a magnifying glass (or on a microscope slide) to see whether tubes are growing from them. Which sugar solution produced the most germination?

Introduction

Fusiform Rust Disease is a disease that affects trees. Research on Fusiform Rust Disease has progressed over the years. *Technology* has become more advanced and many new studies are used to find out more about the disease. There is no treatment for infected trees, but a huge step is being taken to find out what makes a tree resistant to the disease. Scientists George E. Kuhlman, H. V. Amerson, and W. D. Pepper, have studied the disease for a very long time. They have not found a cure for the disease, but are working on finding the secret to *resistance*.

Reflection

1 What are the scientists trying to accomplish with their research?

2 What other types of genetic information do you think trees can inherit? What other types of genes do you think you inherit?

A fusiform rust gall on a branch.

Methods

Dr. Kuhlman and his colleagues used the *offspring* from loblolly pine trees to conduct their experiment. Some of the trees that they used were resistant to the disease as far back as three generations. The resistant loblolly pines were then bred with other pine trees that were *susceptible* to Fusiform Rust Disease. The susceptibility passes on to other trees through *pollen*, which contains genetic material that is passed on the seeds which eventually sprout into seedlings.

Pollen is usually transported to the other trees by wind, rain, or by simply falling off one tree to another. Dr. Kuhlman purposely cross-bred the trees to determine which *genes* played a major factor in the *resistance* of Fusiform Rust Disease. When humans control plant pollination, it is called selective breeding. Scientists use selective breeding in plants to grow larger tomatoes or sweeter watermelons, for example.

Dr. Kuhlman was able to look at the DNA of loblolly pine trees by removing it from seedlings that had just sprouted. DNA is responsible for carrying the *genes* which are inherited from parents. Dr. Kuhlman looked at the *genetic codes* in the cells taken out of the trees. The codes show whether the tree is resistant or not. This complicated research is done with the use of advanced *technology*.

Reflection

1 Why do you think the scientist tried breeding healthy trees with sick trees?

2 Why do you think the scientist is studying the genes rather than the symptoms of the disease?

Results

Dr. Kuhlman and his colleagues came up with some interesting results. They found that half of the tree's *offspring* were resistant to the disease. Dr. Kuhlman found that trees are resistant to the disease primarily because of one gene, even though other genes contributed to *resistance*. Dr. Kuhlman and other scientists had previously believed that *resistance* to the disease was caused by an equal combination of *genes*.

The scientists concluded that purposely breeding trees with a particular mixture of *genes*, and especially those with the primary *gene*, could produce healthier trees.

Reflection

1 Can you think of other ways that purposeful or selective breeding is used by scientists? What are selective breeding's advantages? It's disadvantages?

2 Do you think trees in natural forests have the same problems as trees in orchards? Why or why not?

Lions and Tigers and Bears – Oh My!
Understanding Wildland Visitation

VOCABULARY
Vocabulary in article indicated in italics

Demographic
Physical characteristics of people, such as their age, sex, or race

Hypothesis (hi poth' eh sis)
An educated guess about the solution to a question or problem based on existing knowledge

Meaning
In this study, different meanings of *wildlands* are predicted by the attitudes people have toward those *wildlands*

Outdoor recreation
Activities done outdoors for fun and enjoyment

Quantify
To measure something and assign a number to it

Rural
Outside of the city

Scale
A special kind of questionnaire that social scientists use to understand people's opinions or attitudes

Wildland
Forested or other natural environment that does not contain buildings or other human construction

Adapted from:
Johnson, Cassandra Y., P. M. Horn and W. D. Pepper. 1997. Race, rural residence, and wildland visitation: Examining the influence of sociocultural meaning. *Journal of Rural Sociology.* 62:89-107.

The scientists in this study conducted **basic research** to better understand why some people do not visit some natural areas, such as national forests and parks. Basic research is not always aimed at solving a particular problem, but serves to advance knowledge in a particular area of interest. In this study, however, the findings could be used by forest and park managers to improve the opportunities for all people to visit forests and parks.

Introduction

National forests, parks, and other *wildland* areas are provided by state and federal governments for the use and enjoyment of all Americans. Not all people, however, use these areas for outdoor recreation. *Outdoor recreation* enables people to see and enjoy the great outdoors. Therefore, it is important that all Americans have an opportunity to visit *wildlands* if they want. When people do not visit *wildlands* and other outdoor areas, forest and park managers want to know why. In this research, social scientists Cassandra Johnson, Pat Horn, and William Pepper wanted to compare visitation to *wildland* areas for rural African Americans and White Americans. The scientists had a *hypothesis* that *wildland* visitation is related to the *meaning* that *wildlands* have for different people. In the past, scientists discovered that their race, age, gender, and other characteristics might explain why some people do not visit *wildlands*. The scientists wanted to test the *hypothesis* that a person's race, age, or gender are not the only factors involved with wildland visitation. They hypothesized (guessed) that the *meaning* of *wildland* areas plays a large part in whether a person will want to visit wildland areas for *outdoor recreation.*

Do the discovery activity on page 24!

Methods

The scientists mailed a questionnaire to people living in a *rural* area. People who received the questionnaire were asked to give their age, sex, and other *demographic* characteristics. But they also used a special kind of a questionnaire to collect information on *wildland meaning*. This kind of questionnaire is called a *scale*. The scientists' *scale* consisted of many statements about *wildlands*, and people were asked how much they agreed or disagreed with each statement. If a person did not agree with the statement at all, the scientist gave that statement a score of one for that person. If they agreed completely with the statement, the scientist gave them a score of five. In this way, the scientists were able to *quantify* the responses. For example, the scientists might have asked people if they thought *wildland* areas were safe places to visit. If the person did not think wildland areas were safe to visit, they would get a score of one for that statement. The scientists also asked people whether they visited wildland areas. They compiled answers from 124 African Americans and 303 White Americans living in the *rural* Florida panhandle. The Apalachicola National Forest is located within this area.

Reflection

1 How do you feel when you think of your favorite outdoor place?

2 What does your favorite place mean to you?

3 Do you think that your favorite outdoor place would be different if you were a member of the opposite sex? Why or why not?

4 Would your favorite outdoor place be different if you grew up in a country other than the United States? Why or why not?

Reflection

1 What do you think the advantages are to assigning numbers to people's responses? What are the disadvantages?

2 What do you think the scientists found out about wildland visitation and a person's age, race, and gender?

3 Do you think wildland meaning was more important than age, reace, and gender for people who did not visit wildlands?

Results

Ms. Johnson and her colleagues found that *rural* African Americans visited wildlands less than *rural* White Americans. They also found that when people's attitudes toward wildlands were less favorable, they visited less--regardless of their race.

The scientists also found that older people and women visited wildlands less than younger people and men--regardless of their race. They concluded that *demographic* characteristics such as race, age, and sex helped them to understand some things about wildland visitation (see Fig. 1).

Based on the results of the *scale*, however, the scientists now believe that a person's attitude toward wildlands may be one of the most important things determining whether he or she visits a *wildland*. In particular, Ms. Johnson thinks that when a person feels that *wildlands* are not safe places for them to go, they are not likely to visit.

This research is important because it helps managers to understand that visitation may be more related to the *meanings* outdoor places have for a person, rather than to the person's race, age, or sex. With this information, forest and park managers may be able to take actions that would welcome more people to *wildlands*. This way more people can enjoy *wildland outdoor recreation.*

Factors Affecting Wildland Meaning

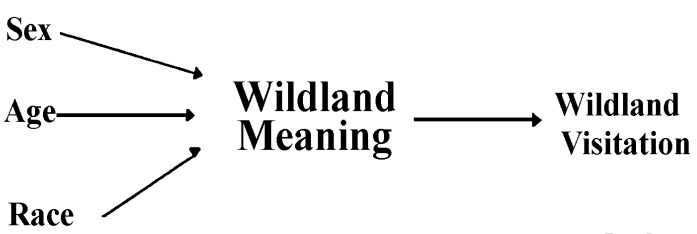


Fig. 1
This model illustrates how race, gender and age contribute to the overall meaning of wildlands. Wildland meaning, then, has an effect on visitation.

Discovery

Respond to the following statements by circling the number on the right that corresponds to how much you agree with the statement:

	Strongly Disagree	Disagree A Little Bit	Agree A Little Bit	Strongly Agree
1. Wildland areas are dangerous because of animals.	1	2	3	4
2. Six Flags over Georgia is safer than most wildland areas.	1	2	3	4
3. I have an outdoor hang-out where I feel safe.	1	2	3	4
4. I like going to parks and outdoor areas where I can only see trees and other vegetation around me.	1	2	3	4

Reflection

1 If you were a forest manager, what would you do to encourage more people to visit your forest?

2 How might your actions have been different before you read this research?

2 What other ways could a scientist discover people's attitudes and the meanings they have toward wetlands?

You have just completed a *scale,* assessing your attitudes towards safety in *wildland* areas. To get your total score, you will need to reverse the numbers in statements 3 and 4. For statements 3 and 4, take your pen and cross out the numbers 1, 2, 3, and 4. Write 4, 3, 2, and 1 in their place (1 becomes 4, 2 becomes 3, and so on). Add all of the numbers that you circled for all four statements (substituting the new numbers for statements 3 and 4). If your score is between 1 and 8, move to one side of the room. If your score is between 9 and 16, move to the opposite side of the room. With the help of your teacher, hold a class discussion about how each group feels about being in wildlands. What is the difference?

Goodbye Nematodes
Heat-Treating Southern Pine Lumber

VOCABULARY
Vocabulary in article indicated in italics

Bolts
Short, round sections of logs

Conifers
Evergreen trees containing pine needles or true cones

Infestation
Large amount of parasites swarming an area

Kilns
Oven used for burning, firing, or drying substances

Lumber
Boards sawed from logs

Moisture content
The amount of moisture an object contains

Nematodes
Parasitic, microscopic eel worms

Sapwood
The soft wood beneath the bark of a tree

Stem
The main trunk of a tree

Some scientists are interested in solving problems that involve international **policy**. When the United States tries to sell, or export, goods abroad, we must respect the policies, or regulations, of the other countries. In some cases, the policies of other countries can make exporting goods very difficult or expensive. The scientist in this study wanted to show people who export *lumber* how to prevent the spread of destructive organisms that live in the *lumber*. He wanted other countries to feel comfortable about using lumber from the United States so that their policies would not cause lumber exporters to spend too much money unnecessarily. Therefore, he studied ways to kill the organisms using the least amount of time and money.

Here's the head of a pinewood nematode, magnified 13,000 times. This worm is actually so small, it can only be seen through an electron microscope.

Adapted from:
Dwinell, David L. 1990. "Heat-treating and drying southern pine lumber infested with pinewood nematodes." *Journal of Forest Products.* 40:53-56.

Introduction

Lumber is an important product produced from trees. The production of quality lumber is very important, especially when two countries are involved in exporting goods to one another. The European Union acquires lumber from the United States. They are now making it mandatory that the United States put the lumber into *kilns*, which are ovens. This kills any organisms that may damage the lumber and spread diseases to the European forests. Lumber mills are now responsible for using kilns due to the regulations, or policies, of other countries. Dave Dwinell is a scientist who studies harmful organisms on lumber. His studies include ways of treating the lumber after it has been infested with organisms such as the pinewood nematode, which is a small microscopic worm, to assure that the European Union receives healthy wood. The pinewood *nematode* may cause weaknesses in many different types of *coniferous* trees. The *nematodes* rarely affect living trees, but are usually found in wood chips or in trees that have recently been cut down. For this reason, Dr. Dwinell has begun studying heat-treating techniques to kill the pinewood nematodes in the lumber. He wants to find out if high temperatures will kill the nematodes without having a major effect on the *moisture content* of the wood. This is very important due to the fact that if lumber dries out, it may split and become unusable.

Reflection

1 What problem is the scientist trying to solve?

2 Why is this problem important to people who export lumber?

Methods

To determine if heat-treating techniques could be used to kill pinewood *nematodes*, two 12-year old slash pines were cut down at the Baldwin State Forest near Milledgeville, Georgia.

The *stems*, or the main trunks of the trees, were cut into 5-foot-long *bolts*, or sections, and stacked up. To make sure that the *bolts* were infested with *nematodes*, 0.5 inch holes were drilled on one side of each of the sections, and *nematodes* were placed in each of the holes. The *bolts* were cut into lumber three weeks later at a sawmill. In addition to the slash pines, three 16-foot loblolly pines and two other slash pines collected from a previous natural *infestation* were also sawed into lumber.

The boards were weighed so that the amount of moisture lost in the *kilns* could be monitored at the end of the heat-treating procedures. Because wood is heavier when it has a lot of moisture, the loss of moisture can be determined by subtracting the weight recorded after heat-treating.

Many tests were conducted to determine which temperatures would be most effective for killing *nematodes* and protecting the lumber as well. Heat sensor probes were inserted into the boards. These were placed in the *kilns* to determine how much time it would take for the temperature inside of the wood to reach 60° C, 71° C, and 97.6° C. Other boards were allowed to air-dry in buildings so that a different drying method could also be evaluated.

Results

The scientist found that all procedures used were effective in killing the *nematodes*. The boards placed in a *kiln* for 24 hours at a temperature of 97.6° C contained no *nematodes*. The *moisture content* of the wood did drop, however. Before drying, the wood contained 25 percent moisture. After drying, the wood contained 7 to 9 percent moisture. This means that 64 percent of the moisture was lost (Fig.1).

The pine *lumber* that was dried in the *kiln* at 71° C was also free of *nematodes*. *Moisture content* dropped slightly from 34.3 percent to 30.3 percent. This meant that the wood only lost 12 percent of the moisture.

Dr. Dwinell found that it took one hour to kill *nematodes* at a temperature of 60° C. He tried lower temperatures, but they were not as

Reflection

1 Why do you think the scientist also studied pines from natural infestations?

2 What do you think will happen to the namatodes on the lumber placed inside of the kiln?

3 What do you think will happen to the nematodes in the air-drying process?

effective. He determined that treatment at 60˚ C was most effective because the *nematodes* were destroyed quickly and very little moisture was lost from the *lumber*. Dr. Dwinell also found that moisture loss was responsible for killing the *nematodes* in the air-drying process. The problem with this method was that it took the *nematodes* two months to die.

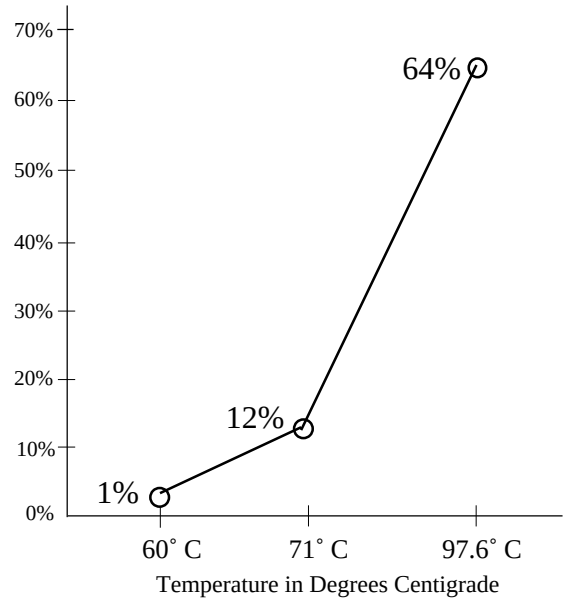


Fig. 1 Notice that moisture content decreases at higher temperatures. Therefore, 60˚ C is the ideal temperature to use

Discovery

Divide into teams of four. Each team selects one tree at the school. You will perform a similar experiment to Dr. Dwinnell's heat treatment experiment. Carefully break off two twigs from your tree. Make sure that they are approximately the same size. One will be the experimental twig and the other will be the control. Study the twigs carefully and record your observations carefully on a seperate sheet. Weigh each twig and record the weight, time and air temperature. Set the control twig aside. Place the experimental twig in a microwave for three and a half minutes. (That's the time it takes one cup of water to boil in a microwave). Record the temperature (212 degrees F) and the time (3 1/2 minutes). CAREFULLY remove the twig and allow to cool. Record the weight of your twig. Does it weigh less than it did before? If so, why do you think that is? Compare to the control twig.

Wait several more days. Record the air temperature and the time, and measure the control twig. Does it weigh less than it did before? If so, why do you think that is? If not, why not? Does it weigh less than it did the second day? If so, why do you think that is? If not, why not? Compare it to the experimental twig.

Reflection

1 What factors determined the death of nematodes in the heat-treating procedures?

2 Both heat-treating and air-drying were effective in controlling pinewood nematodes. What are the advantages and disadvantages of each method?

3 What method of pinewood nematode control would you recommend? Why?

What is the Forest Service?

The Forest Service is part of the federal government. It is made up of thousands of people who care for the nation's forest land. The Forest Service manages over 150 National Forests and almost 20 National Grasslands. National Forests are similar in some ways to National Parks, except that unlike National Parks, National Forests are used for many purposes. These purposes include providing clean water, places for wildlife and fish, places for people to hike, camp, and do other outdoor activities, healthy soil, trees for lumber, minerals, and many other uses. Some people in the Forest Service are natural resource scientists, whose research is presented in this journal. Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our environment is healthy, now and into the future.