CHANGES

Student Notebook

Savanna Module

Student Number

_____

Grand Bay
National Estuarine
Research Reserve

The National Academies of SCIENCES ENGINEERING MEDICINE

GULF RESEARCH PROGRAM

Table of Contents

What's this CHΔNGES program anyway?

The Grand Bay National Estuarine Research Reserve (GNDNERR) is home to wetland pine savannas which require constant application of management, monitoring, and restoration. Without regular wildfires, wetland pine savannas have become overgrown and invaded by exotic plants. This suppresses their biodiversity and suitability for native species. Through the employment of management practices, the GNDNERR seeks to restore functions to these unique ecosystems.

This project, Conceptualizing Human Alteration and Natural Growth in Estuaries and Savannas (CHΔNGES), will use these unique habitats and current management applications as a platform to educate students about ecological processes and applicable restoration practices. Students will be introduced to the GNDNERR savannas through immersive educational experiences. Students will use research instruments to collect data and map invasive species using GPS and GIS technology. Activities and simulations will familiarize students with restoration practices associated with each environment. Students will observe and participate in monitoring processes from experimental design planning and data collection, to data entry and manipulation. They will identify differences between natural and anthropogenic change, discuss pros and cons of efforts to restore the ecosystem to a previous functional state, and assess ecosystem responses to weigh the benefits of each decision. In short, they will gain direct exposure to the real-world work of natural resource managers at the GNDNERR.

This project is funded through The National Academies of Sciences, Engineering, Medicine Gulf Research Program's Capacity Building Grants.

Lesson 1: What's a pine savanna?

Concept Map

First, let's see what you think we'll be learning about pine savannas! Using the word bank, create a concept map. A concept map shows relationships between a number of concepts. Use the word bank below to complete the map. The relationship between concepts should be shown with a directional arrow that is clearly labeled. There can be more than one relationship between concepts. *Hint: a concept map should not be linear! We have started a concept map for you with the word "savanna."

Word Bank:

fire monitoring restoration savanna structure succession

In a few sentences, explain what your concept map is showing. _____

_____

_____

_____

Introduction

The **pine savanna** ecosystem is one of beauty. These ecosystems are fire-maintained grasslands with scattered pines and shrubs and a sun-loving, species-rich understory. A layer of clay found below the surface prevents the water from draining from these sites and results in wet, acidic soils that are of poor nutritional quality. Although poor in soil quality, these habitats support some of the highest diversities (as many as 40 different species per square meter) of grass, sedge and wildflower species ever described in North America. Noteworthy are the large number of endemic species such as carnivorous plants (those plants that are adapted to attract, capture and digest prey such as insects and other small animals) including pitcher plants, sundews, bladderworts and butterworts as well as the beautiful orchids and sunflowers (Grand Bay NERR, 2010).

These grassland habitats are characterized by sparse canopy cover, mostly **longleaf pine**, with an understory dominated by grasses, mostly **wiregrass**. These ecosystems are shaped by fire. **Succession** after a fire plays a major role in maintaining these ecosystems. Without fire, these ecosystems could not exist. The Grand Bay NERR and National Wildlife Refuge contain some of the best remaining examples of this habitat type along the northern Gulf of Mexico.

Figure 1. Pine savanna north of Grand Bay Coastal Resources Center. Photo by: Sandra Huynh

The longleaf pine ecosystem appeared about 5,000 years ago. After Native Americans arrived at the Coastal Plain, they began applying early land **management** practices to this ecosystem. They understood that fire was an important part in shaping the savanna. They set low intensity fires to produce favorable hunting and agricultural lands.

1-1. *Cultural History:* Which Native American tribes do you think lived in the Grand Bay NERR all those years ago?

_____

_____

1-2. How did you find out the information to back up your answer? _____

_____

The longleaf pine savanna is perhaps the most endangered ecosystem in the United States. Before the arrival of Europeans in the 1600s, these landscapes stretched from Virginia to Texas and acquired some 90 million acres. Now, because of the economic value of the longleaf pine, suppression of fire, and **fragmentation**, pine savannas comprise a mere 3 to 4 million acres of the areas where they once stood.

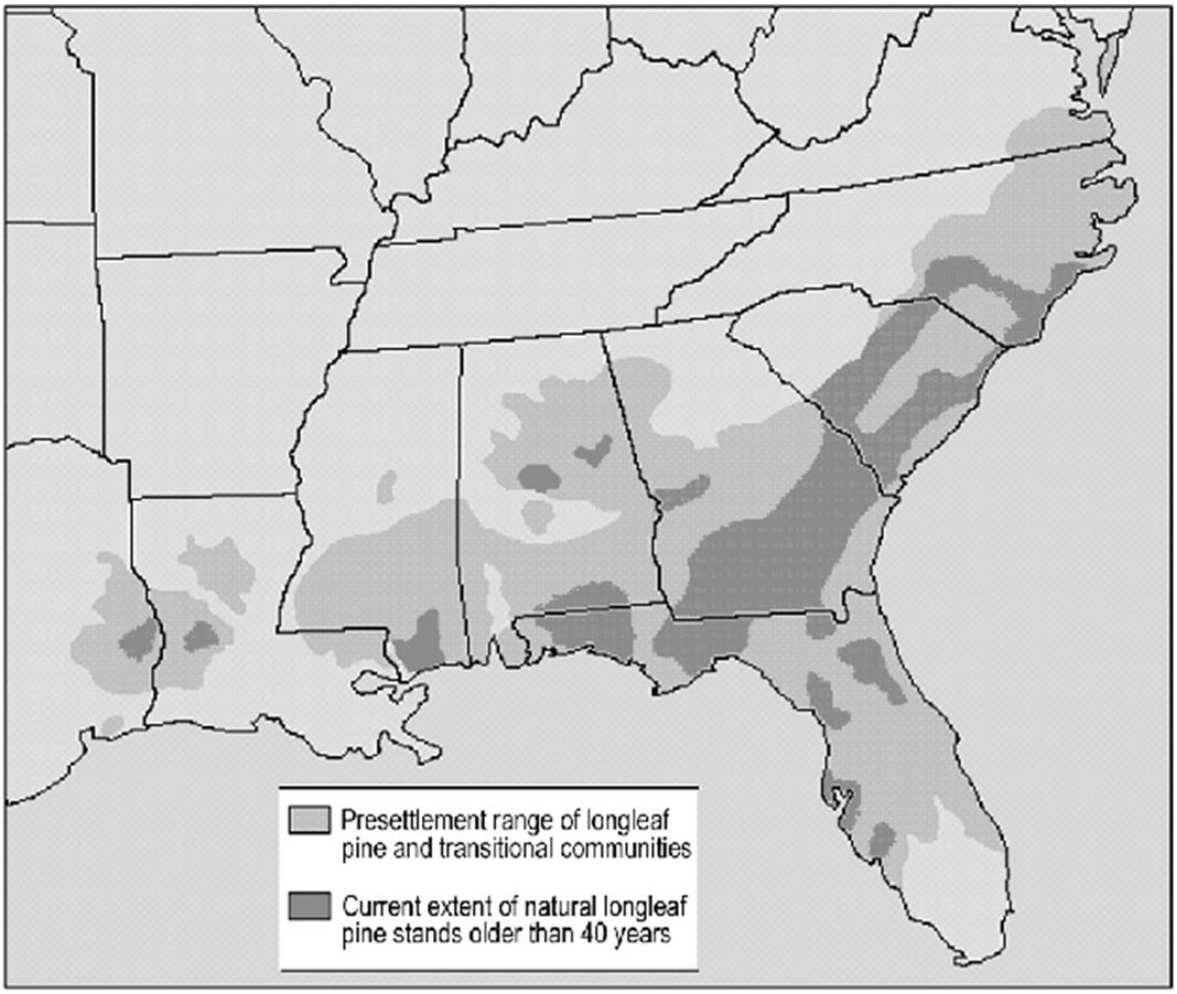


Figure 2. Historic and current (1998) extent of longleaf pine trees. Source: White et al., 1998.

1-3. *Interpret the map*: What does this map show you? _____

_____

_____

1-4. Why does it depict "pine stands older than 40 years"? What's the significance of that age?

_____

_____

Structure- What makes up a pine savanna?

Perhaps you have studied the structure of a rainforest in the tropics and have heard of words like "understory" and "canopy." A pine savanna habitat also has those familiar characteristics. Pine savanna plant species are adapted to survive in very wet, nutrient-poor soil conditions. These **hydric** soils are a result of an underlying layer of clay that prevents water from draining from these areas. The high **water table** from late Fall to early Spring can result in standing pools of water that remain in the savanna for a majority of the year. These are referred to **ephemeral ponds**.

The pine savanna is a grassland habitat, meaning it is an ecosystem dominated by grasses. **Wiregrass (*Aristida stricta*)** is the dominant species of **ground cover**. In the **understory**, there is a large variety of herbaceous vegetation as well as a few shrub varieties. In fact, most of the **biodiversity** occurs at this level, with anywhere from 150 to 300 species of understory vegetation per acre. Another aspect of savanna structure is sparse **canopy** cover, where "sparse" means that there is less than 50% cover (compared to a really dense canopy in a rainforest, for example). In most cases it is much less than this. In a longleaf pine savanna, the canopy consists mostly of **longleaf pine (*Pinus palustris*)**. This long-lived pine species requires a lot of room to grow, and being spaced apart contributes to the light canopy layer. All of these species are important to this particular ecosystem especially when it comes to spreading fire, which is absolutely critical in developing the pine savanna structure. Wiregrass is highly flammable, and with fallen longleaf pine needles, they're perfect fuel for fire to be carried throughout the habitat.

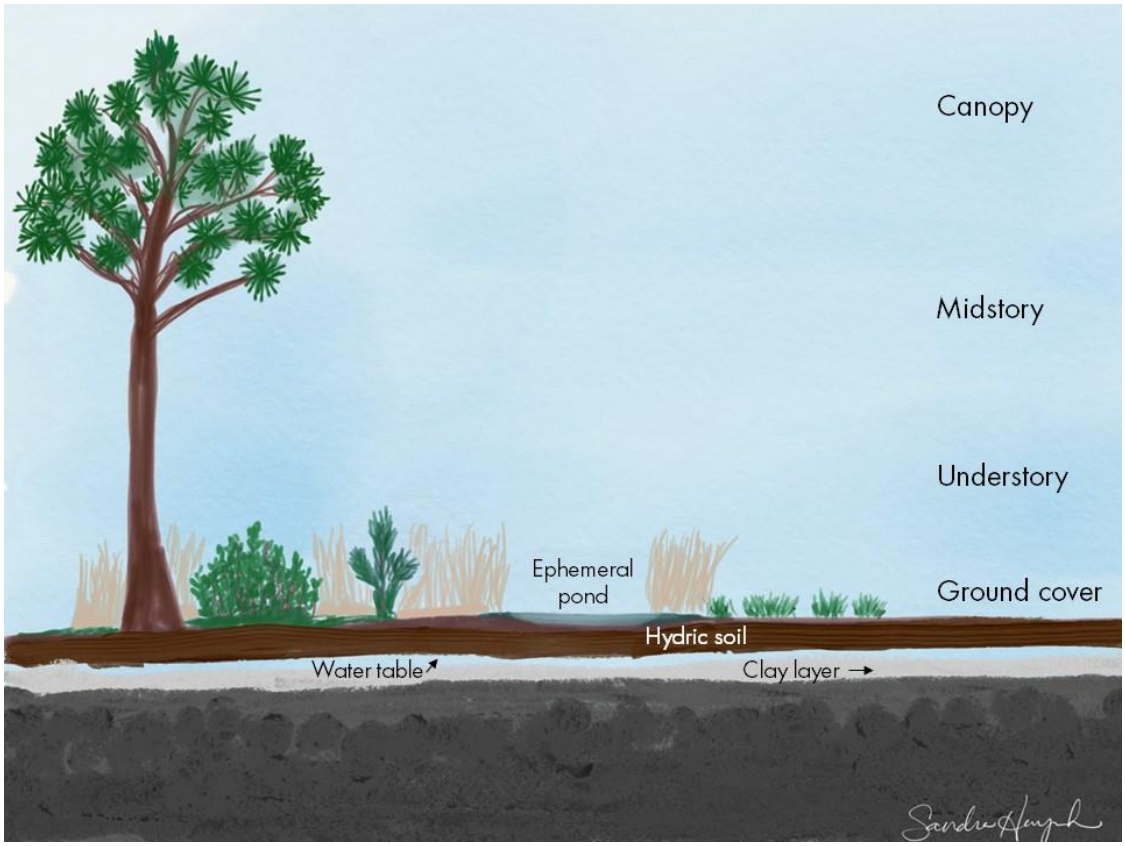


Figure 3. A simple sketch of a longleaf pine savanna system. Figure by: Sandra Huynh.

Function- What does a pine savanna do?

Pine savannas have many ecosystem functions, but one of its primary functions is to serve as habitat for numerous species. Habitats provide food, water, shelter, and viable mates for reproduction. The high diversity of plants provides a large food source for many primary consumers, in turn providing food for animals in higher trophic levels. The tall grasses create increased surface area for shelter and protection.

Ecosystem Services

An **ecosystem service** is a benefit that humans get from a functioning ecosystem. These can be natural resources that we consume like food and water, support natural cycles like the nutrient cycle and primary production, help with regulating things like waste and pests, and provide cultural services from spiritual to recreational, to education and therapy. At Grand Bay NERR, we estimate that ecosystem services of upland habitats (17.6% of the Reserve) are valued at $299,651.20 per year. The Grand Bay NERR has been a Reserve for 20 years, so calculate that number! _____. Our estuarine habitats (82.1% of the Reserve) and their ecosystem services are valued at $137,010,265.60 per year!

1-5. List some of the ecosystem services for a pine savanna below: _____

_____

1-6. What might be some ecosystem services in other areas of the Grand Bay NERR, like the estuary? _____

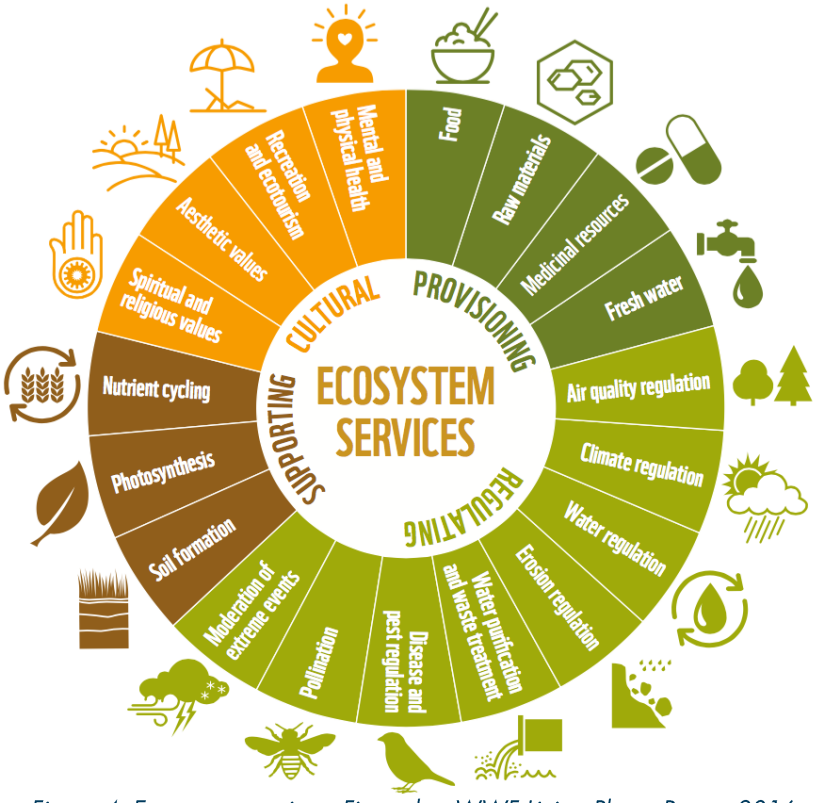


Figure 4. Ecosystem services. Figure by: WWF Living Planet Report 2016

Biodiversity- What lives in a pine savanna?

Biodiversity is the amount of different species of organisms in a specific area. Areas that are closer to the equator tend to have higher levels of biodiversity. In other words, tropical areas that stay warm year-round are high in biodiversity, whereas temperate regions have lower biodiversity because they have fluctuations in their climates (e.g. warm summers and cold winters). Areas with extreme conditions have the lowest biodiversities on the planet, such as deserts and arctic regions.

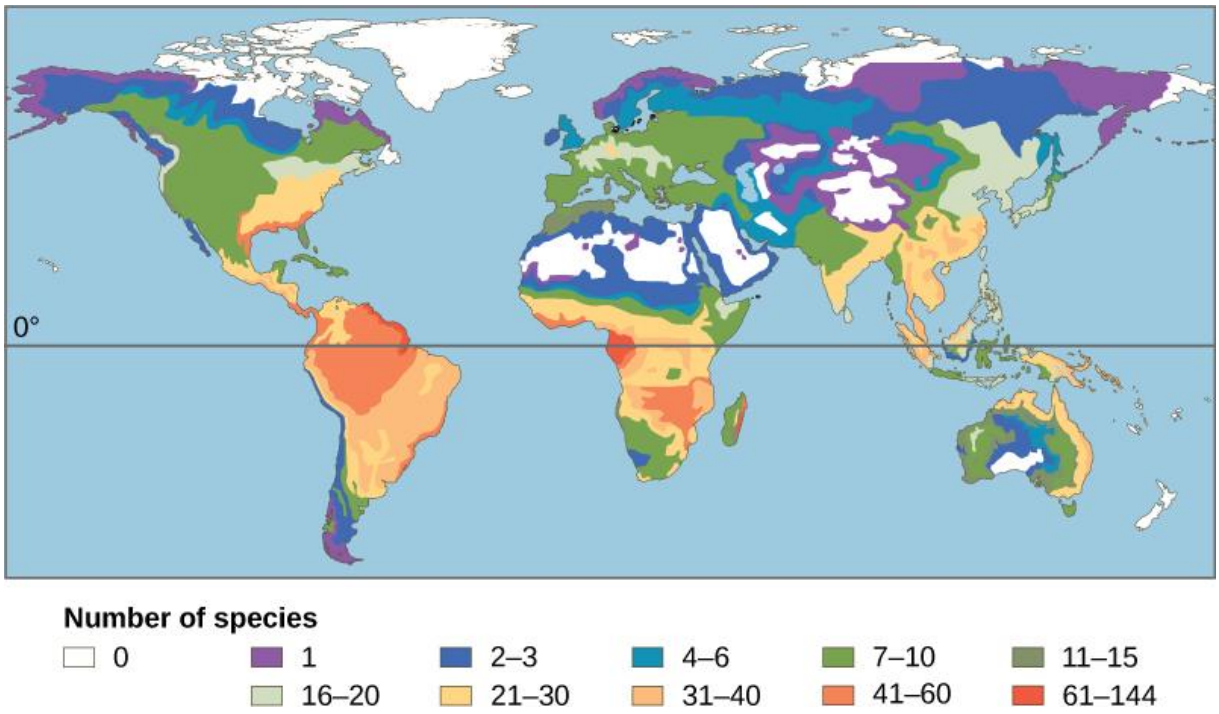


Figure 5. This figure from Fisher (2018) shows that biodiversity tends to be higher at lower latitudes (towards the equator). This map depicts the number of amphibian species around the world, but similar patterns of biodiversity occurs with most plant and animal groups.

Ecosystems around the planet with the highest levels of biodiversity and high numbers of **endemic species** (species that exists nowhere else on the planet) are considered "biodiversity hotspots." The pine savannas of the Coastal Plain are some of these areas.

Biodiversity is high in the savanna. As a matter of fact, when looking at the understory on a small scale, pine savannas can contain more diversity in a square meter than a tropical rainforest. Many savanna species are specialists and highly adapted to live there. Plants are adapted to either withstand frequent fires or regenerate afterwards. Some even require fire at some point in their life cycle. Plants must also be able to survive in extremely wet conditions as the pine savanna is essentially a wetland.

Data and Observations Tip: As we venture into our field trips at Grand Bay NERR, you can observe and note examples of different species you encounter in your field journaling or notes pages at the end of this notebook.

Ecological Processes

If you're from the Gulf Coast area, you might be familiar with natural processes like thunderstorms or hurricanes, and associate them with natural hazards like flooding and lightning strikes. Sometimes, these processes actually benefit the environment like providing water to places that have been dry or starting lightning fires in ecosystems that need it.

Figure 6. Fires that occur in pine savannas are low intensity, like in the photo on the left. Prescribed fires, depicted on the right, mimic these low-intensity burns. Photos by: Sandra Huynh

Fire is an important ecological process for pine savannas. It allows the pine savanna to remain healthy and maintain unique plant communities. These plant communities in turn support diverse species of wildlife. In a major way, fire influences the natural environment here at the Reserve. Pine savannas require low intensity fires occurring every 2-5 years to maintain its structure. This keeps the canopy open allowing sunlight to penetrate to the understory. The plant communities there require full sunlight and are adapted to cope with fire, with some of those species requiring it to survive.

Fire is so important in the savanna ecosystem because it acts as the reset switch to succession. Ecological **succession** is the natural process by which the structure of an ecosystem changes over time. This begins with some sort of disturbance. In the case of the savanna it is fire. The fire consumes any litter or dead plant material and mal-adapted woody vegetation or shade-tolerant species that might be competing with savanna species. Fire also adds much needed nutrients to the soil and stimulates **germination** of certain species, namely ones established in the seed bank of the savanna. Fire interrupts and resets succession keeping the savanna from reaching a **climax stage**.

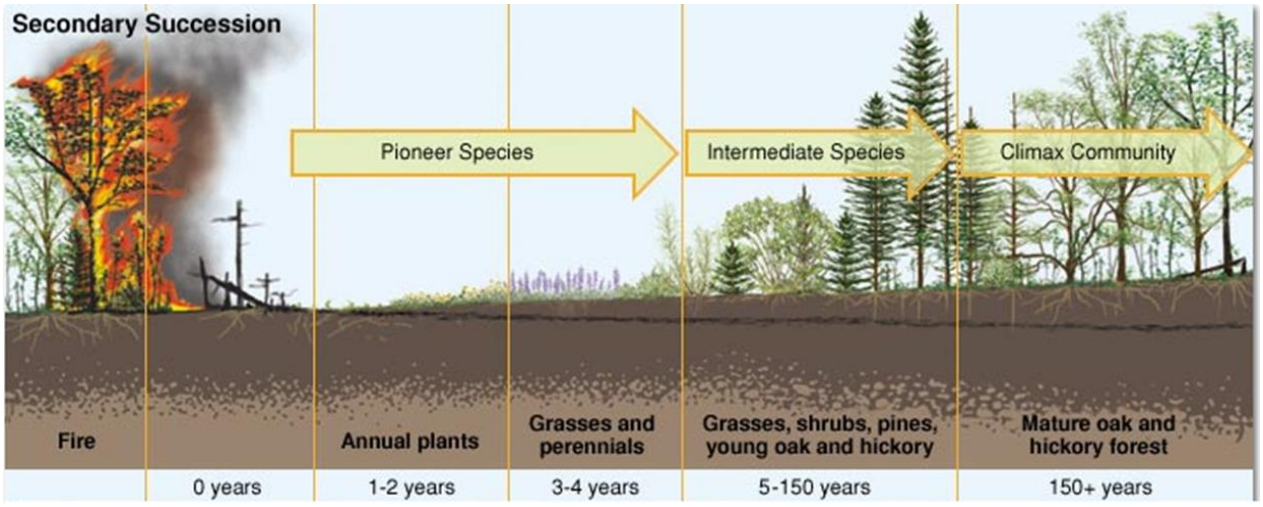


Figure 7. Secondary succession of a burned forest. Figure source: Encyclopedia Britannica, Inc. 2006.

1-7. *Let's pause*: We've talked a little bit about fire suppression, but what does that mean?

_____

_____

1-8. If fire is suppressed in an area, do you think it would burn at high intensity or low intensity? Why?

_____

_____

Because of fire **suppression** and some other factors, the succession process is not always reset. This allows encroachment from woody vegetation and shade-tolerant hardwoods, in time transforming the savanna from grasslands to forests. Therefore, sometimes it is necessary to burn certain areas in a controlled manner. Prescribed fires are excellent management tools and help restore the pine savanna to its natural state.

Figure 8. Images from a prescribed burn and its timeline after a burn. Photos by: Sandra Huynh

Prescribed burns require a lot of planning and teamwork. Did you know that there are certain weather conditions necessary for a prescribed burn? Take a moment to do a quick search online to see if you can find those conditions, and jot down why we would need those conditions.

Lesson 2: Methods and Technology

Welcome to the Grand Bay NERR! We're excited to have you onsite today, and we have a lot of activities to cover. Each component of today's field trip will help inform your Day 5 Restoration Plan that you'll design and present with a group.

Today's activities will introduce you to monitoring, management, restoration practices, and various impacts to the environment. We'll also explore some of the scientific instruments and methods our scientists at the Grand Bay NERR use to manage and monitor our Reserve.

Here's what to expect today:

- Group work: Our scientists and resource managers hardly work alone to accomplish a task, especially in the field where conditions could be extreme (very hot, in the wilderness). We also work in groups to help each other carry equipment and help with the data collection process. You will be working in small groups for the same reasons our scientists do.

- Handling equipment: Scientific equipment is meant to be durable, but they can also be very expensive. While you're in the field, be sure to take good care of any equipment you handle. When equipment is in good, working condition, you know that your data is reliable.

- Outdoors: At some point today, you will be working outside. Make sure to wear proper protective gear like boots, sunscreen, and/or bug spray, or a jacket in case the weather changes. We'll be doing a lot of walking, so be sure to watch where you're going and follow a path if there is one to reduce disturbing the land.

- Writing in your notebook: Scientists are always writing, whether they are quick notes from observations, or writing down numbers or other types of data neatly so they can read it later, or creating a more formal report or scientific paper to explain the work they conducted and what it means to the scientific (and local) community. Keep your notebooks and something to write with handy. We'll be referring to it quite often.

- Information: Today will be packed with activities and information, and the best way for everyone to learn is to participate and be actively involved in what's going on. Active participation also means active listening! The way to succeed today is to pay attention and become familiar with the concepts, technology, and how they work together to help you do your best science.

Impacts Grid Activity

Environmental impacts come in a variety of forms, whether they are natural or **anthropogenic** (human-influenced), or whether they are good or bad for the environment. For this activity, we're going to explore some environmental impacts and see how you might classify them on a grid.

First, we need a large area to create our grid and for us to be able to move around. A "large area" maybe a courtyard or grassy spot at your school, or maybe the gym or classroom if you move things around. At the Grand Bay NERR, we're going to use the amphitheater outside by the front door. In the middle of the amphitheater, we'll create a life-sized grid with two axes coming together in the middle like a cross. On one axis, let's say the x-axis, we'll make a scale that goes from "human" to "natural" for the *type* or *source* of the environmental impact. On the y-axis, we'll make a scale that goes from "positive" to "negative." Label these axes with a sign, so everyone can remember which way to go.

2-1. *Draw it out: Use this space to draw out the grid we'll be creating in the amphitheater based on the example above. *Hint: Think math classes.*

Your class will start at the origin, or (0, 0) on the grid. A moderator (who could be NERR staff or maybe your teacher), will call out an "impact" and you have to move on the grid where you think it falls. *Hint: Think for yourself! Even if your teacher is participating, don't assume that he or she is correct. In fact, some of these impacts don't necessarily have a "right" or "wrong" answer.

Next, look around to see who else is standing by you and talk about why you chose to stand there. The moderator will ask for volunteers to tell the entire group why they chose to stand where they did.

You won't need your notebook with you for this activity, but when you come back or have time later, fill out the table on the next page and jot down your notes on environmental impacts from this activity.

IMPACT	Where did you stand? (Label your axes first!)	DISCUSSION- What did you discover about this particular impact?
invasive species		
flooding		
hurricanes		
fire		
fragmentation		

2-2. *Let's pause:* There really isn't a right or wrong answer for some of these impacts. Understand that impacts are different based on who or what is affected. Thinking back to the pine savanna, how might we understand or know what is affected by impacts? How will we know what's the most appropriate restoration practices are for the environment that needs to be restored or managed?

Percent Cover Activity

Percent cover is a method used by NERR scientists to estimate the percentage of plant species in a given area. After monitoring the plants over extended periods, scientists can look at how the vegetation communities change over time. To do this they establish long-term monitoring plots across the reserve and record the percentage of each species within the plot annually. They record the percentage of each species within a smaller **quadrat**. This method can be subjective from person to person. To get the most accurate percentage, our scientists will perform this method as a group and discuss which percentage is best. We will be using percent cover to monitor vegetation in our own plots when you return for a field day at GNDNERR.

Figure 9. NERR scientists trek in the field to estimate percent cover for native species. Photo by: Sandra Huynh

Today we will practice by completing the following activity. On the tables in the NERR classroom are laminated sheets with various shapes and colors. In small groups, your task is to estimate the percent of the colored paper. There is a correct answer for each sheet, so do your best!

2-3. Estimate the percent cover to the nearest 5% for each "example" and write down your estimates.

	Your Guess	Correct Answer
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____
9.	_____	_____
10.	_____	_____

2-4. What was the most challenging part of this activity? Why? _____

_____

_____

2-5. How might this be challenging in the field when looking at plants? _____

_____

_____

2-6. What do you think is a way you could get consistent answers for percent cover in the field?

_____

Species Surveys

In order to properly manage an area, you must know what species can be found there. Some species may require special conditions or may be sensitive to some management practices. Endangered species can also be of great concern when considering management applications. Vegetation can be easily surveyed using visual encounter surveys, that is to record species based on seeing them. While this method is also used for animals like birds, it can be time consuming and subjective. Trapping is another survey method that is very effective. We use **minnow traps** and **drift fences** at the Reserve to survey reptile and amphibian, or **herpetofauna**, species.

Drift fences are an easy way to obtain data on certain types of animals (e.g. herpetofauna and small mammals). Drift fences are long, continuous barriers used to collect animals for research. Different types of traps are constructed along the fence (bucket/pitfall traps) and at both ends (funnel traps). As an animal comes into contact with the fence it moves along it in either direction until it is caught in a trap. Drift fences should be constructed in an area where there is thought to be a lot of movement of the target species. Drift fences do take some time to construct, but once they are complete, one can obtain much data with very low maintenance or upkeep.

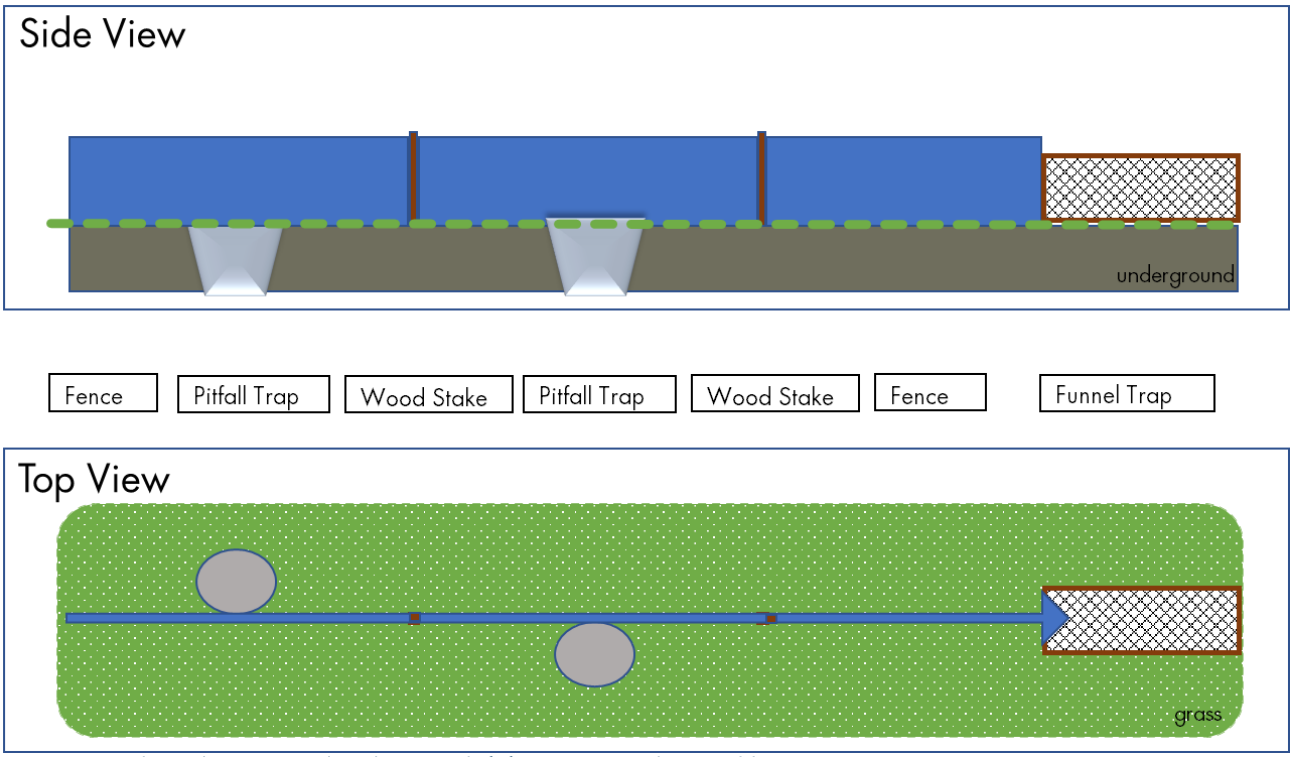


Figure 10. Side and top views that depict a drift fence. Figure designed by Dennis McGrury.

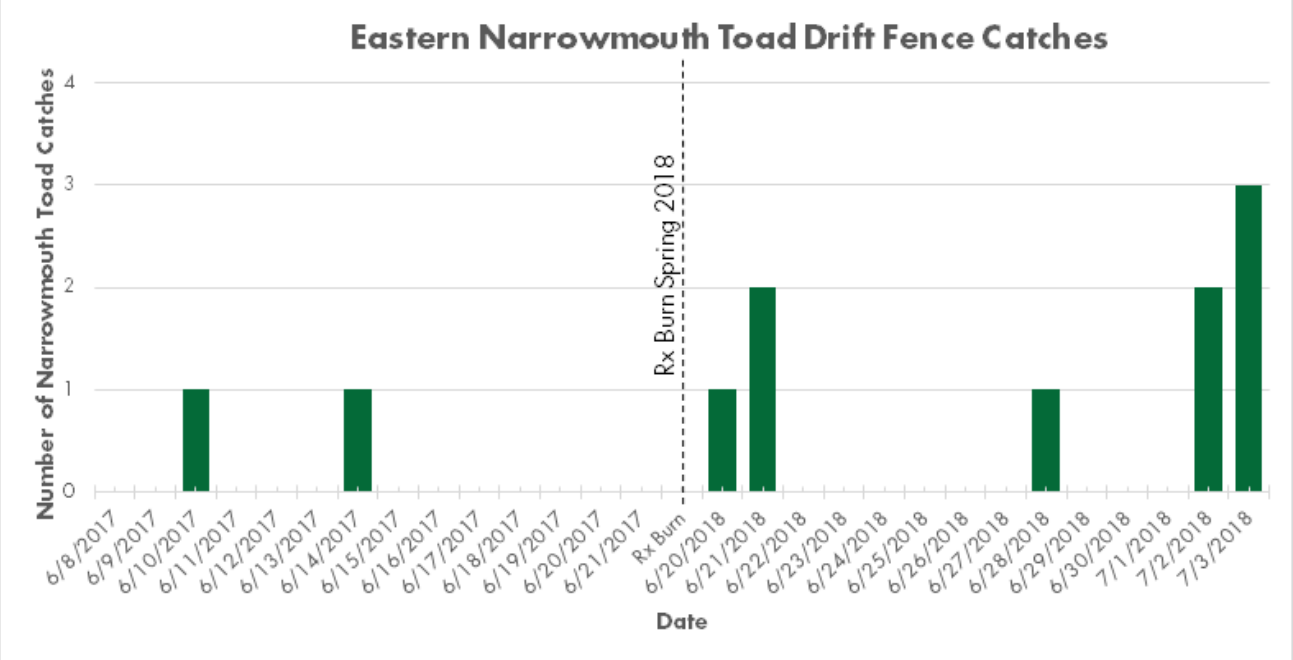
Interpreting Species Survey Data

The following dataset was collected at a drift fence located in a savanna habitat at the Reserve. Each time a species was caught in the trap it was recorded. In Spring of 2018 GNDNERR, restoration specialists conducted a controlled burn in this savanna. Scientists want to compare the occurrence of eastern narrowmouth toads (*Gastrophryne carolinensis*) caught before and after the burn to determine if the toad prefers the thick cover of underbrush in the savanna prior to the burn or the more open environment after the underbrush was cleared by the fire.

2-7. *Hypothesis:* Which environment do you think the narrowmouth toads prefer?

_____

_____



2-8. What can we say about the number of occurrences of the narrowmouth toad before and after the
burn?_____

_____

2-9. What are some factors that could have contributed to these results, other than fire?

_____

_____

2-10. Is this enough data to say conclusively that this species prefers either of these habitats? Why or why not?

_____

_____

2-11. What could be done to further test your hypothesis?

_____

_____

The narrowmouth toad isn't the only species that could be found in the traps. What other common herpetofauna species do you think we may find? _____

_____

In your opinion, do you think you would prefer vegetation monitoring and using percent cover or herpetofauna monitoring and trapping species? _____

Why?

_____

If you could add a plant or animal to monitor at the Grand Bay NERR, what would it be? How would you monitor it?

_____

_____

Geocaching Grand Bay

The Trimble Nomad is an important tool used to collect geospatial data. Tools like this one are used by NERR restoration specialists to effectively monitor plant communities in the savanna.

The Nomad will be necessary to collect monitoring data for the next lesson. The following activity was designed to familiarize you with this tool. *Note: The Nomads are on an Android operating system.

Use the Nomad to navigate to the following points and record the identity of the object. The photos are meant to be clues of the objects you are meant to find. Write down the identity of the object in the lines below. If you don't know what that object is, describe it as best as you can.

	1. 30.429333, -88.427372		2. 30.429782, -88.427568
	3. 30.429702, -88.427760		4. 30.429963, -88.427752
	5. 30.430593, -88.427715		6. 30.430302, -88.428361
	7. 30.429677, -88.428455		8. 30.429332, -88.429572
	9. 30.429388, -88.428701		10. 30.429152, -88.427994

Find a group of five trees. Use the Nomad's polygon function to draw a polygon around them. Take a GPS point of each tree also using the Nomad. While you take each point, use the DBH tape to determine the DBH of each tree then record that in the note section of each datapoint. Record your data in the chart below as well.

	Species	**Coordinates**	**DBH**
1			
2			
3			
4			
5			

Note: The DBH tape has two sides. You will need to use the "diameter inch" measurements.

Matchstick Savanna

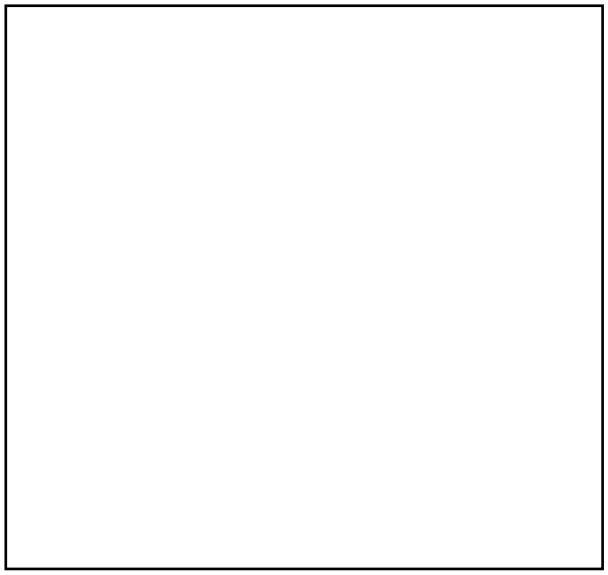
For this activity you will be imitating management practices in a "matchstick savanna". First you will see a demo matchstick savanna lit on fire. This is meant to demonstrate a savanna that has had no management undergoing a wildfire.

2-12. What do you predict will happen to this savanna?

_____

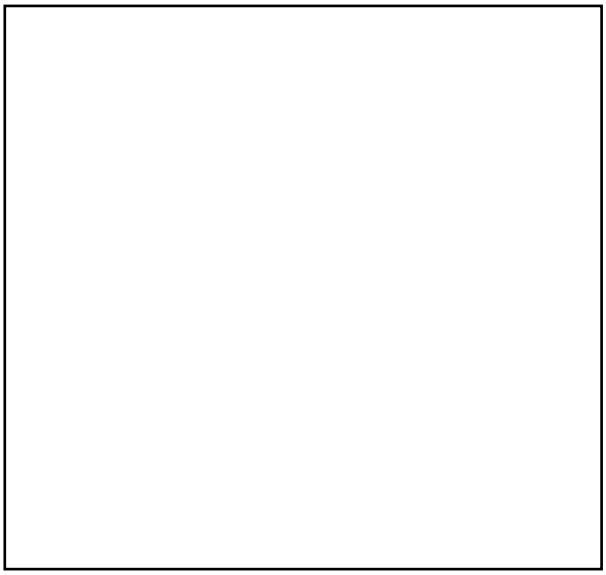
_____

You will be given 50 matches, which represent trees, to construct your own matchstick savanna. You will be conducting management practices in this savanna then it will be subjected to a "wildfire", so keep this in mind when building your savanna. Place the matches in the clay, match head facing up. Draw the arrangement of your forest in the block below.



Now you will be able to conduct management practices in your savanna. You can use **tree thinning or hand clearing**. This will be simulated by simply removing matches from the savanna. Another method available is **mechanical clearing or mulching**. This will be stimulated by removing a match, breaking it in half, and placing both pieces on the clay surface. The last method you may use is to create a **fire lane**. This is accomplished by removing matches. The fire lane may only be two trees wide and can be as long as you wish. You may use as few or as many of these methods as you wish, but you can only remove 15 matches total. The object is to have the least amount of savanna burned by the fire as possible.

In the block below draw your managed savanna. Be sure to label the management practices.



2-13. Which management practices did you use and how many matches did you remove with each? Why? What was your thought process?

_____

_____

_____

_____

2-14. How much of your savanna do you predict will be burned by the wildfire?

_____

_____

Now your savanna will be subjected to wildfire. Bring the savanna outside and have the instructor light it. After the savanna has cooled down, go back to the last sketch and indicate which matches were burned using a different color.

2-15. How much of your savanna was actually burned?
# of trees_____cm2_____

2-16. Was this what you predicted? What factors do you think contributed to the results?

_____

_____

Imagery

Imagery is an excellent tool for restoration scientists to view the landscape as it was in the past. While one cannot usually identify vegetation to species level, imagery along with other restoration tools can assist in developing a restoration plan. Take a close look at the aerial photographs on the next few pages and compare those taken in 1967 to the satellite imagery overlays (on transparencies) of the same site from 2016.

2-17. What are some similarities amongst the imagery taken in 1967 versus the modern-day imagery?

Pristine Site

Intermediate Site

No management site

2-18. What are the differences between the imagery taken in 1967 versus the modern-day imagery?

Pristine Site

Intermediate Site

No management site

2-19. Can you make any assumptions as to what you might find at these sites if you were to visit them? Think of the types of vegetation and animals.

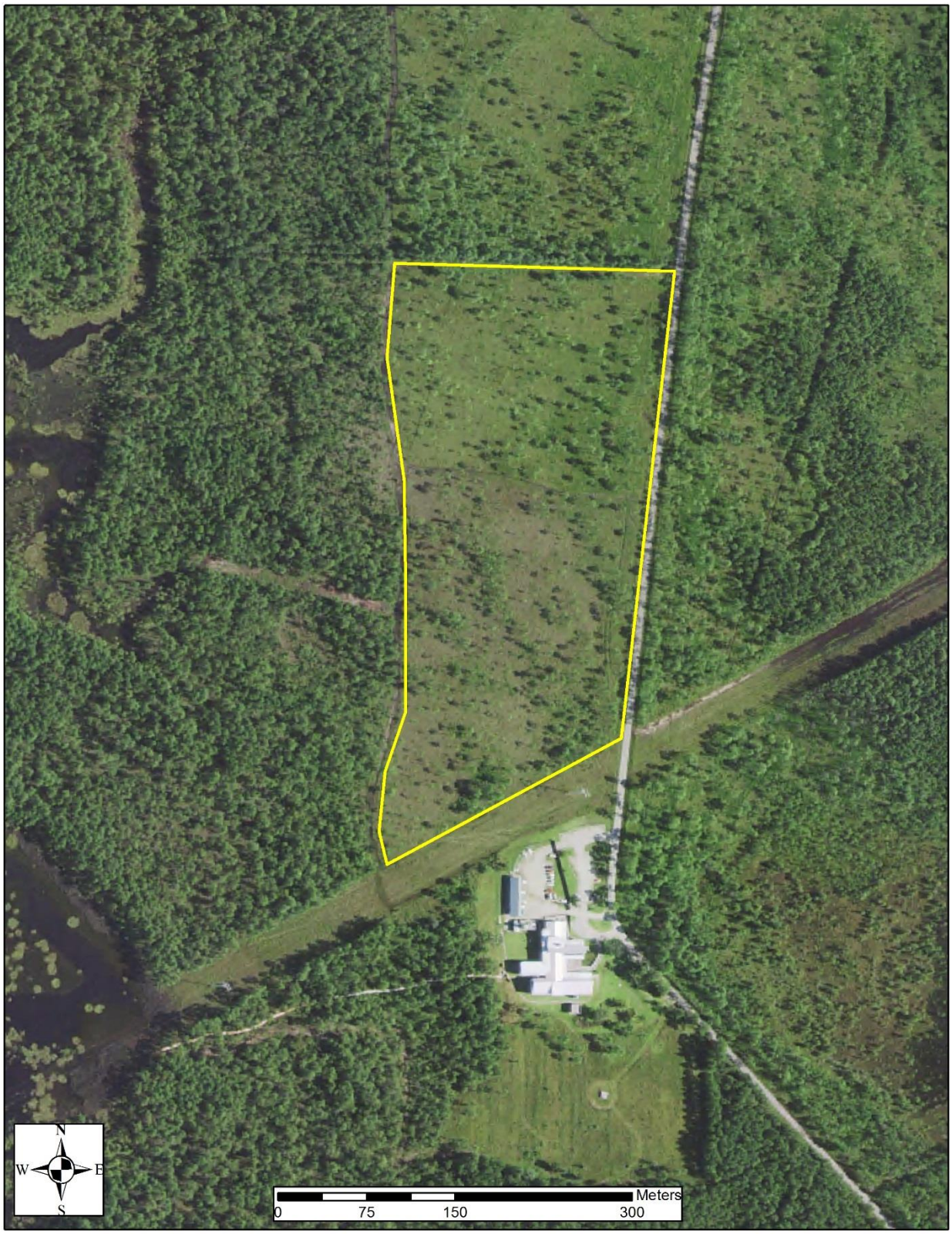
Pristine Site

Intermediate Site

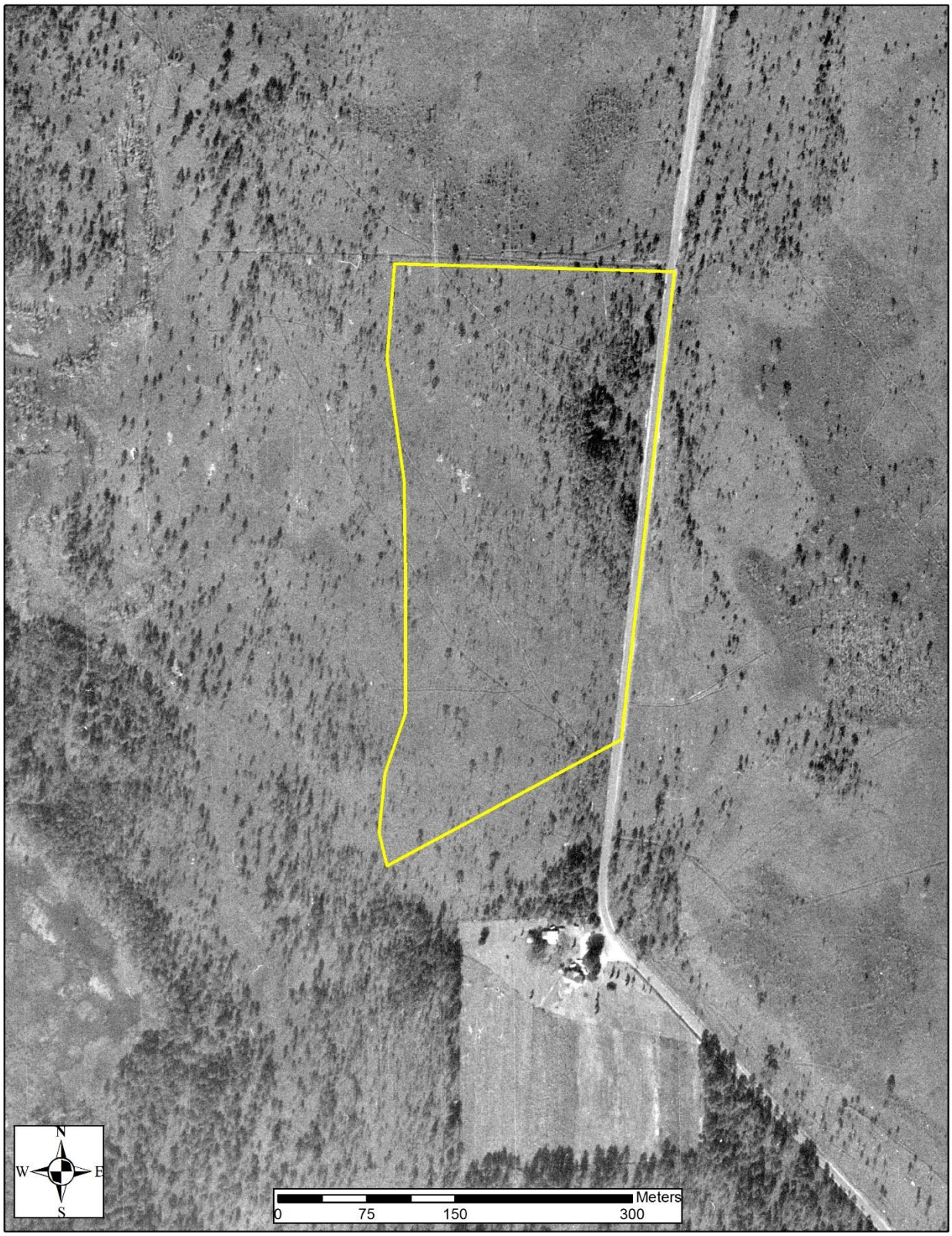
No management site

How old is aerial photography? How was aerial photography and imaging accomplished?

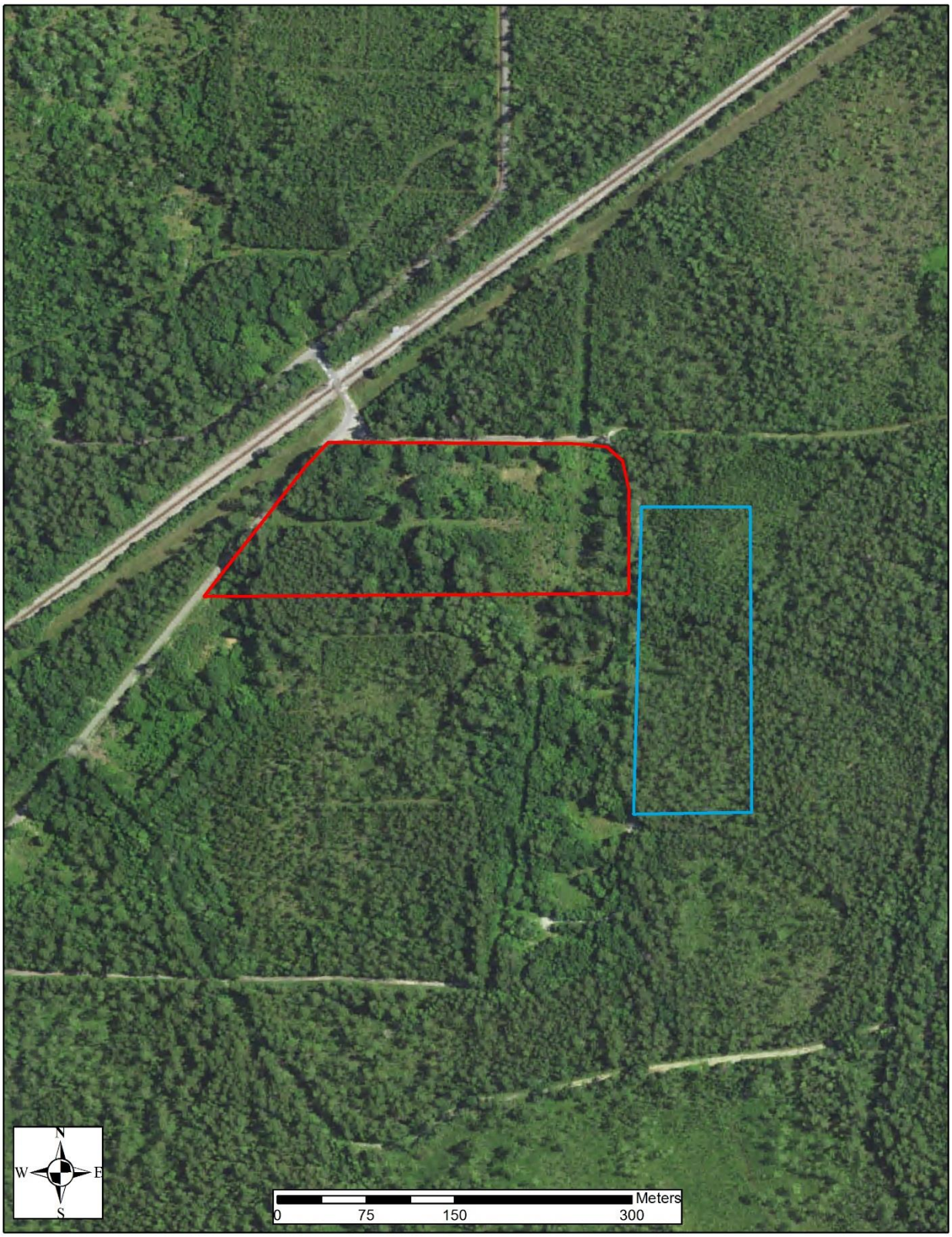
Pristine Site 2016



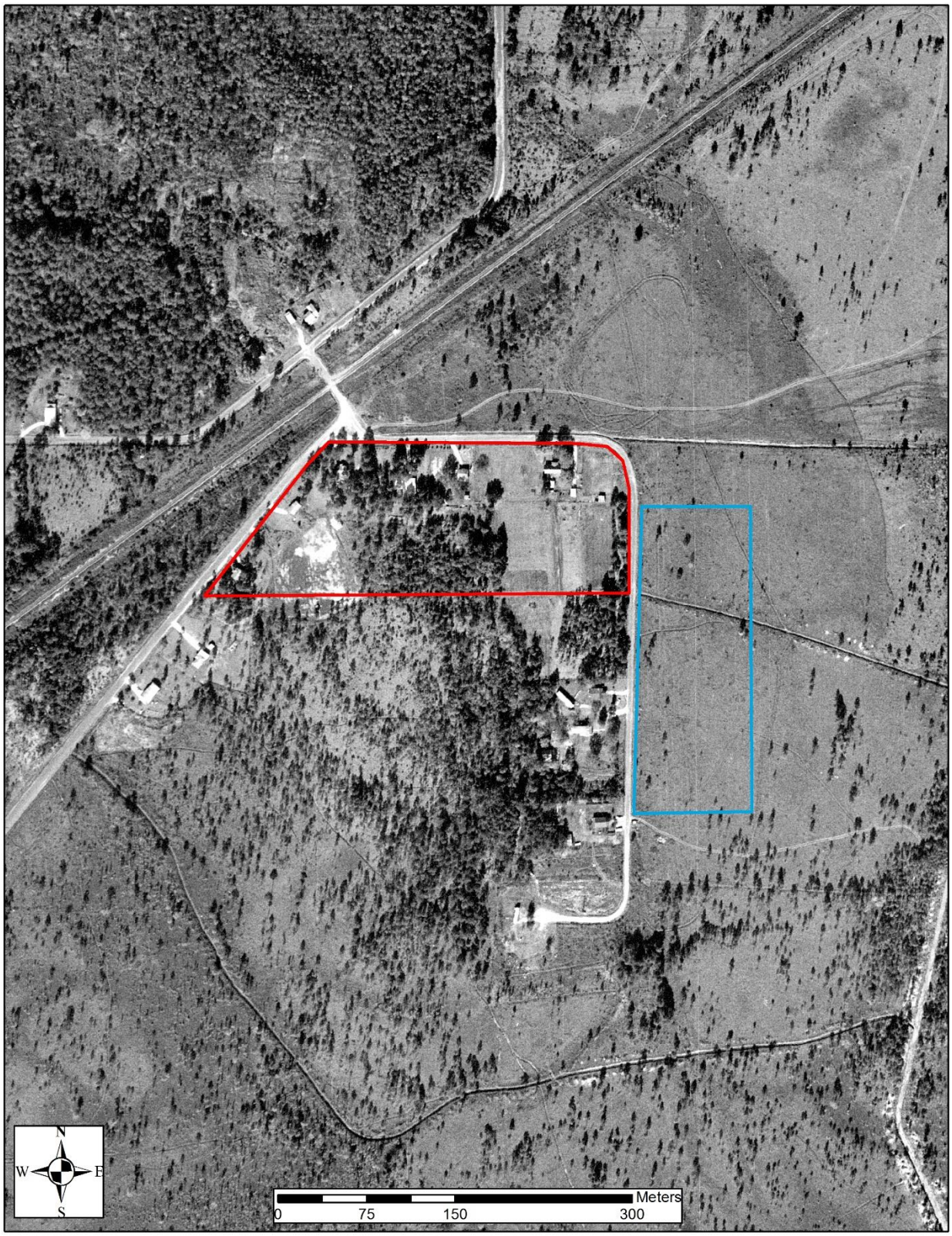
Pristine Site 1967



Intermediate (vertical box) and No Management (horizontal box) Sites 2016



Intermediate (vertical box) and No Management (horizontal box) Sites 1967



Restoration Practices

management: replacing or augmenting missing or damaged natural processes, while using the least amount of manipulation to achieve a maximum benefit to wildlife or ecosystem health and function through active human intervention and action.

monitoring: processes and activities that take place to assess environmental conditions and ecosystem health by helping scientists establish current status and determine environmental trends. It is used to inform management.

Hand clearing: Thinning out woody underbrush and trees with the use of hand tools or chainsaws in order to restore light to the herbaceous layer. Relatively inexpensive, but a slow process.

Planting native species: Planting saplings or sowing seeds to restore the native seed bank. This process is used when the native species have been greatly reduced or aren't able to propagate. This is frequently used to restore longleaf because the tree takes such a long time to mature.

Mechanical clearing: Process to remove woody vegetation through use of heavy machinery, like a tractor, drum chopping, or mulching. By removing slash pine and gall berry, this method will increase the amount of incident light reaching the herbaceous layer. Note: This would occur in areas that aren't safe for burning or be used to jumpstart the succession process. This can take a lot of time and is expensive.

Prescribed (Rx) burn: Method of reducing woody vegetation and enhancing native herbaceous plant communities through the deliberate introduction of controlled fires to selected areas every 2-4 years. This is usually the best method, but there are many limiting factors (i.e. construction of fire lanes, safety, smoke, nearby houses, roads, weather, etc.).

Chemical treatment: Process to remove nonnative vegetation through application of herbicide. Native vegetation can be removed with this method as well, like if there is an abundance of woody vegetation. There are many options when it comes to herbicides. Land managers will look for chemicals that kill the target species and have the least effect on non-target species. These herbicides have been researched and tested thoroughly.

Note: Often the cheapest management options are the ones that are the most practical. However, if a fast result is desired and money is no object, scientists may choose a different path. These practices are meant to imitate fire, which is usually the best option but not always ideal.

The following table shows some examples of restoration practices used to manage longleaf pine ecosystems in different stages of degradation.

Table 1. "Restoration Prescriptions" from Brockway et al (2005).

Prescriptions for Restoring Longleaf Pine Savannas			
Degradation Stage:	**Moderately Degraded**	**Very Degraded**	**Highly Degraded**
Canopy:	**Longleaf Pine**	**Other Trees**	**Other Trees**
Understory:	**Native Vegetation**	**Native Vegetation**	**Nonnative Vegetation**
Prescription:	**Growing-season fire** **Dormant-season fire** at 2-year intervals	Growing-season fire Mechanical harvest (chainsaw) Mulch once and burn Plant LLP seedlings	Mulch twice and burn Herbicide if needed Plant LLP seedlings Sow native understory seed

Restoration Tour

At this point, we are wrapping up our first day at Grand Bay NERR. We'll pack up, load buses, and take a quick tour to view some areas that have been managed using several different practices. Pay close attention to how each site looks and write down observations in your field journaling pages. We've given you a lot of information today, so make sure to take some time and review it with a classmate or friend and come up with some questions you may want to ask us next time!

Lesson 3: Monitoring Stages of Restoration

Today we will visit three upland savanna sites, each showing you a different stage of restoration. During this field day, we're going to observe some similarities and differences among the three sites as well as collect samples and data.

Pristine (savanna north of Coastal Resources Center): This is what we want other savannas on the Reserve to look like.

3-1. What do you observe at the **pristine** site?

Successed Community (30°25.457' N, 088°25.441' W): This site is a good representation of an ecosystem that has entered the later stages of succession due to fire suppression. Before a controlled burn in spring of 2018, this site hadn't seen fire in a very long time. Restoration specialists have also implemented brush cutting, tree thinning, and chemical treatments for invasives here.

3-2. How does this site compare and contrast to the **pristine** site?

Old Homestead (30°24.754′ N, 088°24.233′ W): This site is an old homestead from before this land was a reserve. This site was mulched at the beginning of 2019 and was treated with herbicide in 2020.

3-3. How does this site compare and contrast to the other sites?

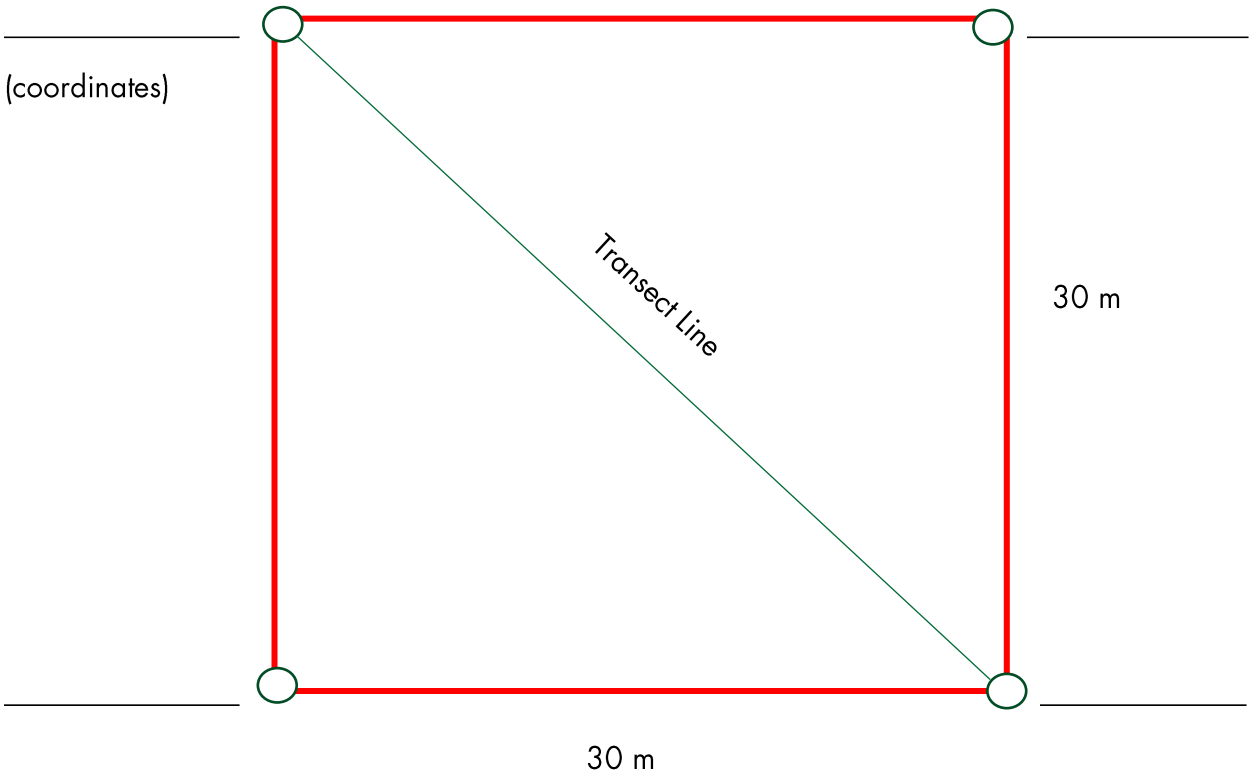
Knowledge Checkpoint

Place a check in the box you think is the correct answer.

	Pristine	Successed	Old Homestead
3-4. Which site is the most prone to dangerous wildfire?			
3-5. Which site might you find the highest number of invasive species?			
3-6. Which site is what we want our savannas to look like?			
3-7. Which site has experienced the most fire suppression?			

Finding and Marking Your Plot

You will be given the GPS coordinates to the 4 corners of your 30 m x 30 m plot. (You can refer to the GPS instructions from Lesson 2 if you need a refresher on how GPS works.) You must work with your group to find these coordinates and mark them with a piece of PVC. Then, use the flagging tape to mark the sides of your plot. Each side will measure approximately 30 m. The plot is also bisected by a transect line. This will also need to be marked with flagging. Tie the flagging to one corner of your plot (bottom of PVC) then run it diagonally across to the other corner. Your study area should look like the picture below.



Vegetation Monitoring

3-8. Monitoring vegetation types is an important part of restoring these habitats to a functional state. Why do you think this is important? _____

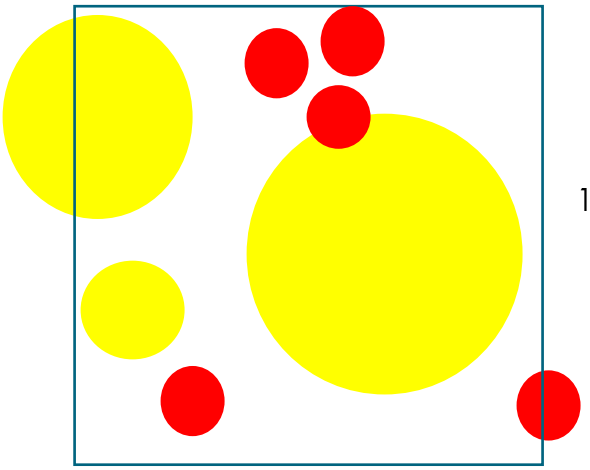
_____

3-9. Restoration specialists attempt to restore vegetation communities to their historical state. Do you think a "historical" state is different from a "functional" state? Why or why not? _____

_____

_____

For the purposes of this study we will identify a few target species to monitor. We will look for these species in three small plots along your transect line. Their presence will be recorded in the percent cover, or the percentage present in the plot. Please look at the example below.



3-10. In the example, the percent cover of the yellow is 40%. In other words, the plot (the square) is 40% yellow. The portion of the yellow circle that is not inside the plot is not considered when determining the percent cover. What is the percent cover of the red? _____%

Plant communities in the savanna are well adapted for survival in this environment. They must be able to withstand frequent fires. The soil in the savanna is poorly drained, highly acidic, and nutrient poor. Yet, there is more biodiversity in one of these square meter plots here in the savanna than in most tropical rainforests. We will be monitoring for the following species on the next page.

Target Species You May Find in a Longleaf Pine Savanna

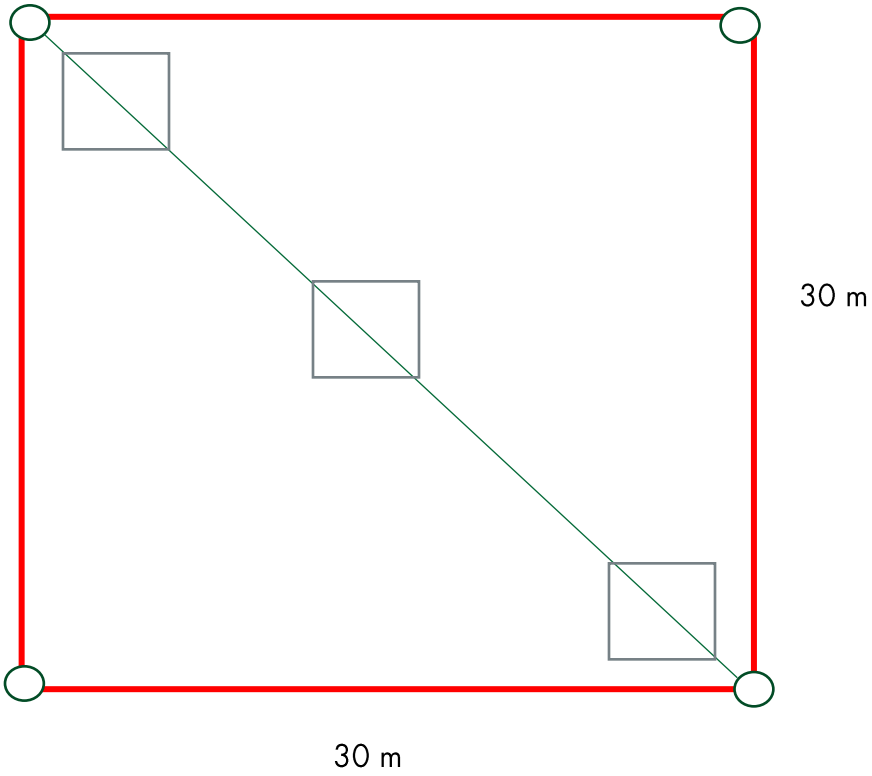
Wiregrass (*Aristida stricta*):
- 0.5 m - 0.9 m (1 ½ - 3 ft) tall
- Grows in dense bunches
- Long, thin, wiry, needle-like leaves
- Very common grass in the savanna

Inkberry (*Ilex glabra*):
- Simple, alternate leaves with few teeth.
- Sometimes leaves have red spots on lower surface.
- Green to black berries.

Data Collection Tip

Instead of writing the entire scientific name of species, scientists and resource managers might abbreviate the names to save some time when writing in their field notebooks or spreadsheets. For example, *Aristida stricta* (wiregrass) might be abbreviated using the first two letters of each name: **ARST**. *What is the abbreviation for inkberry?*

Place the square meter quadrat on the transect line in a random spot (see figure below). Mark the GPS coordinates with your device (bottom left corner of the quadrat). Look for wiregrass (ARST) and estimate the percent cover. After you record the data, do the same thing for inkberry (IRGL). After you have percent cover for both species, move the quadrat to another random spot and repeat the process. You should have three data sets when finished.



Quadrat Number	**1**	**2**	**3**
Coordinates			
% cover ARST			
% cover ILGL			

Stand Density Index

The pine savanna ecosystem has very little canopy cover, less than 50%. Historically, the small amount of canopy the savannas did have in this region were dominated by longleaf pine. Since the arrival of Europeans, these trees have been highly sought after because of their long, straight timber. Along with the species' long time to reach mature stages, this has also led to its decline. When longleaf pines were cut for timber in the late 1800s, they were replaced with other pines, like slash pine, that yield higher amounts of resin because of the high demand for **turpentine**. Slash pine does naturally occur in this habitat, but not in the abundances found at Grand Bay. Longleaf pine cannot be reestablished until other tree species are thinned.

Therefore, we must determine the amount of pines that should be present. To do this we will use a tool known as **stand density index (SDI)**. We will count (and mark with GPS) the number of pine trees within the plot, identify them to species level, and measure the **diameter at breast height (DBH)** of each tree. We will use these data to calculate the SDI during data analysis on day four. First, we must know the difference between slash and longleaf pines. Look at the pictures below and list all the differences you notice between the two trees.

	Slash pine (*Pinus elliottii*)	Longleaf pine (*Pinus palustris*)
Branches		
Needles		
Cones		
Other?		

The next step in determining the SDI of our site is to measure the DBH of each tree in our plot. The DBH is measured using the logger's tape.

1. At about 4 ½ feet from the ground measure the diameter of the tree using the "diameter inch" side of the tape.
2. Record the DBH along with the species of each tree in the table below. Don't forget to create a GPS point for each tree using the Trimble Nomad.

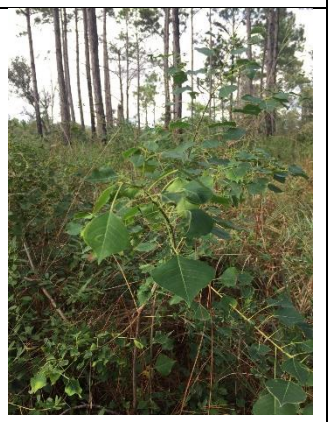
Species	**DBH**	**Did you mark the tree?**	**Species**	**DBH**	**Did you mark the tree?**
1.			12.		
2.			13.		
3.			14.		
4.			15.		
5.			16.		
6.			17.		
7.			18.		
8.			19.		
9.			20.		
10.			21.		
11.			22.		
The pine trees in my plot are at least bigger than _____ DBH.					

Invasive Species Monitoring

Invasive species are non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Two species that immediately come to mind when dealing with savanna restoration are cogon grass and Chinese tallow tree.

Cogon grass (*Imperata cylindrica*) is native to southeast Asia, Australia, and southern Africa. It is thought that cogon grass actually entered the United States through Grand Bay, Alabama. Now a common sight in the southeast, this grass has invaded more acreage than kudzu. Cogon grass can grow to 4 feet tall with leaf blades about one inch wide. A good "field mark" is the off-center mid-rib, (see picture below).

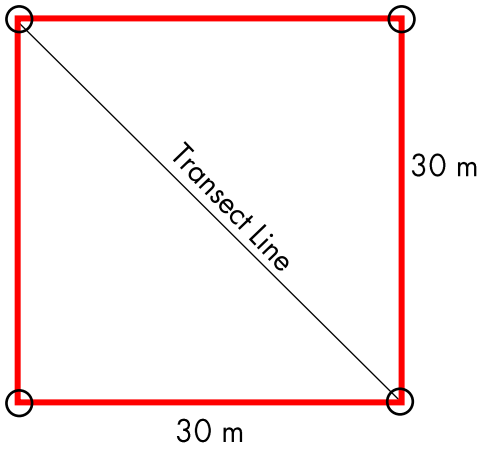
The Chinese tallow tree (*Sapium sebiferum*), or popcorn tree, is a native of China introduced to South Carolina around 1776 for the ornamental use and oil production of its seeds. Now, this tree is common throughout the Southeastern United States and even parts of California. This tree has extremely high growth rates and reproductive ability. Therefore, once this invasive becomes established, it is almost impossible to completely remove it. The problem with this species is that it easily out competes native vegetation forming a monoculture, which lowers species diversity and resilience in an area.

Cogon grass (*Imperata cylindrica*):			Chinese tallow tree (*Sapium sebiferum*):	
				
Finely serrated leaves.	Off-center mid-rib.		White seeds resembling popcorn	Heart shaped leaves

Cogon grass and Chinese tallow will be the two invasives that we will monitor. For this activity you will be drawing virtual polygons and points for groups of these invasives and labeling them with the GPS device. First you will need to locate any patches of cogon grass or Chinese tallow within your plot.

On your Trimble Nomad GPS:

- Draw a polygon around any cogon grass you see.
  Check the box after you've completed this task: ☐
- Assign a point for each Chinese tallow tree you see.
  Check the box after you've completed this task: ☐



Because we will be looking for invasive species in the entire 30m x 30m plot, we will be estimating percent cover of each target invasive species within the whole plot. (Instead of using a 1-meter quadrat like earlier, think of your flagged plot as a much larger quadrat.) In the spaces below, write down your estimate for percent cover of each invasive species.

	IMCY	**SASE**
% cover		

That completes the data collection for the **Pristine** site. Next, we will visit the **Successed Community** and **Old Homestead** sites and collect the same types of data.

Successed Community (30°25.457′ N, 088°25.441′ W):

Plot Coordinates

_____ _____ _____ _____

Native Vegetation

Quadrat Number	**1**	**2**	**3**
Coordinates			
% cover ARST			
% cover ILGL			

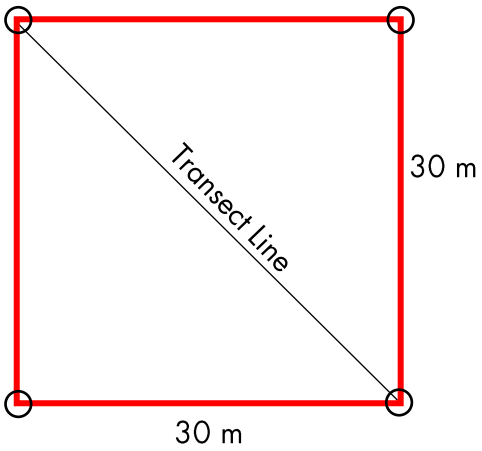
Stand Density Index

Species	**DBH**	**Did you mark the tree?**	**Species**	**DBH**	**Did you mark the tree?**
1.			8.		
2.			9.		
3.			10.		
4.			11.		
5.			12.		
6.			13.		
7.			14.		
The pine trees in my plot are at least bigger than _____ DBH.					

Invasive Vegetation

On your Trimble Nomad GPS:

- Draw a polygon around any cogon grass you see.
  Check the box after you've completed this task: ☐
- Assign a point for each Chinese tallow tree you see.
  Check the box after you've completed this task: ☐



Estimate percent cover of invasive species in the spaces below:

	IMCY	**SASE**
% cover		

Old Homestead (30°24.754′ N, 088°24.233′ W):

Plot Coordinates

_____ _____ _____ _____

Native Vegetation

Quadrat Number	1	2	3
Coordinates			
% cover ARST			
% cover ILGL			

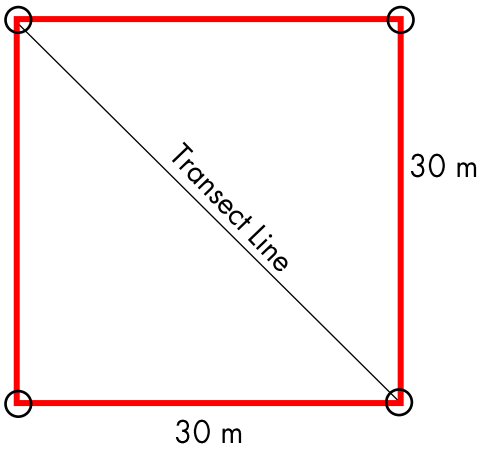
Stand Density Index

Species	DBH	Did you mark the tree?	Species	DBH	Did you mark the tree?
1.			8.		
2.			9.		
3.			10.		
4.			11.		
5.			12.		
6.			13.		
7.			14.		
The pine trees in my plot are at least bigger than _____ DBH.					

Invasive Vegetation

On your Trimble Nomad GPS:

- Draw a polygon around any cogon grass you see.
  Check the box after you've completed this task: ☐
- Assign a point for each Chinese tallow tree you see.
  Check the box after you've completed this task: ☐



Estimate percent cover of invasive species in the spaces below:

	IMCY	SASE
% cover		

Meet the Scientist

Name:
Dr. Jonathan Pitchford

Career:
Stewardship Coordinator – Grand Bay NERR

Education:
Bachelor of Science in Zoology at Auburn University
Master of Science in Biology at Appalachian State University
Ph.D. in Forest Resource Science at West Virginia University

Research: Most of Jonathan's research now is focused on understanding the effects of habitat restoration and how salt marsh ecosystems are changing over time.

Notes:

Jonathan was first inspired to study **habitat restoration** during his time as an intern in Canandaigua, NY when he assisted a watershed conservation program with the construction of a wetland that would store stormwater and provide wildlife habitat. He began studying restoration in graduate school where he was focused on understanding how restoring streams in West Virginia impacted erosion rates and plant, invertebrate, and fish communities. Now Jonathan studies wet **pine savanna** restoration at Grand Bay NERR. Here, he is focused on understanding how land management activities such as prescribed burning, invasive species treatments, and mechanical clearing impact plant and wildlife communities. The goal of these treatments is to restore native grasslands by reducing woody vegetation and **invasive species** cover so that herbaceous plants can grow and flourish. Jonathan learns how restoration is working by monitoring plant and animal communities at several different sites from **control sites** (no restoration) to **pristine sites** (beautiful wet pine savanna) within the reserve. Jonathan expects that land management activities will help sites with poor habitat quality transition into pristine sites that can support greater **diversity** of plants and animals.

Figure 11. Native grassland along the Mississippi coast. Photo by: Jonathan Pitchford

Lesson 4: Data Comparison and Analysis

Native Vegetation Analysis

Fill out the tables below with other groups' averaged percent cover estimates for each site. We will then discuss the results and determine the health of these sites.

Pristine Site

Group	Red	Green	Yellow	Purple	Blue	Average
% cover ARST						
% cover ILGL						

Successed Community Site

Group	Red	Green	Yellow	Purple	Blue	Average
% cover ARST						
% cover ILGL						

Old Homestead Site

Group	Red	Green	Yellow	Purple	Blue	Average
% cover ARST						
% cover ILGL						

Discussion Questions

4-1. Do you see any trends with the group data? _____

_____

4-2. Are the average percentages of each species different for each site? _____

_____

4-3. Which species had the highest percent cover at the Successed Community Site? What about at the Old Homestead Site? What does that tell you? _____

_____

Stand Density Index Analysis

For our purposes, the Stand Density Index (SDI) is a direct measure of the crowding of trees in a stand. It is correlated in terms of basal area (cross sectional area of trees in an area). We will calculate the SDI of each site. Let's start using the data gathered from the pristine site. In order for us to find the SDI we must think in terms of acres. So, we need to estimate the number of trees per acre at our site. There are 4.5 of our plots inside an acre. Multiply the number of trees in your plot by 4.5 to get the estimated number of trees in an acre. **4.5 x # of trees =_____# of trees in an acre.**

Next, use the chart below to determine the basal area of your plot. Do this by using the smallest DBH in your plot and the total number of trees you measured. **Basal Area = _____**

	Basal area/acre													
DBH (inches)	**BA10**	**BA20**	**BA30**	**BA40**	**BA50**	**BA60**	**BA70**	**BA80**	**BA90**	**BA100**	**BA110**	**BA120**	**BA130**	**BA140**
	Trees/acre													
1	1834	3667	5501	7334	9168	11001	12835	14668	16502	18335	20169	22002	23836	25669
2	458	917	1375	1834	2292	2750	3209	3667	4125	4584	5042	5501	5959	6417
3	204	407	611	815	1019	1222	1426	1630	1834	2037	2241	2445	2648	2852
4	115	229	344	458	573	688	802	917	1031	1146	1261	1375	1490	1604
5	73	147	220	293	367	440	513	587	660	733	807	880	953	1027
6	51	102	153	204	255	306	357	407	458	509	560	611	662	713
7	37	75	112	150	187	225	262	299	337	374	412	449	486	524
8	29	57	86	115	143	172	201	229	258	286	315	344	372	401
9	23	45	68	91	113	136	158	181	204	226	249	272	294	317
10	18	37	55	73	92	110	128	147	165	183	202	220	238	257
11	15	30	45	61	76	91	106	121	136	152	167	182	197	212
12	13	25	38	51	64	76	89	102	115	127	140	153	166	178
13	11	22	33	43	54	65	76	87	98	108	119	130	141	152
14	9	19	28	37	47	56	65	75	84	94	103	112	122	131
15	8	16	24	33	41	49	57	65	73	81	90	98	106	114
16	7	14	21	29	36	43	50	57	64	72	79	86	93	100
17	6	13	19	25	32	38	44	51	57	63	70	76	82	89
18	6	11	17	23	28	34	40	45	51	57	62	68	74	79
19	5	10	15	20	25	30	36	41	46	51	56	61	66	71
20	5	9	14	18	23	28	32	37	41	46	50	55	60	64
21	4	8	12	17	21	25	29	33	37	42	46	50	54	58
22	4	8	11	15	19	23	27	30	34	38	42	45	49	53
23	3	7	10	14	17	21	24	28	31	35	38	42	45	49
24	3	6	10	13	16	19	22	25	29	32	35	38	41	45
25	3	6	9	12	15	18	21	23	26	29	32	35	38	41
26	3	5	8	11	14	16	19	22	24	27	30	33	35	38
27	3	5	8	10	13	15	18	20	23	25	28	30	33	35
28	2	5	7	9	12	14	16	19	21	23	26	28	30	33
29	2	4	7	9	11	13	15	17	20	22	24	26	28	31
30	2	4	6	8	10	12	14	16	18	20	22	24	26	29

Figure 12. Table from Elledge and Barlow (2010).

The next two steps require a little calculation. We need to determine the quadratic mean diameter (DQ) to calculate the SDI. The DQ will tell us the average tree diameter in our stand. Determine the DQ using the following formula: (forester's coefficient = 0.005454)

$$DQ = \sqrt{Basal\ Area\ /(forester's\ coefficient * \#of\ trees)}$$

Now calculate the SDI using the formula below. Then, determine the condition of our canopy using the metrics table.

$$SDI = \#\ of\ trees\ \left(\frac{DQ}{10}\right)^{1.6}$$

Canopy Condition

Poor	Fair	Good	Excellent	Good	Fair	Poor
<10	10-20	20-35	35-120	120-155	155-180	>180

Now repeat this process for the other two sites.

Site Name	# of trees	Basal Area	DQ	SDI	Condition
Successed Community					
Old Homestead					

4-4. What are the implications of your results? What can or should be done in terms of management for these sites?

4-5. What is the dominant species of pine at the pristine site? The Successed Community site?

4-6. What would be your plan for removal of slash pine at any of these sites?

4-7. At the Successed Community site there were many other types of encroaching hardwood tree species present. What do you think would be the best plan to remove these from the site?

4-8. Do you think these trees should be removed? Why or why not?

Invasive Vegetation Analysis

Invasive Vegetation Assessment Table			
Excellent Health	**Good Health**	**Fair Health**	**Poor Health**
None present	1 to 5 % cover	5 to 10 % cover	> 10% cover

4-9. Look at the invasive vegetation assessment table. According to the data you collected, what can be said about the Successed Community site in terms of invasive species?

_____

_____

_____

4-10. What management recommendations can you give concerning this site?

_____

_____

4-11. What are your recommendations as to what types of management practices could be applied to the Old Homestead site? Remember the goal is to restore this site to the same status as the Pristine Site. Use datasets from both sites when considering the answer to this question.

_____

_____

_____

_____

4-12. Let's combine all our group data on the following page and discuss our results as a class. Jot down some of your thoughts and responses to the questions that come up after seeing the class data.

_____

_____

_____

_____

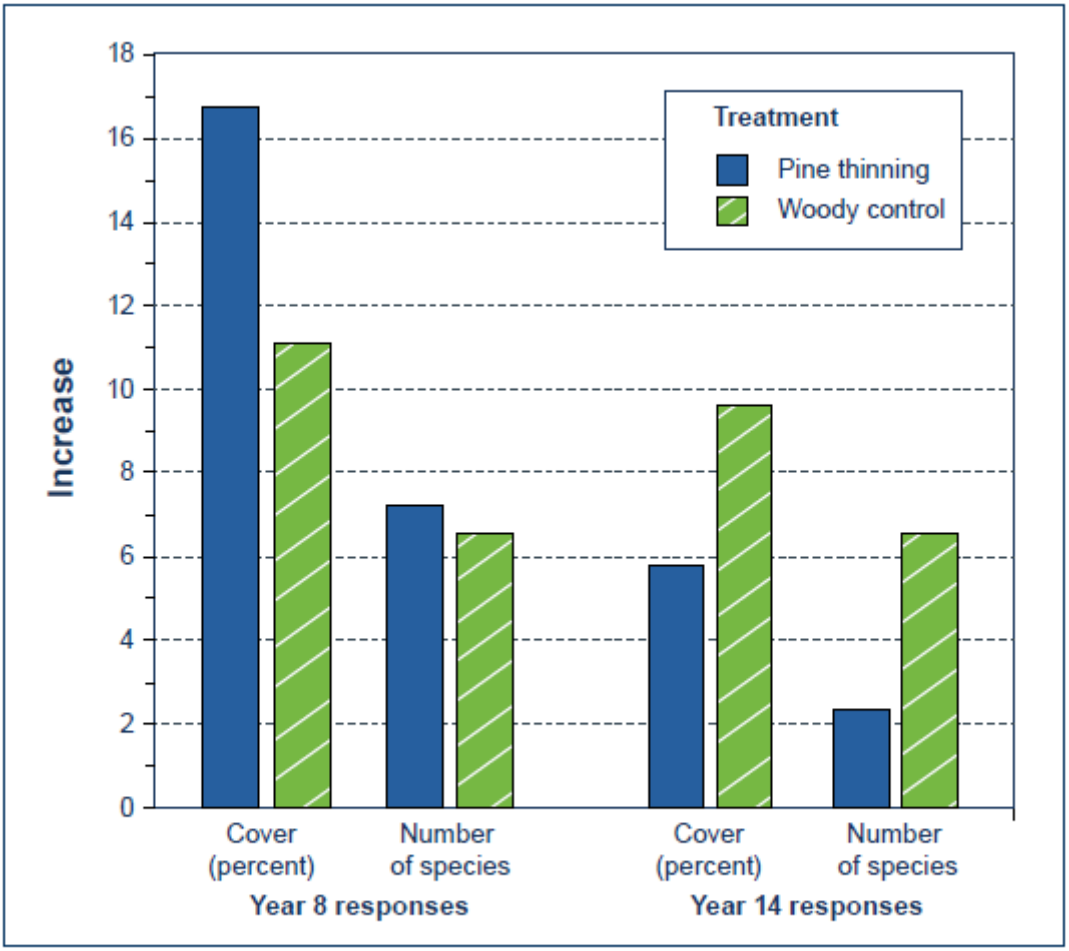
_____

	Group	Red	Green	Yellow	Purple	Blue	Average
Pristine Site	**% cover IMCY**						
	% cover SASE						
Successed Community Site	**% cover IMCY**						
	% cover SASE						
Old Homestead Site	**% cover IMCY**						
	% cover SASE						

Analyzing a Graph from a Scientific Paper

The following are results from a restoration study by Harrington and Edwards (1999) converting a longleaf pine plantation back to savanna habitat. Through years of fire suppression, the plantation became overgrown with hardwood tree species which in turn gave rise to thick understory filled with woody shrubs and vines. The thick shade and leaf litter choked out much of the pine savanna plant species that once thrived there.

Study sites were chosen and split into four smaller plots. At each site one plot had no management, one was thinned manually, one had herbicide treatments, and one had a combination of thinning and herbicide treatments. Researchers carried out baseline plant surveys at the beginning of the study followed by one at eight years and one at fourteen years. The graph below was derived from the data collected at the thinned site plots and the plots that had thinning and herbicide (woody control).



Increases in cover and number of herbaceous species 8 and 14 years after pine thinning and non-pine woody control. By year 14, the gains had diminished in thinned plots.

Figure 13. Summary graph from Harrington et al. (2013).

4-13. What is another word for the number of species in an area?

_____

4-14. What does this graph say about tree thinning? What about herbicide treatments?

_____

_____

_____

_____

4-15. What caused the herbaceous understory species to stay the same in the woody control site? Why?

_____

_____

_____

Lesson 5: Designing a Restoration Plan

You will further develop collaboration skills with your peers by creating a restoration/management plan using one of the scenarios we will assign to you. You'll be using information and knowledge gained from the previous days in the CHΔNGES program to help you formulate a well-informed sequential plan. Each scenario has a different issue, but the steps you plan might sound similar. While you're developing your plan, consider costs, sociological factors, and possible repercussions for both natural and human aspects.

This exercise requires you to do a good bit of critical thinking and brainstorming. Although we've discussed and demonstrated a lot of different methods and processes, some of these scenarios could have management practices that we didn't talk about. Meaning, you'll have to do some critical thinking to find some feasible solutions. If you don't have access to a computer for this assignment, write down some questions you may ask or searches you would need to do to get to your answer. While the scenarios each have one page of questions, this is not limiting your plan; it is only providing some guiding questions and space for an outline and brainstorming.

What we are looking for in your restoration plans are ways you and your group have incorporated the science and methods learned from our lessons and activities. We are also looking for questions you might ask or methods you may employ that we didn't discuss in the CHΔNGES program. The beauty of restoration is finding ways to improve your practice or approach a problem, with the least harmful impact as possible.

Crucial to this process is also communicating with your group. What may help is having roles for each person. At the end of this, you'll be presenting your group's restoration plan in front of your classmates, so be sure to check out the rubric found in your reference pages. Your classmates will be expected to ask questions and give your group constructive feedback.

As you have experienced from our program, restoration requires many working parts and needs effective communication to make sure everything runs properly and is working for the betterment of the habitat and the potential ecosystem services they provide.

Depending on the time your teacher has allotted, you may be writing a simple outline, or you may be developing a full-on plan. Regardless, you must work with your group and communicate your plan to the class. Presentations should be between 3-5 minutes long, so take a little bit of time if you can to practice! Also be prepared for questions after your presentation.

Good luck!

Managing for the Bobwhite Quail

Bobwhite quail prefer habitats with native grasses and shrubs, particularly found in early succession of a forest or grassland. Agriculture has created habitats for bobwhite quail especially when there is abandoned open land with recent soil disturbance to begin plant succession. However, if the land remains undisturbed and more vegetation begins to grow, it's no longer the appropriate habitat for bobwhite quail. Similarly, bobwhite quail that live in pine savannas and forests experience habitat loss when there's too much vegetation growing from lack of disturbance. In Mississippi, pine forests are the main systems managed for bobwhite quail habitat. How would you manage a pine forest for the bobwhite quail?

In your own words, describe the major issues or problem in this scenario. This will help you determine what restoration is required. (Problem)

Outline your monitoring process. To do this, think about what information you might need to begin addressing the issue and work towards a solution. (Monitoring)

What restoration/management practice(s) would you employ to address the issues/problem and why? Also describe any steps that should be taken before your team begins restoring the site. For example, how do you fund your restoration? (Management)

Which professionals will be involved in your restoration plan? See the list on page 62 for ideas.

Degradation by Succession

A new housing development has been built next to a pine savanna. Before this, the pine savanna was regularly burned by land managers. After the introduction of the houses, prescribed burning has been suspended because of residents concerned for their safety. After 15 years of no management, the savanna has succeeded to a thick underbrush, and hardwood species have encroached creating a thick canopy cover.

In your own words, describe the major issues or problem in this scenario. This will help you determine what restoration is required. (Problem)

Outline your monitoring process. To do this, think about what information you might need to begin addressing the issue and work towards a solution. (Monitoring)

What restoration/management practice(s) would you employ to address the issues/problem and why? Also describe any steps that should be taken before your team begins restoring the site. For example, how do you fund your restoration? (Management)

Which professionals will be involved in your restoration plan? See the list on page 62 for ideas.

Timber

In a savanna, longleaf pine trees were harvested for timber and naval stores (products made with pine sap), but they take a long time to grow. Slash pines, however, grow and mature faster making them a species more suited for timber production. As a result, after longleaf pine trees were harvested, slash pines were planted in their place and now pine forests are dominated by slash pines. Now, there is an interest to restore those forests back to longleaf pines.

In your own words, describe the major issues or problem in this scenario. This will help you determine what restoration is required. (Problem)

Outline your monitoring process. To do this, think about what information you might need to begin addressing the issue and work towards a solution. (Monitoring)

What restoration/management practice(s) would you employ to address the issues/problem and why? Also describe any steps that should be taken before your team begins restoring the site. For example, how do you fund your restoration? (Management)

Which professionals will be involved in your restoration plan? See the list on page 62 for ideas.

Degradation by Invasive Species

Wild hogs have invaded a pine savanna. While foraging on plants and invertebrates in the soil, they completely striped a large portion of the savanna of its native vegetation. They have carried with them, attached to the coarse hair covering their bodies, seeds from invasive cogon grass. These seeds are dispersed and trampled into the soil. The seeds sprout and the cogon grass becomes established in the savanna. Over the next few years, the cogon grass thrives and outcompetes many of the native grasses.

In your own words, describe the major issues or problem in this scenario. This will help you determine what restoration is required. (Problem)

Outline your monitoring process. To do this, think about what information you might need to begin addressing the issue and work towards a solution. (Monitoring)

What restoration/management practice(s) would you employ to address the issues/problem and why? Also describe any steps that should be taken before your team begins restoring the site. For example, how do you fund your restoration? (Management)

Which professionals will be involved in your restoration plan? See the list on page 62 for ideas.

During your monitoring process you hear the call of a dusky gopher frog recorded on one of your call boxes. The dusky gopher frog is one of the most endangered amphibians in North America. How would your management plan change, if at all?

Fragmentation by highway

A pine savanna habitat was altered with the introduction of a highway. It was constructed to increase tourism in the local area, which boosts the economy. It's also a great way for more people to see the wonders and beauty of the local pine savanna, something they may not have seen before without public access created by the highway. However, one side of the highway floods a lot more when it rains because the pine savanna has nowhere to naturally drain, and it's causing people that have built houses there to either learn how to adapt and protect their homes or move away from the area. A major restoration effort to remove the road will cost a lot of money and is likely to make local homeowners unhappy, but there is an opportunity to restore a section of the pine savanna habitat where there aren't as many people.

In your own words, describe the major issues or problem in this scenario. This will help you determine what restoration is required. (Problem)

Outline your monitoring process. To do this, think about what information you might need to begin addressing the issue and work towards a solution. (Monitoring)

What restoration/management practice(s) would you employ to address the issues/problem and why? Also describe any steps that should be taken before your team begins restoring the site. For example, how do you fund your restoration? (Management)

Which professionals will be involved in your restoration plan? See the list on page 62 for ideas.

Jobs for Restoration Plan Scenarios

The following "jobs" are examples of positions/people that might be needed for a restoration plan. While each "job" is general, be sure to specify what they do or study in your plan (e.g. botanist who specializes in native wildflowers instead of just "botanist").

Restoration specialist- specializes in restoration practices and knows how to balance natural processes with human impacts. https://www.agcareers.com/career-profiles/restoration-specialist.cfm

Monitoring specialist- this person might spend most of their field work monitoring different things to assess ecosystem trends and can provide data analyses and reports outlining their work. https://www.environmentalscience.org/career/environmental-monitor

Forester- manages forests, and is involved in ecological restoration and/or manages protected areas of forests. https://www.environmentalscience.org/career/forester

Wildlife Biologist- study and survey animals and can specialize in certain types of animals (e.g. birds or small mammals) or animals belonging to a specific ecosystem (e.g. all animals that live in a grassland). https://www.environmentalscience.org/career/wildlife-biologist

Botanist- study and survey plants and can specialize in certain types of plants (e.g. carnivorous plants or mosses) or plants belonging to a specific ecosystem (e.g. all plants that live in a grassland). https://www.environmentalscience.org/career/botanist

Wildland Firefighter- firefighters that work in fire prevention and prescribed burning. https://www.fs.fed.us/managing-land/fire/careers

Conservationist- generic term for someone who works to preserve the environment. For these scenarios, it may help to focus on a conservation group such as The Nature Conservancy. https://www.environmentalscience.org/career/conservationist

Contractor- miscellaneous "contract" jobs you may need to specify in your restoration plan (e.g. civil engineering contractor for road project)

Other: if you feel the need to bring another "job" for your restoration plan, be sure to describe who they are and what they do. Most importantly, detail *why* they've been added to your plan.

Communicating Your Science

Communicating your science is a college class on its own, but here are a few tips and tricks for sharing your science knowledge with someone.

First, who is your **audience**? This is probably the most important part about communicating, because talking science with a kindergartener is quite different than talking with a college student.

Next, what's your **topic**? Do you think your audience will be receptive to your topic? How can you make it engaging enough to where your audience might learn something? For example, if your topic is about a sunflower, you may focus on things like "flower" or "colors" for a small child, but to an adult you may talk about whether or not the sunflower is an annual or perennial, something you can grow in your garden, or see as wildflowers. Or if you're talking about a blue crab, you may act out how it moves with a child but talk about seafood recipes or crab fishing with an adult.

You always want to identify a few **takeaway points**. It's a good rule of thumb to have at least three, just in case your audience is varied. Let's take the blue crab example, for instance. You might want to highlight things like the difference between male and female blue crabs and how to identify them. Or you may want people to know that they're part of a group of crabs that are called swimming crabs! Or you might talk about crab traps and ways you can help unwanted animals escape the traps.

Now that you have an idea of what you're talking about and who you're talking to, here are some ways professionals communicate in science:

Poster presentation
Oral presentation with slide show
Discussion/expert panel
Webinar
Demonstration
Video/Vlog
Web post/blog
Social media posts
Science exhibits/displays

Can you think of other types of presentations or ways to communicate scientific messages?

Elements of a good presentation:

- Appeal to senses (see, touch, smell, hear, taste)
- Visuals (photos, videos, real specimens, fake specimens)
- An activity (something you can demonstrate, something the audience can do with you, or something they can do later)
- Hitting your takeaway points- you want your audience to leave learning something new
- Finding a balance of too little information and too much information

Think about presentations you've seen and enjoyed. How did those appeal to you? How were they engaging? When crafting your presentation, think of these things and incorporate them!

Communication Rubric

Restoration Scenario: _____ Time 3-5 mins? Y N

Presentation	4	3	2	1	Score
Content (See presentation handout)	*All* of the necessary information was included.	*Most* of the necessary information was included.	*Some* of the necessary information was included.	*None* of the necessary information was included.	
Delivery (Eye contact, audibility, body language, etc.)	The speaker did an *excellent* job delivering the information in the presentation.	The speaker did a *good* job delivering the information in the presentation.	The speaker did a *fair* job delivering the information in the presentation.	The speaker did a *poor* job delivering the information in the presentation.	
Comprehensibility (Quality of presentation, how well information is taught)	The presentation was *exciting and really made me understand* the purpose and results of the scientist's work.	The presentation was *somewhat exciting and helped in my understanding* of the purpose and results of the scientist's work.	The presentation *was not very exciting and I did not get a clear understandin g* of the purpose and results of the scientist's work.	The presenter *did not demonstrate an understanding* of the purpose and results of the scientist's work.	
Creativity (Thought of ways to solve problem outside of the box, creative presentation/ communication.)	The speaker did an *excellent* job with thinking outside the box.	The speaker did a *good* job with thinking outside the box.	The speaker did a *fair* job with thinking outside the box.	The speaker did not think outside the box.	
Reference (All references cited on the last slide of the presentation)	*All* of the references were included.	*Most* of the references were included.	*Some* of the references were included.	*None* of the references were included.	
				Presentation Score (Average)	

Comments:

Concept Map

fire monitoring restoration savanna structure succession

In a few sentences, explain what your concept map is showing. _____

_____

_____

_____

Careers Pages

The following scientists are highlighted in both our savanna and estuary module notebooks for the CH∆NGES program and will give students a look at various jobs.

Generally, scientists begin their career development right out of high school when they choose to attend college, whether it's a community college or 4-year university. During their time in college, they also look for volunteer opportunities or internships to gain experience. Science is a broad field, and each scientist's adventure to where they are today is different for each person we've highlighted below. Take a look at some Mississippi natives, Mississippi transplants (people who were born somewhere else and moved here), and other scientists that come from across the country and the world, chose their careers. They may have some good advice that speaks to you!

Mai Dang- Mississippi Department of Marine Resources
Marine Fisheries Technician

Mai Dang is a Marine Fisheries Technician of the Seafood Technology Bureau (2007-Present). She works in the Office of Marine Fisheries with the **Mississippi Department of Marine Resources**. She came from a family who are members of the Shrimp Industry of Mississippi and Louisiana. Her mother worked for several shrimp factories since arriving in **Biloxi, MS**. Both parents came from **Vietnam** and had fishing experience where they came from. Mai was born in California, where her parents were first processed. Before long, they transferred to Mississippi to work in the boats. She grew up with knowledge of shrimp processing in factories and on the shrimp boats. She spent her summers working almost 90 hours every week at the shrimp processing factory. She chose her career field in Marine Fisheries because of the influence of her background and greater knowledge and understanding of her people's needs. She is continuing to help by using her mastery in speaking English and Vietnamese. It is a way to form a bridge of understanding between parties in the **seafood industry**.

Mai has an Associate Degree in Applied Science in Business. She also has the following certifications: Basic Seafood Hazard Analysis Critical Control Point Plan, Sanitary Control Procedures on Seafood Processing, Serve Safe Certification.

A Marine Fisheries Technician can do many things. Mai assists in administrative, regulatory, and education and outreach tasks for her job. She collects bi-annual water quality sampling and maintains projects/grants financial status and budgetary needs. She maintains database of Statistical Data Landings and regulatory inspection data. She assists regulatory inspections of processing plants, research surveys, validation and verification experiments of processing procedures and on -going regulatory technical assistance helping the Vietnamese community by acting as interpreter and preparing brochures and educational materials in stewardship education especially for the Vietnamese members of the Seafood industry. She co-authored the publication "How to Start a Seafood Business" guide. Mai also assists in seafood safety outreach and education, and mentors trainees and interns in the Seafood Technology Bureau at MDMR.

Dr. Peter Edwards – Coral Reef Conservation Program (NOAA)

Economist & Social Science Coordinator

I was born and raised in Jamaica, which is a tropical island in the Caribbean. As a child, much of my summers were spent at the beach and with my grandparents in the rural inland areas. This influenced my career path as you can see from my academic training. My career has evolved over time from specializing in **biology, tropical ecology and marine sciences and coastal management** to my present vocation as an **environmental economist and social scientist**. In recent years, my primary driver has been the need to improve the link between biological and ecological sciences and the human dimension – that is, social science, the **science and policy link**.

Our natural resources, including oceans, coasts and atmosphere, have been impacted over time by humans. So while it is critical to devote time and money to better understand the processes and changes that are occurring in these environments, we **also need to understand the impact that society and human beings have on our natural resources** as well as understand how these threats or changes will affect society. If we are aware of people's preferences, their motivations for their behavior, and their level of information about oceans and coastal issues, then agencies such as NOAA can improve how we inform and educate the public as part of our natural resource management strategies. For example, we do need to continue biological monitoring of coral reefs, however if we don't monitor what people are doing to impact the reef, and if we don't understand why or how best to communicate with the public, then biological scientists may simply be monitoring reefs as they slowly disappear. My decision to focus on being trained as a natural resource economist was also due to a need to acquire these skills in order to demonstrate that there are elements in nature that actually have an economic value. This is because if we ignore these economic benefits of nature then we will continue to over exploit these precious natural resources.

I most enjoy the **interdisciplinary** nature of my work. My formative background as a marine scientist and now as a social scientist/economist means I am able to work across various disciplines to try and fuse ecological and social sciences together. I also enjoy **working with various teams** of committed individuals both domestically and internationally.

I would advise [students] to **follow their passion**! For this kind of work I would recommend having a **good grounding in science and biology** as well as **some social sciences**. This will help to improve their understanding of the importance of the ocean and coastal environment and the role they play in human existence. You may start out as a biologist, chemist, economist or philosophy student but you never know where you'll end up! **I believe the future of conservation will require interdisciplinary approaches**, including being able to relate to other disciplines, i.e., economists, biologists, atmospheric scientists, natural resource managers and even lawyers. But most importantly: follow your passion!

BSc., Zoology, University of the West Indies, Mona Campus, Jamaica
M.Phil., Marine Sciences, University of the West Indies, Mona Campus, Jamaica
Ph.D., Marine Studies, University of Delaware, College of Marine and Earth Sciences

Dr. Ana Spalding – Oregon State University Assistant Professor of Marine and Coastal Policy

After I finished my **BA** in **Economics** and **International Relations** at the University of Richmond, in Virginia, I returned to Panama (my home country) and spent a week in Bocas del Toro. This is an archipelago on the Caribbean NW of Panama, where most of our time was spent on boats between islands, [where the] vulnerabilities of oceans and people are so visible. Originally interested in providing lasting solutions to economic development issues in Latin America, I figured that working towards better understanding and saving our marine spaces would be a good place to start. Studying **marine policy** seemed a good way to work in development AND spend more time by the ocean.

Research interests? In practice, I focus on **contemporary and emerging issues** faced by our **global oceans**. I am interested in the evolution of marine policy and ocean governance. As an intellectual exercise, this draws from my training as a development **economist** (undergrad), **marine affairs and policy specialist** (Masters), and **critical political ecologist** (PhD). I basically want to understand what we have done, what the threats are, and how to make it better for all of us.

I want to emphasize my interest and **commitment to diversity, equity, and inclusion**. I have started to explore what this means to my own identity and how I navigate an institution and state where being "different" (in my case, a woman of color) is super obvious. I would much rather be in a place where there are more people like me (of color or other types of diversity). So, I started out learning about myself, and am starting to try to work in support of others (primarily students) who are working to navigate the challenges of being women, people of color, international students, in a very homogeneous town and institution.

Advice for students? Be brave! There is no clear path (YET!). So, talk to everyone about what they do on a daily basis, what path they took, what are some of the challenges they face. Learn to speak the language of other disciplines that are more "prominent" in ocean-related studies and **work really hard on your own communication skills** to make sure that you also don't alienate others with your jargon. **Find your own voice** and **develop confidence** around it.

Tate Thriffley – De Soto National Forest Ecologist

I grew up in **Bay Saint Louis, MS**. I spent a lot of time down along the shores of the Bay and the Mississippi Sound. I always felt connected to the waves and the water. There were several acres of wooded areas near my home as well, and I spent many days playing in the woods, climbing trees, playing hide and go seek, building forts of natural materials, etc. I attended a week-long **marine biology camp** at the University of Southern Mississippi Gulf Coast Campus when I was 13 and also attended a vision quest program in a terrestrial nature setting at La Terre Bioregional Center in south Mississippi **when I was 16**. In college, I took as many **field biology courses** as I could to diversify my knowledge of biology and ecology. In **graduate school**, my primary focus was **plant ecology**. Two great biology professors showed me how rewarding the study of biology could be and I realized that somehow it could be a profession for me.

After 5 years of field work on De Soto National Forest while in graduate school, I secured a job as a National Environmental Policy Act Coordinator for the Mississippi Army National Guard. I learned about legal aspects of conservation and protection for state and federal lands during this time. My education, field work, and understanding of environmental protections and processes prepared me for the job as **Ecologist on De Soto National Forest**, a job I have done for over 16 years. In addition to my regular duties, I often work with groups of children and adults, giving field tours and making presentations about ecosystem types, ecosystem management, and ecosystem restoration.

My advice to young people is to **spend quiet time in nature when you can**. Open up and hold space for your own conservation ethic to rise from within and be realized. Use that passion to fuel the journey toward reaching your goals.

Scott Wiggers – US Fish and Wildlife Service Botanist

I grew up around water, spent a lot of time fishing with my grandfather, and have been interested in science and conservation for as long as I can remember. I went to **college** intending to study freshwater and fish, but quickly became interested in plants when I took an **introductory botany course** taught by a professor who had an infectious passion for wetlands and fire ecology. I caught the plant bug and took most of the plant courses my college offered, while also taking a wide variety of related courses in **geology, chemistry, environmental science, math, and statistics**.

After college, **I wasn't 100% sure what I wanted to do**, so spent several years bouncing around the country working internships through the Student Conservation Association and other entry-level work. During this time, I gained experience in vegetation monitoring, prescribed fire and fire ecology, public outreach, outdoor environmental education, invasive species control, air quality monitoring, geographic information systems (GIS), and scientific research, among other things. I then went to **graduate school** and studied **fire ecology and plants** in the longleaf pine ecosystem. After grad school, I worked for a land trust and helped private land owners protect and conserve their land before starting with the **U.S. Fish and Wildlife Service as a botanist**. I'm now able to help conserve plants in Mississippi and throughout the Southeast, by working with a wide variety of partners and collaborators, while putting to use my knowledge of plants and their habitats, science, and policy.

Glossary

anthropogenic	influenced, caused by humans
biodiversity	amount of different species of organisms in a specific area
canopy	the highest part of a forest characterized by treetops or crowns
climax stage	the last stage of ecological succession when all populations are balanced
control sites	areas that have had no influence from variables being tested in a study
diameter at breast height (DBH)	a method of measuring the diameter of a tree. In CHANGES, we're using 4 ½ feet above the ground as our DBH.
dormant season fire	a fire occurring between the first frost, usually in late fall, and the last frost, usually in early spring, of the year
drift fences	long continuous barriers lined with traps used to collect animals for research
ecosystem service	a benefit that humans get from a functioning ecosystem
endemic species	species that exist nowhere else on the planet
ephemeral ponds	standing pools of water that remain in a savanna for a majority of the year
fragmentation	separating an area into smaller areas
germination	the sprouting of a seed or similar structure after being dormant for a period of time
ground cover	vegetation layer under the shrub layer,. Also called herbaceous layer. Usually grasses, forbs, and other nonwoody plants
growing season fire	a fire occurring between the last frost, usually in early May, and the first frost, usually late fall, of the year
habitat restoration	replacing or augmenting missing or damaged natural processes, while using the least amount of manipulation to achieve a maximum benefit to wildlife or ecosystem health and function through active human intervention and action
herbarium	collection of preserved plant specimens used for scientific study
herpetofauna	reptiles and amphibians
hydric soil	soil that is saturated with water for some part of the year. This results in anaerobic conditions.
intermediate sites	In CHANGES, they are sites where some management has been done.
invasive species	organisms that have established a sustainable breeding population in a foreign habitat. These species are able to outcompete or displace native species.
longleaf pine	(*Pinus palustris*) a long-lived pine species that is fire dependent and resistant
management	approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation.
minnow traps	a mesh trap normally used to catch small fish. Herpetologists frequently use these to catch aquatic herpetofauna.
monitoring	processes and activities that take place to assess environmental conditions and ecosystem health by helping scientists establish current status and determine environmental trends. It is used to inform management.

no management sites	In CHANGES, they are sites where no management has taken place to help conserve the natural resources
pine savanna	a grassland ecosystem endemic to the southeastern United States. These diverse ecosystems are characterized by a thick understory dominated by grasses and a sparse canopy consisting of pine, usually longleaf.
pristine sites	In CHANGES, they are our model sites, where longleaf pine savannas are open and grassy, with no invasive species
stand density index (SDI)	Stand density index (SDI) is a direct measure of the crowding of trees in a stand
succession	natural process by which the structure of an ecosystem changes over time, typically beginning with a disturbance
suppression	the act of stopping something from happening
turpentine	a flammable solvent derived from tree resin. It was a valuable product in the early 1900s.
understory	plants growing under the canopy but above the forest floor
water table	A water table describes the boundary between water-saturated ground and unsaturated ground.
wiregrass	(*Aristida stricta*) a dominant grass in the pine savanna ecosystem. It is highly flammable and helps spread fires in pine savannas.

Other words you may not have known and needed to define:

Species Reference Pages

Red-tailed Hawk (*Buteo jamaicensis*)

The red-tailed hawk is the most common hawk in North America. This is attributed to the bird's ability to occupy a wide range of habitats from grasslands and forests to deserts and urban areas. The red-tailed hawk can weigh as much as three pounds with a wingspan of 4 feet. It is considered the second largest hawk of the genus *Buteo* in North America. They are usually dark brown on their dorsal side with a pale, streaked belly. Their tail feathers are lightly colored below and cinnamon-red above, promoting the bird's namesake.

Figure 14. https://www.allaboutbirds.org/guide/Red-tailed_Hawk/id

Oak Toad (*Anaxyrus quercicus*)

The oak toad is the smallest toad in North America, growing to only about 4.45 cm (1.75 inches). They can be easily identified by the light stripe that runs down the middle of their backs (mid-dorsal stripe). The male can be distinguished from the female by its clear, white belly and a slightly distended, loose flap of skin beneath the mouth (vocal sac). The female has a dark-spotted belly and lacks a vocal sac. Their call is said to resemble "peeping of baby chicks." After warm, heavy rains they can be heard from April to October. Unlike most other toads, they are quite active during the day. This toad favors open-canopied pine flatwoods with grassy ground cover.

Figure 15. srelherp.uga.edu/anurans/bufque.htm

Eastern Glass Lizard (*Ophisarus ventralis*)

The eastern glass lizard closely resembles a snake at first glance, but there are some major differences. The glass lizards, like most other lizards (suborder Lacertilia), have external ear openings, immobile jaws, and moveable eyelids. Snakes lack these features. Glass lizards get their names from a strategy they use to distract predators. Glass lizards will drop-off the end of their tail, which still moves once separated, to keep predators busy while they escape. This tail piece is easily broken, like "glass", into smaller pieces.

Figure 16. srelherp.uga.edu/lizards/ophven.htm

Henslow's Sparrow (*Ammodramus henslowii*)

The Henslow's Sparrow has been known to be difficult to identify while flying, so we observe its behavior to help. These sparrows will fly low to the ground, only for a few meters, then drop to the ground using the grass or weeds for cover. The pine savannas along the Gulf Coast are where about 95% of the species winter and we have been spotting these birds in our savannas in early February.

Figure 17. www.allaboutbirds.org/guide/Henslows_Sparrow/maps-range

Fox Squirrel (*Sciurius niger*)

The fox squirrel is a large rodent found on the Reserve. These differ from gray squirrels in that they're multicolored with reddish/rust fur and black and white faces. These animals prefer habitats with dispersed trees and moderately undeveloped understory. Meaning, this is another species that depends on fire to keep these open woodlands an appropriate place to live. Weird fact: they accrue a chemical in their teeth, bones, and tissues making their skeletons pink!

Figure 18. www.iucnredlist.org/species/20016/115155257

Gulf Fritillary Butterfly (*Agraulis vanillae*)

The gulf fritillary butterfly is a beautiful inhabitant of the southern US. They are bright orange with black streaks with the females having wings that are darker orange with more streaks than the males. In addition to color, the females tend to be larger than males. At a quick glance, they could be mistaken for monarch butterflies, except gulf fritillary butterflies have silvery spots whereas monarch butterflies look like they've been outlined with a thick black marker.

Figure 19. www.butterfliesandmoths.org/species/Agraulis-vanillae

Orange Candyroot (*Polygala lutea*)

Orange candyroot, or orange milkwort, is a common sight at Grand Bay NERR from April to October. This beautiful wildflower can be found in the pine savannas and boggy areas. It can grow to be 31 cm (12 in) tall but is usually found at around 15 cm (6 in) tall. The plant itself can be chewed or made into tea. It has a sweet taste from which its name originates. This species is a great candidate for drying by a plant press.

Figure 20. plants.usda.gov/core/profile?symbol=POLU

Narrow-leafed Barbara's Button (*Marshallia graminifolia*)

This beautiful wildflower is known as narrow-leaf Barbara's button. The pink and lavender flower can be found in wet pine savannas and pitcher plant bogs from early July to September. This plant will grow between 46 - 61 cm (18-24 in) tall. It is usually a species of concern in Mississippi.

Figure 21. plants.usda.gov/core/profile?symbol=MAGRC2

Savanna meadowbeauty (*Rhexia alifanus*)

The savanna meadowbeauty is dependent on wet soil and fire. They can grow up to 4 feet tall. Members of the *Rhexia* genus have urn-shaped seed pods, or hypanthium. *R. alifanus* is distinguished from other species in its genus by its deep purplish color and spiky, or glandular, seed pods. Flowering begins in May and lasts until September. This is a difficult species to preserve by pressing because it is rather frail.

Figure 22. plants.usda.gov/core/profile?symbol=RHAL4

Longleaf Pine (*Pinus palustris*)

The longleaf pine tree can grow to be 36.5 m (120 ft) tall, 0.9 m (3 ft) in diameter, and over 500 years old. During the tree's life-cycle, there are distinct growth stages: the seedling stage, grass stage, candlestick or bottlebrush stage, sapling stage, and mature stage.

During the grass stage (1-7 years), the tree begins to grow an extensive root system. Once the diameter reaches 1 inch, the tree begins to grow upward into the bottlebrush or candlestick stage (1-3 years).

During this stage the young longleaf shoots up quickly to secure a good position to absorb sunlight and elevate its growing tip above potential fires. During the next several years as a sapling, the longleaf grows lateral branches and its bark thickens. The tree will be mature after around 30 years when it begins to produce cones with fertile seeds.

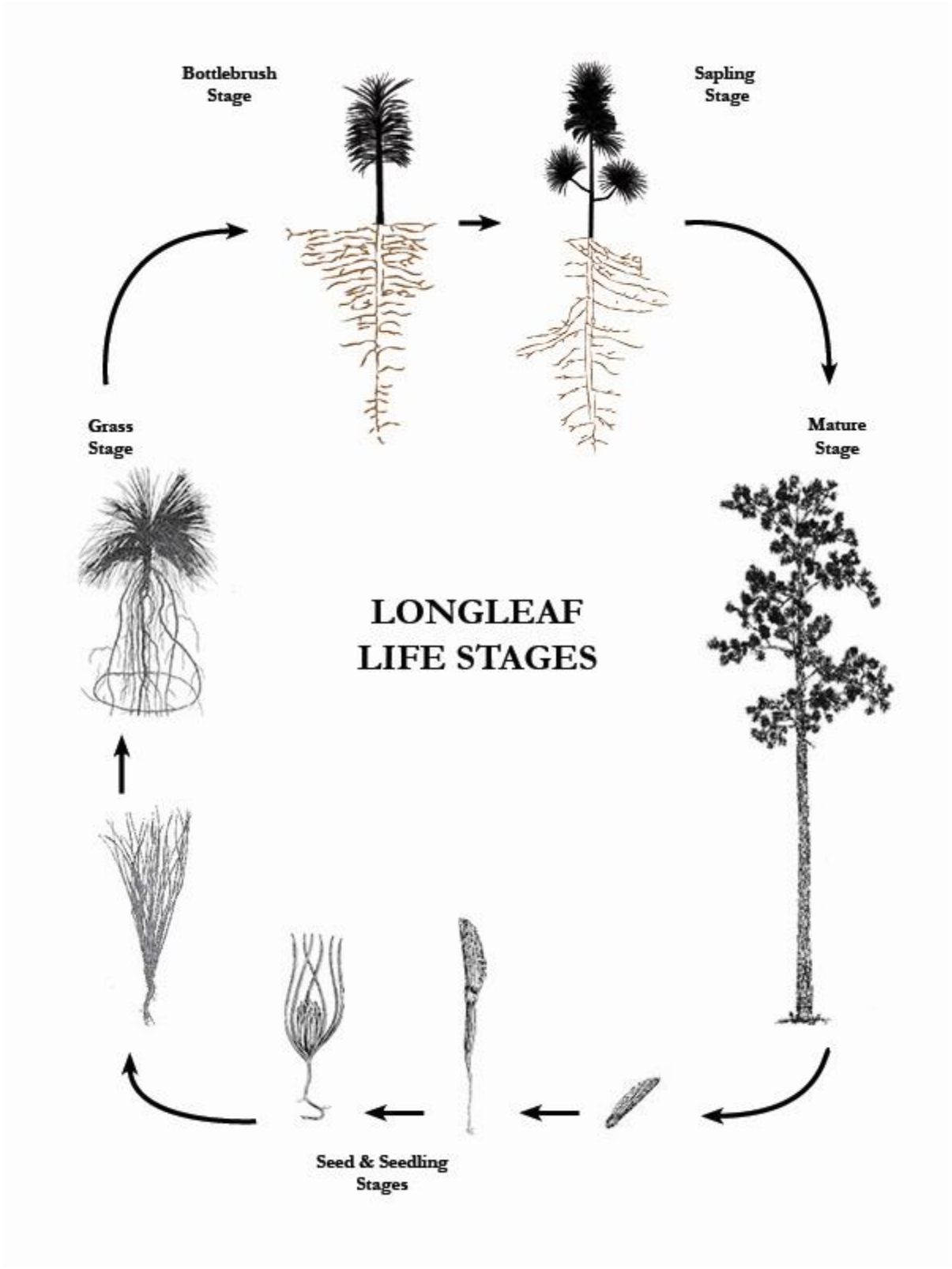


Figure 23. www.longleafalliance.org/what-is-longleaf/the-tree/life-stages

Longleaf Pine Fire Adaptations:

- Natural wildfire selects for this species by killing other trees, leading to open longleaf pine forests.
- A clean seed bed is needed to germinate
- In the grass stage, the embedded terminal bud is protected by long needles
- After a fire, the young pine shoots up from grass stage to bottlebrush (or candlestick) stage to be elevated above flame height for next growing stages.
- Adult longleaf stands aren't as susceptible to fire reaching the crowns because they aren't surrounded by ladder fuels (i.e., fire helps to "prune" the low limbs and they don't regenerate well in close proximity to each other).
- Longleaf pines are able to withstand fire thanks to thick outer bark to protect the inner tree.
- Adult trees also produce needles that fall and became a perfect fuel for surface fires.

Field Journaling:

Name:		Date:		Time In:	Time Out:
State:	County:	City:	Specific Location:		
Coordinates:					
Weather:					Temp:
Observations:					
Notes:					

Field Journaling:

Name:		Date:	Time In:	Time Out:
State:	County:	City:	Specific Location:	
Coordinates:				
Weather:				Temp:
Observations:				
Notes:				

Field Journaling:

Name:		Date:		Time In:	Time Out:
State:	County:	City:	Specific Location:		
Coordinates:					
Weather:					Temp:
Observations:					
Notes:					

Field Journaling:

Name:		Date:	Time In:	Time Out:
State:	County:	City:	Specific Location:	
Coordinates:				
Weather:				Temp:
Observations:				
Notes:				

Herbarium

An **herbarium** is a collection of preserved plant specimens used for scientific study. The plants are usually pressed and then dried for several days. The oldest herbarium dates back to Italy in the 1500s. Today, herbariums are kept to preserve a record of the types of plants in an area. While you're outside and in the field, observe some plants that you might like for starting your own herbarium.

The simplest way to press plants is by using a book. At Grand Bay NERR, we also have plant presses your class can use, and we can bring the completely pressed plants back to your classroom on the last day of the program, with your teacher's permission.

In the meantime, you can also use the herbarium pages in this notebook to start collecting and describing plant species.

Figure 24. Here is an example of plants from Grand Bay NERR before (left) and after (right) they were pressed for about a week in April 2018. Photos by: Sandra Huynh

After pressing plants, you want to attach your plants to archival, acid-free paper and label each page with the species' common name and scientific name. It also helps to write down when and where you obtained your specimen.

Press and display your own plant species on the next few pages.

Common name: _____

Scientific name: _____

Location: _____

Date: _____

Common name: _____

Scientific name: _____

Location: _____

Date: _____

Common name: _____

Scientific name: _____

Location: _____

Date: _____

Notes Pages

Notes Pages