



Fire and the BWCA:

A No Boundaries to the Boundaries Waters Case Study

*Boundary Waters case studies are a 3-lesson series where students explore the ecology of the Boundary Waters before conducting their own research. In this case study, students investigate the question: **Should controlled burns be used as a management tool in the BWCA?***

Students address this question through 3 lessons:

- 1. Research the role of fire in secondary succession and discover how controlled burns have been used historically*
- 2. Collect data to compare and contrast biodiversity in areas before and after a controlled burn,*
- 3. Use the results of their investigation and case study to create a fire management plan for the Boundary Waters.*

Case Study Overview	
Investigation Question: Should controlled burns be used as a management tool in the Boundary Waters?	
MN State Standards	9L.4.2.2.1 Obtain and communicate information about how Minnesota American Indian Tribes and communities and other cultures construct solutions to mitigate threats to biodiversity.* (P: 8, CC: 7, CI: LS2, ETS1) 9L.4.1.1.3 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (P: 7, CC: 2, CI: LS4) 9L.2.2.1.1 Use a computational model to support or revise an evidence-based explanation for factors that have ecological and economic impacts on different sized ecosystems, including factors caused by the practices of various human groups.** (P: 5, CC: 3, CI: LS2)
NGSS Standards	HS-LS2-2; HS-LS2-6; HS-LS2-7; HS-LS4-5
Objectives	- I can explain how prescribed burns influence forest succession and biodiversity in BWCA - I can analyze historical and cultural fire management practices, including those of Native American Tribes, to understand different approaches to ecosystem stewardship. - I can collect and interpret ecological data to identify how fire impacts species diversity and population trends over time. - I can analyze and discuss the role of fire in ecological succession and relate it to habitat regeneration and nutrient cycling
Key Vocabulary	Ecological Succession, Prescribed Burn, Disturbance, Resilience, Ecosystem, serotiny, adaptation, selective pressure
Lesson Snapshots	
Lesson 1: BWCA Succession and Controlled Burns	Students are introduced to the Boundary Waters, and learn about ecological succession. Students explore how controlled burns have been used in Minnesota and their cultural significance to indigenous communities. This lesson includes a mixture of small group activities, reading, and discussion.
Lesson 2: Field Experience	Students simulate a quadrat survey using mock-data from a site in the Superior Forest outside of the Boundary Waters. Students will use their results to write a formal lab report. This lesson includes an extension opportunity for students to conduct a real quadrat survey in their communities with their teacher or with support from a Friends of the Boundary Waters staff member.
Lesson 3: Data Analysis and Extension	Students analyze transect data in a data dig discussion. They then explore a case-study example of how this data is being used in land management practices outside of the Boundary Waters. Students learn about how the National Park Service and Indigenous communities are collaborating to create modern fire management plans. This lesson ends with students creating their own fire management proposal for the Boundary Waters.



Lesson #1: Introduction to BWCA Fire Ecology

Essential Question: What is the role of fire in the BWCA ecosystem succession and biodiversity?

Lesson Objectives

- I can explain the effect of prescribed burns on ecological succession and biodiversity in the BWCA.
- I can analyze historical and cultural fire management practices, including those of Native American Tribes, to understand different approaches to ecosystem stewardship.

MN State Standards

- 9L.4.2.2.1 Obtain and communicate information about how Minnesota American Indian Tribes and communities and other cultures construct solutions to mitigate threats to biodiversity.* (P: 8, CC: 7, CI: LS2, ETS1)
- 9L.4.1.1.3 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (P: 7, CC: 2, CI: LS4)

NGSS Standards

- HS-LS2-2

Key Vocabulary

Ecological Succession, Secondary Succession, Resilience, Ecosystem, Prescribed Burn, Cultural Burn, Disturbance

Lesson Materials and Resources

- [Lesson Slides](#)
- [Succession Photo Deck](#)
- [Student Handouts](#)
- [Fire and the BWCA Reading](#)
- Supplementary Resources:
 - [Your First Boundary Waters Trip Video](#)
 - [DNR History and Use of Prescribed Burns](#)
 - [\(Un\)Natural Selection: Rekindling Wilderness Podcast](#)
 - [Indigenous Fire Practices Shape our Land, NPS Article](#)
 - [Paddles and Pines LiveStream 4: Fire and Water](#)

Learning Activities/Sequence

Warm-up Question: *What do you notice about these photos? What might be happening*

As students enter the class they are informed that we will be starting a new unit on Fire Ecology and the BWCA. Show students the slide deck with photos of the BWCA before, during, and after a prescribed burn. Students record observations about the landscape and brainstorm a list of questions.

Whole-Group Discussion and Lesson Overview:

1. After students have brainstormed and reflected on the warm-up, have them share their ideas. Ask students to consider:
 - a. What changes do they notice in the ecosystem before and after the fire?
 - b. How might this ecosystem continue to change?
2. Introduce students to the guiding question of this investigation: *What is the role of fire in BWCA ecosystem health?* Then, review the agenda for the day.
3. Have students share what they already know about the Boundary Waters.



4. Introduce students to the Boundary Waters, show a map of the area. Provide the definition of a wilderness area. Optional: show students an [introductory video clip](#) to provide a stronger understanding/background of the Boundary Waters.
5. Provide students with an overview of the Boundary Waters ecosystem. This area is primarily boreal (coniferous) forest. Emphasize that these environments have nutrient-poor soils and are dominated by conifers.
6. Students are introduced to the idea of succession. You can inform students that in the Boundary Waters fire is a key element in driving ecological succession, in this investigation they'll explore how fire affects succession and what role humans play in that. Before they do that, they'll first explore what succession is.
7. Students transition to small group work

Small Group Work: Succession Card Sort Activity

1. Split into small groups of 3-4.
2. Pass out a "succession photo deck" to each group
3. Students work together to sort the cards into the correct order of succession. One deck shows primary succession, the other shows secondary succession.
4. Students then answer the reflection questions and compare and contrast primary/secondary succession
5. Bring the group back together to reflect on the activity. Ask students:
 - a. *What differences do you notice between primary and secondary succession?*
 - b. *What type of event(s) drives (causes) secondary succession?*
 - c. *What type of succession is caused by fire, primary or secondary? How do you know?*
 - d. *How could secondary succession affect an ecosystem?*

Independent Work: Fire and the BWCA Case Study Reading

1. Pass out the "Fire and the BWCA" article to students
2. Students read and annotate the text, before answering comprehension and reflection questions.
3. After reading, have students share out in small groups:
 - a. What is the role of fire in succession?
 - b. How has fire shaped the ecology (species diversity) of the BWCA? What type of species found there are adapted to need fire?
 - c. How has the presence of fire changed over time in the BWCA? What has been the role of humans in this change?

Whole Group: Review/Wrap-up

1. End the lesson by reviewing the big ideas from this lesson.
 - a. Ecosystems change over time through the process of succession
 - b. The BWCA ecosystem has been shaped by secondary succession driven by fire.
 - c. The BWCA has a history of frequent small-scale prescribed burns (by native peoples) as well as fire suppression.
 - d. Currently, government agencies and tribal groups are working together to address the question of how fire can and should be used in the BWCA. In the next lesson, we'll collect data to better understand the impact of fire on ecosystems.



Lesson #2: Field Experience

Essential Question: What is the effect of fire on species distribution in the Boundary Waters?

Lesson Objectives

- I can collect and interpret ecological data to identify how fire impacts species population trends over time.

MN State Standards

- 9L.4.1.1.3 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (P: 7, CC: 2, CI: LS4)
- 9L.2.2.1.1 Use a computational model to support or revise an evidence-based explanation for factors that have ecological and economic impacts on different sized ecosystems, including factors caused by the practices of various human groups.** (P: 5, CC: 3, CI: LS2)

NGSS Standards

- HS-LS2-2, HS-LS4-6

Key Vocabulary

Secondary Succession, Resilience, Ecosystem, Prescribed Burn, Transect, Biodiversity

Lesson Materials and Resources

- [Lesson Slides](#)
- [Transect Investigation](#)
- [Transect Investigation Mock Data](#)
- Supplementary Resources:
 - [How to Conduct a Quadrat Study](#)
 - [The Camp 8 Stand: History and Story](#)
 - [Structural Reconstruction of the Camp 8 Old-Growth Red Pine Stand](#) (information on prescribed burns at Camp 8 Stand)

Learning Activities/Sequence

Warm-up: *The image shows you a tree-cross section. The tree started growing in 1756 and has fire scars from 1802 and 1816 shown. No fire record is seen on the tree after 1909. Based on what you know from our last lesson: why do you think there is no fire damage after 1909? What does this suggest about the land-management history of this forest?*

As students enter the class, remind them that we are looking at the role fire plays in the Boundary Waters Ecosystem. Have students look at the example tree cross section and discuss their answers to the warm-up question in small groups. Bring students back together and have them share their ideas. Remind students that:

- 1) Fire is a driver of secondary succession in the Boundary Waters
- 2) PreColonization there were frequent low-intensity fires were set by indigenous peoples
- 3) Post 1900, government policies prohibited prescribed burns. (*This is why we see no fire record post 1909*)

Whole Group Introduction and Lesson Overview

- 1) After discussing the warm-up question, introduce students to the guiding question for the day: *What is the effect of fire on species distribution in the Boundary Waters?*
- 2) Go over the agenda for the day.
 - a) Review Boundary Waters and Fire Basic Concepts
 - b) Conduct a Mock-Lab:



- i) Write Hypotheses
 - ii) Collect Data
 - iii) Analyze and Graph Data
 - iv) Write a Conclusion
- 3) Review the key concepts from lesson 1:
 - a) Show students the map of the Boundary Waters and review where it is and what constitutes a wilderness area
 - b) Review the major ecosystem of the Boundary Waters (Boreal Forest). Emphasize that these environments have nutrient poor soils and are dominated by conifers
 - c) Redefine succession, and differentiate between primary and secondary succession.
 - d) Remind students that the Boundary Waters ecosystem is largely driven by secondary succession from fire. Discuss some of the effects of fire on ecosystem health. Emphasize that fires have been linked to changes in species composition and diversity and that this is what they'll investigate today.
- 4) Introduce the Investigation and Review the steps of a scientific investigation.
 - a) For this investigation, students will be asking the question "What is the effect of fire on species distribution?" To measure this, they'll compare mock data sets from sites that have experienced controlled burns and sites that have not.
 - b) Remind students that in a full investigation the steps are:
 - i) Observation/Ask a Question
 - ii) Write Hypotheses
 - iii) Data Collect
 - iv) Data Analysis
 - v) Claim
 - vi) Ask new Questions
 - vii) *For this investigation students will start by writing hypotheses.

Independent: Pre-Lab Activity

- 1) Introduce students to the investigation:
 - a) In this activity, they will use mock data to compare 2 sites - one that has experienced a controlled burn and one that has not.
 - b) The data from this investigation is based on a real experiment done in the Camp 8 Stand - an experimental forest managed by the University of Minnesota.
- 2) Pass out the transect investigation to students.
- 3) Students work independently to read the background information and answer the preLab questions.
- 4) Optional: while students work, play the "UMN CFC Camp 8 Wellscape Video." The video has no sound and provides an aerial tour of the sites that the investigation data is based on.

Independent/Small Group: Hypothesis Writing

- 1) After students have completed the pre-lab activity, check for understanding with students. Review:
 - a) The question they'll be investigating: What is the effect of prescribed fire on species distribution?
 - b) How we'll collect data: they will use mock-data based on a real case study to compare the type of plants in a prescribed burn site and a control site.
 - c) Review with students the differences in forest structure that they learned about last class. In the Boundary Waters, we've seen two different forest types emerging:
 - i) Forests with lots of conifers (red pine) and light-dependent understory (blueberry and sweet fern)
 - ii) Forests with more hardwood species (red maple, paper birch) and more shade tolerant



understory (dense hazel).

- 2) Review the definition of a hypothesis with students and review why we write multiple hypotheses.
- 3) Remind students that hypotheses are not guesses, but are possible answers to a question. For this investigation, we'll be looking at how the type and number of species change – their hypotheses should reflect this.
 - a) *Optional:* Have students use the “Fire and BWCA” reading from lesson 1 to help support their hypotheses. Again, remind students that species like blueberries and red pine need an open canopy to grow. In contrast, maple and birch trees do not.
- 4) Have students write hypotheses and support with evidence from the previous day's reading. Sentence stems are provided for additional support:
 - a) H1: Fire will increase the number of blueberry and red pine species because....
 - b) Fire will increase the number of maple and birch species because.....
 - c) Fire will have no effect on species distribution because
- 5) Have students share their hypotheses with small groups before reviewing with the whole class.

Whole Group: Introduction to Data Collection

- 1) For this investigation, students will compare the number and type of species at 2 different locations: prescribed burn site and a control site. They will do this using mock-data.
- 2) Pass out mock data sheets to small groups of students. There are 3 sets (A, B, and C). Choose to either randomly assign groups a data set OR give all students the same data set.
- 3) Pass out one “species ID key” and quadrat square to each small group.
- 4) Once students have their supplies, review the procedure together and then split students into small groups to collect their data.

Small Group: Data Collection

- 1) Once you have reviewed the procedure, split students into their small groups.
- 2) In their small groups, students will:
 - a) Cut out their quadrat square so that it is a hollow frame.
 - b) Randomly lay the square on top of one of their first data sheet (Prescribed Burn Site after 2 years). Squares should be placed randomly, and can be put down in any arrangement.
 - c) Students use the species key to identify any species within (or partially within) their square. They record the number and type of species in the lab data table.
 - d) Students repeat this procedure for each of their 4 data sheets:
 - i) Prescribed Burn after 2 Years
 - ii) Prescribed Burn after 5 Years
 - iii) Control after 2 Years
 - iv) Control after 5 Years
- 3) As students collect their data, circulate between groups to help clarify questions/offer support. *Bar graph.* Encourage students to look for patterns as they collect their data.

Whole Group: Data Analysis Introduction

- 1) After students have finished collecting data, have them share with the class general observations and noticings.
- 2) Introduce students to the analysis step of this investigation. Students will need to:
 - a) Create a graph comparing the number of each species type at the prescribed burn and control sites after 2 and 5 years. Remind students that this will be a *bar graph!* They have been provided a frame for their graph that includes a scale, horizontal axis labels, and a legend/key. They will need to graph their bars and add:
 - i) Title



- ii) Vertical Axis Label
- iii) Color coded legend/key.
- b) Use their graph and data table to answer the analysis questions

Independent Work: Data Analysis and Graphing

- 1) Students work independently to analyze their data and create a bar graph
- 2) Have students check their graphs with a peer to ensure all components are present
- 3) After students have created their graph, have them answer the analysis questions.

Whole Group: Check-in and Conclusion

- 1) After students have created their graphs, discuss the patterns they notice as a class .
- 2) Show students the side-by side photos of the Camp 8 sites that have had prescribed burns and the control site. Use the photos to help facilitate conversation.
- 3) Ask students:
 - a) What patterns did they notice in their data? What species were more common in prescribed burn vs. control sites?
 - b) Looking at the photos: what differences do they notice in the forest floor? (How is that possibly connected to the species they saw in their data-sets?)
 - c) WHY do they think they saw the species distribution they saw at each site?
- 4) After students have shared their ideas, transition and review the process of writing a conclusion using Claim-Evidence-Reasoning (or your preferred conclusion writing format). For Claim-Evidence-Reasoning students will write:
 - a) 1-sentence Claim (answer to their question). Optional sentence stem: Fire (increases/decreases/does not effect) species biodiversity.
 - b) 3-4 sentences of Evidence. This is a description of their experiment and a description of their results.
 - c) 1-2 sentence Reasoning: Explanation for why they saw the pattern. Reasoning should explain the scientific pattern (ex. Species diversity increased with fire because fire provides additional nutrients for soil and increases sunlight allowing for more diverse species to populate an area).

Independent Work: Conclusions

- 1) Students write their conclusions independently using Claim-Evidence-Reasoning format.
- 2) Optional: have students read and revise each other's conclusions.

Whole Group: Review/Wrap-up

- 1) Have students share the results of their investigation with the class, be sure to pay attention to any patterns that emerged from their data.
- 2) End the lesson by reviewing the big ideas from this lesson.
 - e. The BWCA ecosystem has been shaped by secondary succession driven by fire.
 - f. The BWCA has a history of frequent small-scale prescribed burns (by native peoples) as well as fire suppression.
 - g. Fire has an impact on species distribution: areas that experience fire are more likely to have pine as the dominant tree species and light-loving understory plants. Areas without fire have more hard-wood species (like maple and birch) and shade-loving understory plants.



Lesson #3: Data Analysis and Fire Management Proposals

Essential Question: What is the role of controlled burns in the management of a wilderness area?

Lesson Objectives

- I can write a fire management proposal based on biodiversity data and historical/cultural management practices

MN State Standards

- 9L.4.2.2.1 Obtain and communicate information about how Minnesota American Indian Tribes and communities and other cultures construct solutions to mitigate threats to biodiversity.* (P: 8, CC: 7, CI: LS2, ETS1)
- 9L.4.1.1.3 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (P: 7, CC: 2, CI: LS4)
- 9L.2.2.1.1 Use a computational model to support or revise an evidence-based explanation for factors that have ecological and economic impacts on different sized ecosystems, including factors caused by the practices of various human groups.** (P: 5, CC: 3, CI: LS2)

NGSS Standards

- HS-LS2-2, HS-LS2-6

Key Vocabulary

Biodiversity Resilience Traditional Ecological Knowledge Secondary Succession Prescribed Burn

Lesson Materials/Resources

- [Lesson Slides](#)
- [Data Dig Question Guide](#)
- [Oshkigin Spirit of Fire](#) film
- [Stockton Island Case Study](#)
- [BWCA Fire Management Proposal Student Guide](#)
- Supplementary Resources:
 - [Understanding Oshkigin Spirit of Fire \(Panel Discussion\)](#)
 - [Slideshow of Stockton Island Cultural Burn 2017](#)
 - [2025 Superior National Forest Proposed Prescribed Burn Sites](#)
 - [Fire in the BWCA Webinar](#) (information on the effects of climate change on wildfires in the BWCA)
 - [How Fire Use Shaped the BWCA](#) (informative storymap that walks students through BWCA controlled burn history)
 - [Fire, Blueberries, and Treaty Rights Podcast](#)

Learning Activities/Sequence

Warm-up Question: *What are some ways that fire can impact an ecosystem? (Consider how fire might affect plant and animal life, soil health, and other ecosystem functions)*

As students enter the class, remind them that we are looking at the role fire plays in the Boundary Waters Ecosystem. Have students look at the question and write down their ideas before discussing their answers in small groups. Bring students back together and have them share their ideas. Remind students that:

- 1) Fire is a driver of secondary succession in the Boundary Waters
- 2) Fire can change the plant composition in an ecosystem
- 3) Fire can open up a canopy providing more sunlight
- 4) Fire can add nutrients back into the soil allowing for new species to grow.



Whole Group: Data Collection Review

- 1) After discussing the warm-up question, introduce students to the guiding question for the day: What role should prescribed burns play in BWCA management plans?
- 2) Go over the agenda for the day.
 - Review Boundary Waters and Fire Basic Concepts
 - Review the results of their mock-lab
 - Explore a management case study
 - Write their own fire management proposal for the BWCA
- 3) Review the key concepts from lesson 2:
 - a) Show students the map of the Boundary Waters and review where it is and what constitutes a wilderness area
 - b) Review the major ecosystem of the Boundary Waters (Boreal Forest). Emphasize that these environments have nutrient-poor soils and are dominated by conifers
 - c) Redefine succession, and differentiate between primary and secondary succession.
 - d) Remind students that the Boundary Waters ecosystem is largely driven by secondary succession from fire. Discuss some of the effects of fire on ecosystem health. Emphasize that fires have been linked to changes in species composition and diversity and that this is what they'll investigate today.
- 4) Review the investigation from the last class. Review with students:
 - a) The question they investigated: What is the effect of fire on ecosystem biodiversity?
 - b) The methods they used to collect data: selecting of quadrats, counting of plant number and type

Small Group: Data Share out/Data Talk

- 1) Split students into small groups to review the results of their field-experiment.
- 2) Have students look at their graphs/data tables, and discuss the questions in the ["Data Dig"](#) handout
- 3) Students should consider:
 - a) What patterns do they notice in their data? (How does species distribution differ across the different sites?)
 - b) Do sites that have experienced fire have different species than those that didn't?
 - c) Why do they think they saw (or didn't see) differences in their sites?
 - d) How might these results change over time?

Whole Group: Data Discussion and Introduction to Fire Management Plans

- 1) After students have discussed their results in small groups, have them share out their big takeaways with the whole group. Some things to consider with your data:
 - a) Variations in data could result because of:
 - i) Time: In the short term, prescribed burns often result in a decrease in biodiversity, within 10 years they will likely show more biodiversity. Depending on how long after a burn you collected your data you may see varying results.
 - ii) Location/Number of Sites: We looked at a limited data set, we could see different patterns on a larger scale.
 - iii) Other measurements: our data was very simple – we didn't consider the size/height of plants, growth rates of different species, ext.
 - b) Remind students that with this type of field-work, looking at long term patterns might show us differences than in the short-term.
- 2) After discussing the results of the student investigation with the whole class, tell students that today they'll have an opportunity to look at a case study from just outside of the Boundary Waters.



- 3) Show students the “[Oshkigin Spirit of Fire](#)” Video. As they watch, have students write down any wonderings/questions that come up for them. Ask the following:
 - a) How has prescribed fire use changed in the BWCA over time?
 - b) What have been some of the ecological and social consequences of fire suppression?
 - c) What is happening at Stockton Island? Why is this collaboration so unique?
- 4) After watching the video, have students share their ideas/noticings. Then break them into small groups to explore the work being done at Stockton Island more closely.

Small Group OR Independent: Stockton Island Case Study

- 1) Pass out the “Stockton Island Case Study” Handout to students
- 2) Have students work independently to read and annotate the text.
- 3) After reading, have students discuss the reflection questions as a small group.

Whole Group: Introduction to Fire Management Plans

- 1) After students have discussed in small groups, have them share their noticings in the whole group. Ask students:
 - a) What is unique about Stockton Island fire management?
 - b) What are some potential challenges/strengths of using this type of management in the Boundary Waters?
- 2) Introduce students to their task for the day: Create a fire management proposal for the Boundary Waters using support from their field-experiment and the stockton island case study.

Independent: Fire Management Plan

- 1) Pass out the [BWCA Fire Management Proposal Student Guide](#) to students
- 2) Have students read through the example proposal, before they write their own.
- 3) Optional: Have students create fire management plans in small groups OR share and present their individual proposals in small groups.

Whole Group: Wrap-up

- 1) Have students share their ideas for a fire management plan for the Boundary Waters.
- 2) End the lesson by reviewing the big ideas from this lesson series:
 - a) The BWCA ecosystem has been shaped by secondary succession driven by fire
 - b) The BWCA has a history of frequent small-scale prescribed burns (conducted by indigenous peoples) as well as fire suppression
 - c) Fire has an impact on ecological diversity
 - d) Governmental groups are working with indigenous communities to reintroduce prescribed fire into boreal forests, and the Boundary Waters could be a potential site for this type of work.



FRIENDS OF THE
BOUNDARY
WATERS

Warm-up: Look at the two images below, brainstorm:
What do you notice about this landscape? What do you wonder?



These images show the same location before and after a fire: What changes do you notice? How do you expect this ecosystem to continue to change?



2011 (before fire)



April 2012 (after fire)



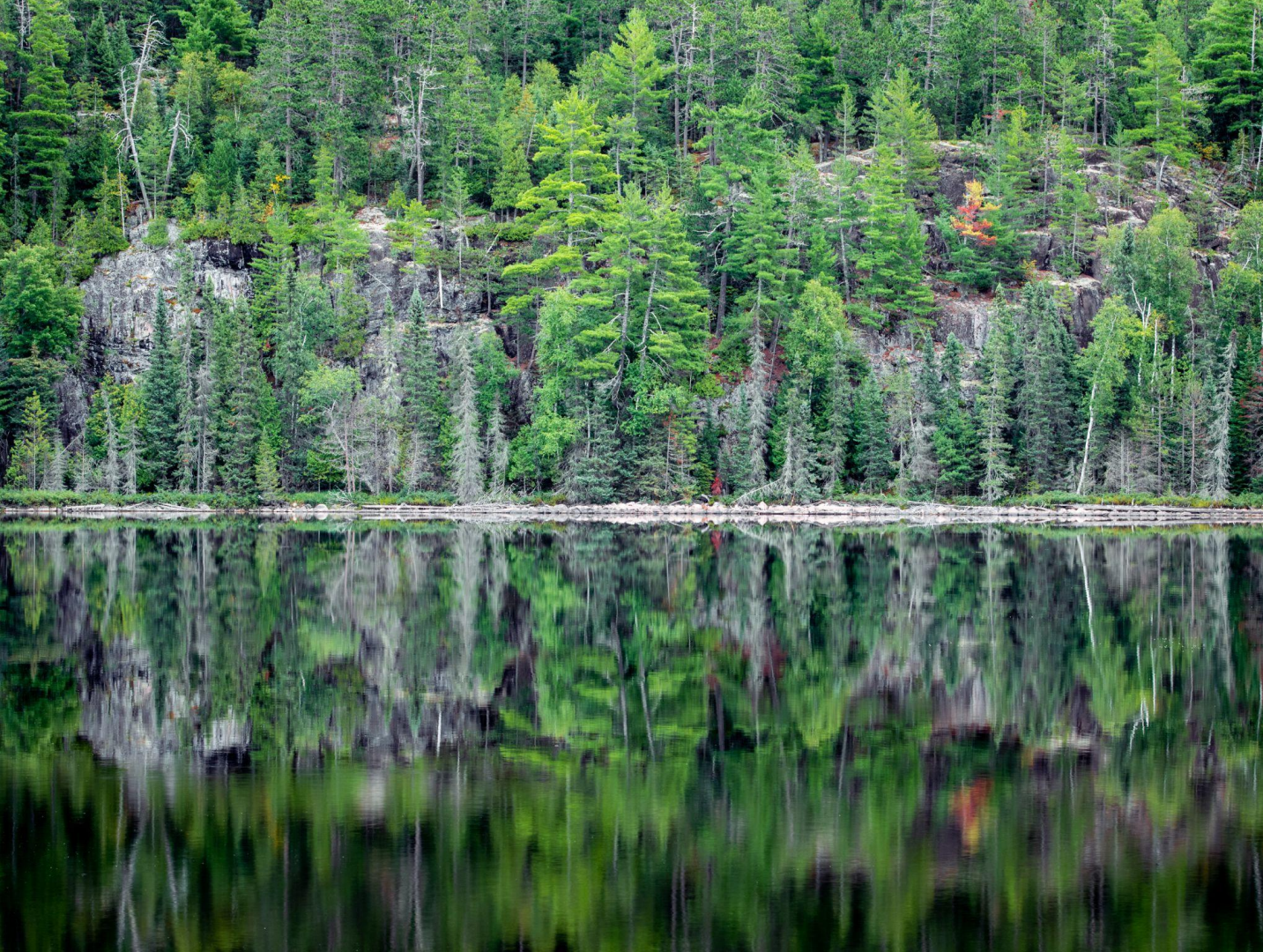
August 2021

The Boundary Waters has a long history of fire, in this lesson we'll explore the question: ***What is the role of fire in Boundary Waters Health?***

Agenda:

- Introduction to the Boundary Waters (BWCA) and BWCA Ecology (Whole Group)
- Succession Card Sort (Small Group)
- Fire and Succession Reading (Independent Work)
- Introduction to Controlled Burn Investigation (Small Group)



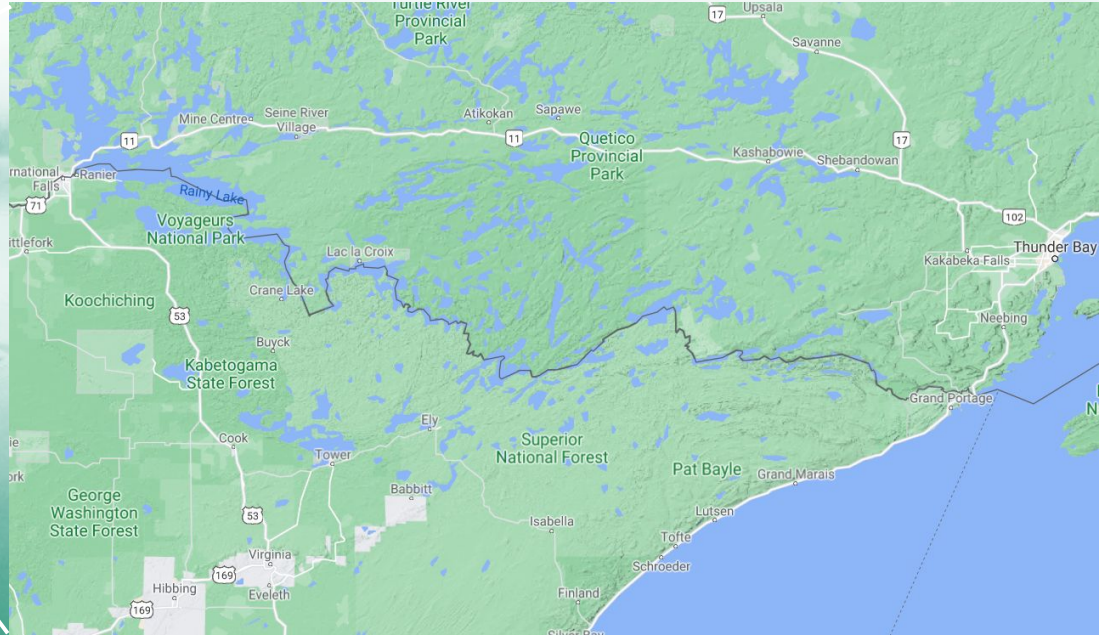
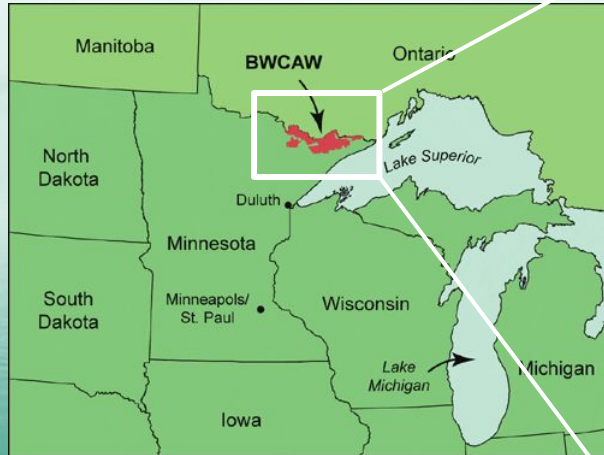


Brainstorm:

What do you
already know
about the
Boundary Waters?
Where is it? What
might you find
there?

The Boundary Waters is the region of wilderness separating Canada from the US between Ontario and Minnesota, west of Lake Superior.

The BWCA is 1.2 million acres, and 20% of it is water!



The BWCA is primarily **Boreal (Coniferous) Forest**

- Short, moist summers, long dry winters
- Temperature Range: -65 - 86F
- Thin, Acidic Soils (nutrient poor)
- Dominated by coniferous trees (spruce, fir, pine, and larch)



The Boundary Waters ecosystem is constantly changing!

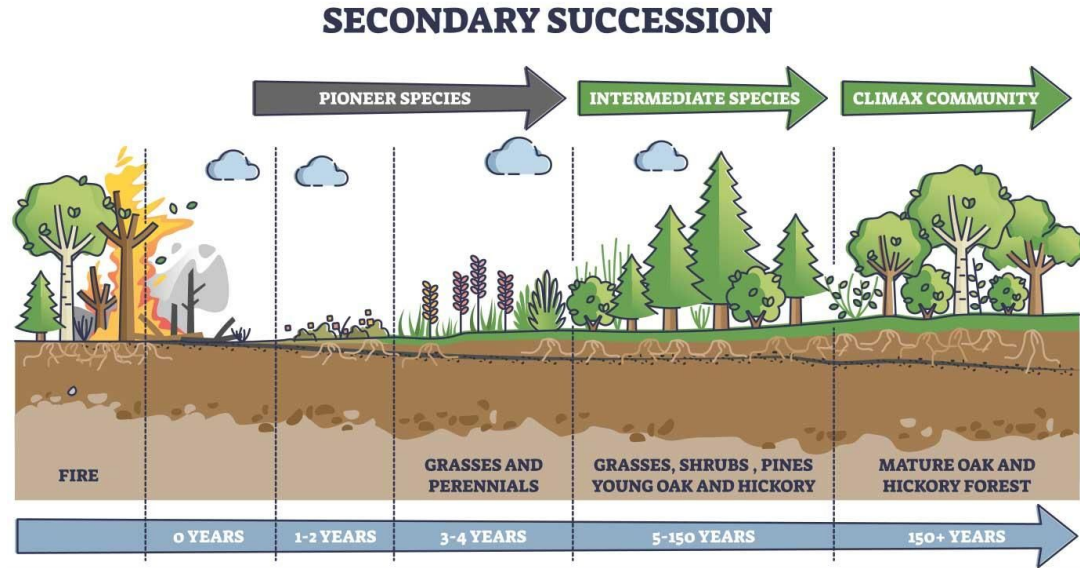
Brainstorm- What can cause ecosystem change?

Succession: a predictable (directional) change in species composition of an area over time. 2 main types:

- 1) Primary Succession
- 2) Secondary Succession

Succession is driven by **disturbance**.
Examples of disturbance:

- Fire
- Windstorms
- Flooding
- Human Activity (logging, urban development)



Explore it: Succession Card Sort

Directions:

- 1) Collect a set of the succession photos for your small group
- 2) Work with your group to sort the cards into the correct order (one set shows you primary succession, the other shows secondary succession)
- 3) Use your photo-deck to answer the reflection questions
- 4) Be ready to share out your observations!

Big Idea: Ecosystems change through a process called **succession**.

2 main types of succession:

- 1) **Primary Succession:** a type of succession where an ecosystem develops on a newly exposed site (place with no existing soil or organic matter)
- 2) **Secondary Succession:** a type of succession in which an ecosystem re-establishes itself after a disturbance

Key Vocabulary:

- *Succession:* process of change in species structure/composition over time
- *Disturbance:* an event that significantly alters (changes) the structure of an ecosystem. Example: fires, flooding, deforestation
- *Resilience:* the ability of an ecosystem to resist and recover from change (disturbance)

Dig-in: Controlled Burns and the BWCA Reading

Succession in the Boundary Waters has historically been driven by **fire**. Tree records show that there have historically been fires every **100 years**, and controlled burns every **5-15** years. Controlled burns have helped to diversify the forests of the BWCA *and* increase resilience of this unique ecosystem! However, there is disagreement about how fire can and should be used in the BWCA.

Directions:

- 1) Collect a copy of the reading
- 2) Read and annotate the article
- 3) Answer the reflection questions



Check-in/Close Out

Big Ideas:

- The Boundary Waters is a region of wilderness in Northern Minnesota protected under the wilderness act. It is 1.2 million acres of freshwater lakes and boreal forest!
- Succession is the process of ecological change
- Fire is a major driver of succession in the BWCA
- Controlled/Prescribed burns have historically been used throughout the BWCA by DNR members and Native communities to maintain ecological diversity and resilience

Next Lesson:

- Explore how fire affects species diversity in the BWCA.
- Examine data from a sample location, and analyze the results.
- Make a fire management recommendation based on species diversity data and local case studies!

PRIMARY SUCCESSION

1) LAND IS EXPOSED

2) PIONEER SPECIES

3) INTERMEDIATE SPECIES

4) CLIMAX COMMUNITY

IN PRIMARY SUCCESSION, NEW BARE ROCK IS EXPOSED. NO PLANT LIFE OR SOIL IS PRESENT. THIS CAN OCCUR AFTER EVENTS SUCH AS LAVA FLOW OR GLACIAL RETREAT.

LICHENS AND OTHER SMALL PLANTS ATTACH TO BARE ROCK AND SLOWLY BEGIN TO GROW, OVER CENTURIES THIS PLANTS BEGIN TO DEVELOP A THIN LAYER OF SOIL

PIONEER SPECIES HELP TO DEVELOP THIN LAYERS OF SOIL, OVER CENTURIES THIS SOIL INCREASE UNTIL GRASSES, PERENNIALS, AND EVENTUALLY SHRUBS AND SMALL TREES BEGIN TO GROW.

SHADE-TOLERANT TREES START TO DOMINATE THE ECOSYSTEM. THE ECOSYSTEM BECOMES MORE DIVERSE AND STABLE. THE DISTRIBUTION OF PLANTS DOES NOT CHANGE MUCH DURING THIS STAGE UNTIL ANOTHER DISTURBANCE OCCURS.

SECONDARY SUCCESSION

1) DISTURBANCE

AN EVENT SUCH AS FIRE, FLOOD, OR HUMAN ACTIVITY REMOVES EXISTING PLANT SPECIES LEAVING BEHIND SOIL. SOMETIMES TRACES OF EXISTING PLANT SPECIES REMAIN

2) PIONEER SPECIES

FAST GROWING SPECIES LIKE GRASS AND SMALL FAST-GROWING TREES (PINES) START TO GROW.

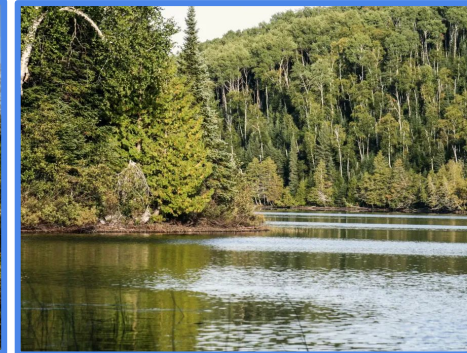
3) INTERMEDIATE SPECIES

PIONEER SPECIES CHANGE THE ENVIRONMENT BY ADDING NUTRIENTS TO THE SOIL, THIS ALLOWS FOR OTHER SPECIES LIKE SHRUBS, SMALL TREES, AND MORE SHADE-INTOLERANT SPECIES TO GROW.

4) CLIMAX COMMUNITY

SHADE-TOLERANT TREES START TO DOMINATE THE ECOSYSTEM. THE ECOSYSTEM BECOMES MORE DIVERSE AND STABLE. THE DISTRIBUTION OF PLANTS DOES NOT CHANGE MUCH DURING THIS STAGE UNTIL ANOTHER DISTURBANCE OCCURS.

Photos for Printing/Sorting



PRIMARY SUCCESSION_ANSWER KEY

1) LAND IS EXPOSED

2) PIONEER SPECIES

3) INTERMEDIATE SPECIES

4) CLIMAX COMMUNITY



IN PRIMARY SUCCESSION, NEW BARE ROCK IS EXPOSED. NO PLANT LIFE OR SOIL IS PRESENT. THIS CAN OCCUR AFTER EVENTS SUCH AS LAVA FLOW OR GLACIAL RETREAT.

LICHENS AND OTHER SMALL PLANTS ATTACH TO BARE ROCK AND SLOWLY BEGIN TO GROW, OVER CENTURIES THIS PLANTS BEGIN TO DEVELOP A THIN LAYER OF SOIL

PIONEER SPECIES HELP TO DEVELOP THIN LAYERS OF SOIL, OVER CENTURIES THIS SOIL INCREASE UNTIL GRASSES, PERENNIALS, AND EVENTUALLY SHRUBS AND SMALL TREES BEGIN TO GROW.

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SECONDARY SUCCESSION_ANSWER KEY

1) DISTURBANCE



AN EVENT SUCH AS FIRE, FLOOD, OR HUMAN ACTIVITY REMOVES EXISTING PLANT SPECIES LEAVING BEHIND SOIL. SOMETIMES TRACES OF EXISTING PLANT SPECIES REMAIN

2) PIONEER SPECIES



FAST GROWING SPECIES LIKE GRASS AND SMALL FAST-GROWING TREES (PINES) START TO GROW.

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4) CLIMAX COMMUNITY



SHADE-TOLERANT TREES START TO DOMINATE THE ECOSYSTEM. THE ECOSYSTEM BECOMES MORE DIVERSE AND STABLE. THE DISTRIBUTION OF PLANTS DOES NOT CHANGE MUCH DURING THIS STAGE UNTIL ANOTHER DISTURBANCE OCCURS.



Fire and the BWCA Lesson 1: Introduction to BWCA Fire Ecology

Student Handouts

Background Information: Ecosystems are constantly changing through a process called succession. This process is driven by a cycle of disturbance and recovery. Events such as fires, floods, and lava flows cause a significant change in the structure of an ecosystem. When this happens, plants will regrow in a predictable pattern. This pattern is called succession. Depending on the type of disturbance either primary or secondary succession will occur.

Activity 1: Succession Sort

Directions:

- 1) Collect a copy of the succession photo deck and the primary/secondary succession graphic organizers.
- 2) Work with a partner or small group to sort the photos onto the corresponding graphic organizers. Photos that show the process of primary succession are outlined in blue. Photos that show the process of secondary succession are outlined in green.
- 3) Check your work against the answer key, then answer the reflection questions.

Key Vocabulary:

- ***Primary Succession:*** a type of succession where an ecosystem develops on a newly exposed site (place with no existing soil or organic matter)
- ***Secondary Succession:*** a type of succession in which an ecosystem re-establishes itself after a disturbance
- ***Disturbance:*** an event that significantly alters (changes) the structure of an ecosystem. Example: fires, flooding, deforestation

Reflection Questions: Answer these questions after finishing the sorting activity

- 1) In your own words, define succession.

- 2) How are primary and secondary succession different? What differences would you look for in a landscape to determine the type of succession occurring?



Activity 2: Controlled Burns and the BWCA

Directions:

- 1) Read the article: [Fire and the BWCA](#)
- 2) Answer the reflection questions below

Reflection Questions:

- 1) What is the Boundary Waters? Why is it significant ecologically and culturally?
- 2) What type of ecosystem is the Boundary Waters? What are the key characteristics of this ecosystem?
- 3) What is the role of fire in ecosystem succession? How has fire shaped the ecology of the Boundary Waters?
- 4) Compare and contrast fire management pre and post colonization. What are the major differences between these time periods? How has this affected the ecology of the Boundary Waters?
- 5) Why is fire management in the Boundary Waters complex? (Consider the role of indigenous communities, legal restrictions of the Wilderness Act, and local communities)



Fire and the Boundary Waters Canoe Area

Introduction

The Boundary Waters Canoe Area is a 1.2 million-acre protected wilderness in northern Minnesota. It is the most visited designated wilderness in the United States, attracting approximately 250,000 visitors each year (U.S. Forest Service, 2021). About 20% of the region is water—primarily interconnected lakes—surrounded by boreal forests. This unique ecosystem supports diverse wildlife, including moose, wolves, and bobcats, as well as iconic flora such as wild blueberries and coniferous trees like red, white, and jack pine. The Boundary Waters was designated as a wilderness area in 1964, primarily to preserve its red pines, however early conservation efforts often overlooked the critical role of fire in maintaining this ecosystem and diversity of species (Heinselman, 1996). In this article, we'll explore the ecology of the Boundary Waters before exploring the role of fire in creating this unique ecosystem.

Ecology of the Boundary Waters

The Boundary Waters lies within the boreal forest biome. It is characterized by long, cold winters, short mild summers, and acidic, nutrient-poor soils. Annual precipitation ranges from 20 to 40 inches, with most falling as snow in winter (Pastor et al., 2000). Dominant tree species include black spruce, northern white cedar, balsam fir, and red pine.

The landscape also features extensive peatlands, bogs, and marshes, which serve as natural water filters. Edible plant species like wild rice, blueberries, cranberries, and sugar maple are abundant. These plants have ecological and cultural importance, particularly to the Anishinaabeg people.

Fire's Ecological Role in the Boundary Waters

Fire has been a critical ecological process in the Boundary Waters for thousands of years. The fire regime—defined by frequency, intensity, and seasonality—has shaped species composition and successional dynamics. Regular low-intensity fires historically cleared the understory, recycled nutrients, increased sunlight penetration, and promoted biodiversity (Heinselman, 1973; Flannigan et al., 2000).

Species such as red pine and blueberries are especially fire-adapted. Red pine, which requires full sun to regenerate, often germinates rapidly after fire. Blueberries also thrive in post-fire environments, where reduced canopy cover and nutrient-rich ash promote growth and fruit production (White, 1983).



Reconstructing Fire History

Researchers have reconstructed fire history in the Boundary Waters using dendrochronology, the study of tree-ring patterns to determine the frequency and intensity of past fires. These studies show that fires occurred every 2–4 years before the 1700s, often as low-intensity surface fires, many of which were intentionally set (Heinselman, 1973; Kipfmüller & Swetnam, 2000).

This evidence, alongside oral histories, points to the significant role of Anishinaabeg fire stewardship. Fires were used to maintain open forest structure, reduce insect populations, improve visibility for hunting, and promote blueberry production (Lake et al., 2017). Fire was not only tolerated but intentionally used to enhance food resources and other ecosystem services.

Colonization and Fire Suppression

With the arrival of European settlers in the 18th century, fire regimes in the Boundary Waters changed dramatically. By the 1900s, federal policies criminalized indigenous burning practices to protect timber resources. Prescribed burning was banned, and fire suppression became the norm (Pyne, 1982).

These changes led to a dramatic increase in fire intervals—from 2–4 years to about 26 years on average (Heinselman, 1973). As a result, fuel loads accumulated, increasing the risk of larger, high-intensity wildfires. Furthermore, the absence of fire led to shifts in forest composition, favoring shade-tolerant hardwoods over red pine, and reducing blueberry abundance and forest biodiversity.

Ecological Consequences of Fire Suppression

Fire exclusion has altered the Boundary Waters ecosystem significantly. Studies show that frequent low-intensity fires enhance plant diversity, reduce invasive species, and promote the regeneration of culturally and ecologically important species like red pine and blueberries (Frelich & Reich, 1995).

Without fire, ecological succession progresses toward hardwood-dominated forests. Fire resets succession, maintaining the open, sunlit conditions that red pine and blueberry require. Additionally, regular fire improves forest resilience against pests and climate change-related stressors (Ryan et al., 2013).

Current Policy and Indigenous-Led Fire Stewardship

Today, the Boundary Waters is managed under the 1964 Wilderness Act, which prohibits most forms of active management—including prescribed burning—within designated wilderness areas (U.S. Congress, 1964). This creates a paradox: the "natural" conditions the wilderness



designation aims to protect were, in fact, the result of intentional indigenous land management practices, particularly fire.

However, efforts to reintroduce cultural burning are growing. In 2017, Damon Panek, in collaboration with the National Park Service, helped reintroduce prescribed fire to the Apostle Islands National Lakeshore. These initiatives aim to restore indigenous-led stewardship and recognize fire as a cultural and ecological necessity (NPS, 2019).

These efforts remain limited to areas outside the Boundary Waters. Yet, the very conditions that conservationists seek to preserve—open red pine forests, abundant blueberries, and diverse understories—were created through indigenous fire management. Reconciling wilderness policy with traditional ecological knowledge (TEK) remains a critical challenge for modern land managers.

Conclusion

The ecology of the Boundary Waters Canoe Area is inseparable from its history of fire—and from the indigenous people who used it as a tool for stewardship. Red pines, blueberries, and forest diversity all depend on frequent, low-intensity fires. As climate change increases the risk of large-scale wildfires, returning to traditional fire regimes may be essential for ecological resilience.

Current wilderness management must grapple with how to incorporate Indigenous fire stewardship into fire policy and land use planning. Doing so offers a path toward more sustainable and just conservation practices that honor both ecological science and ancestral knowledge.

References

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FRIENDS<sup>OF
THE</sup>
BOUNDARY
WATERS

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FRIENDS OF THE
BOUNDARY
WATERS

Warm-up:

This is a cross section from a tree that started growing in 1756. The red arrows in this photo point to peel scars from fires. The tree shows no record of fire after 1909.

Based on what you know from our last lesson: Why do you think there is no fire damage after 1909? What does this tree record suggest about the land-management history of this forest?



Fire is a major driver of succession in the Boundary Waters, in this lesson we'll explore the question:

What is the effect of fire on species distribution in the Boundary Waters?

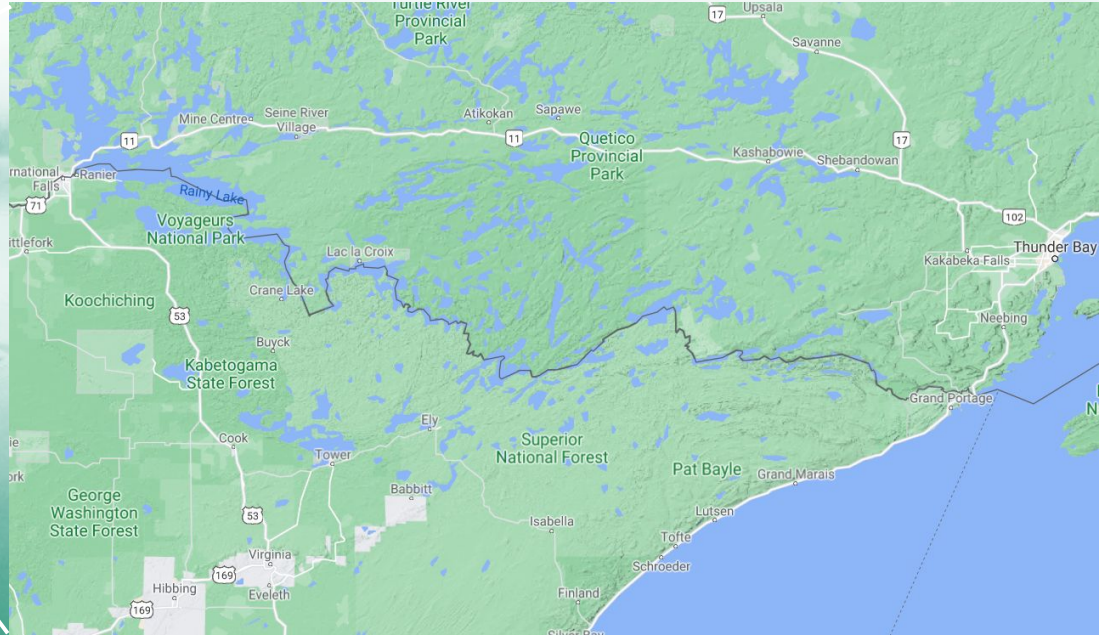
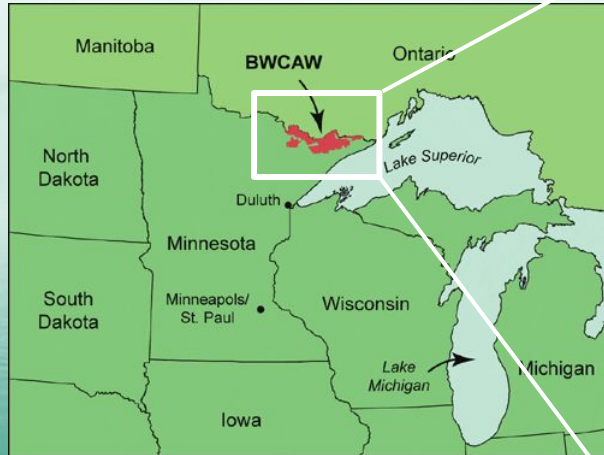
Agenda:

- Boundary Waters and Fire Review
- Mock-Lab:
 - Write Hypotheses
 - Collect Data
 - Analyze and Graph Data
 - Write a conclusion



The Boundary Waters is the region of wilderness separating Canada from the US between Ontario and Minnesota, west of Lake Superior.

The BWCA is 1.2 million acres, and 20% of it is water!



The BWCA is primarily **Boreal (Coniferous) Forest**

- Short, moist summers, long dry winters
- Temperature Range: -65 - 86F
- Thin, Acidic Soils (nutrient poor)
- Dominated by coniferous trees (spruce, fir, pine, and larch)



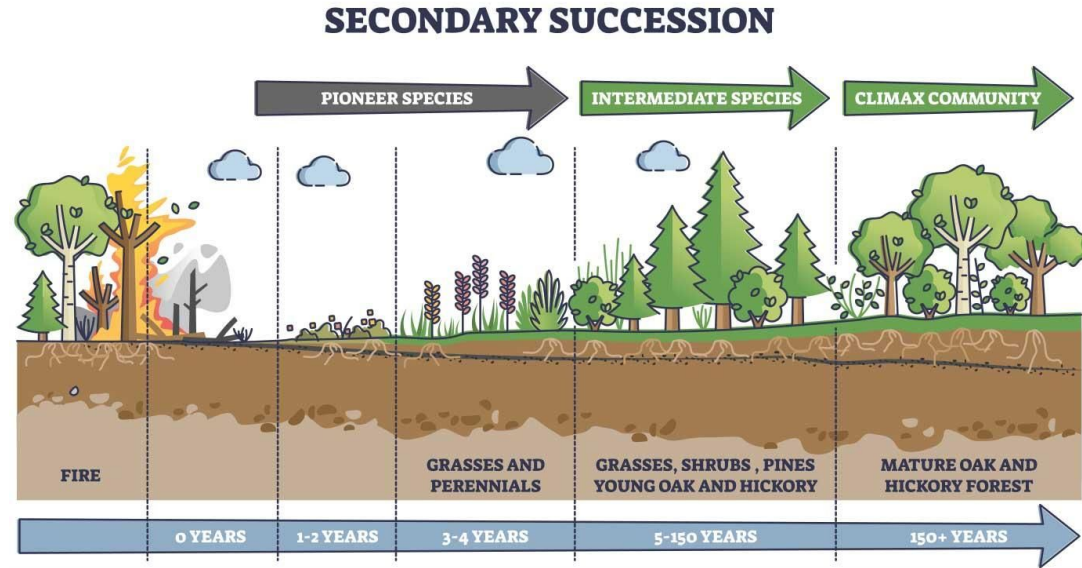
The Boundary Waters ecosystem is constantly changing through the process of **succession**

Succession: a predictable (directional) change in species composition of an area over time. 2 main types:

- 1) Primary Succession
- 2) Secondary Succession

Succession is driven by **disturbance**.
Examples of disturbance:

- Fire
- Windstorms
- Flooding
- Human Activity (logging, urban development)



Succession in the Boundary Waters is driven by **fire**

Succession in the Boundary Waters has historically been driven by **fire**. Tree records show that there have historically been fires every **100 years**, and controlled burns every **5-15 years**. Controlled burns have helped to diversify the forests of the BWCA and increase resilience of this unique ecosystem! However, there is disagreement about how fire can and should be used in the BWCA due to its wilderness status.

Frequent Low-intensity Fires can...

- 1) Clear underbrush and open-up forests providing more light
- 2) Add nutrients into soil
- 3) Increase forest species diversity

In order to make land management plans, scientists need to collect evidence to inform their decisions. Today you'll collect evidence to help create a management proposal!



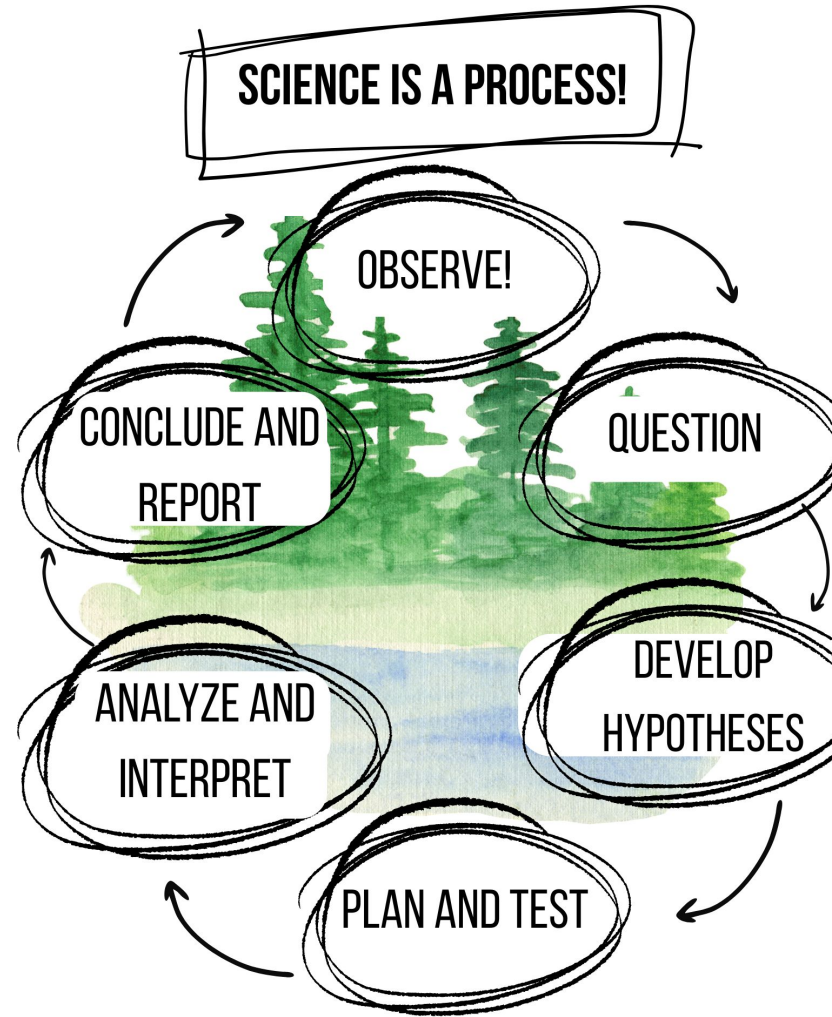
Investigate It: What is the effect of fire on species distribution?

Native communities and the Minnesota DNR (Department of Natural Resources) continuously work together to make recommendations for prescribed burns that help prevent wildfires, honor traditional ecological knowledge, and encourage ecological resilience in the BWCA. To do this they need to collect data ecological data to evaluate the effect of wildfire on species biodiversity.

Your Challenge: Use the process of science to collect and analyze data from a sample site to answer the question: *What is the effect of fire on species distribution?*

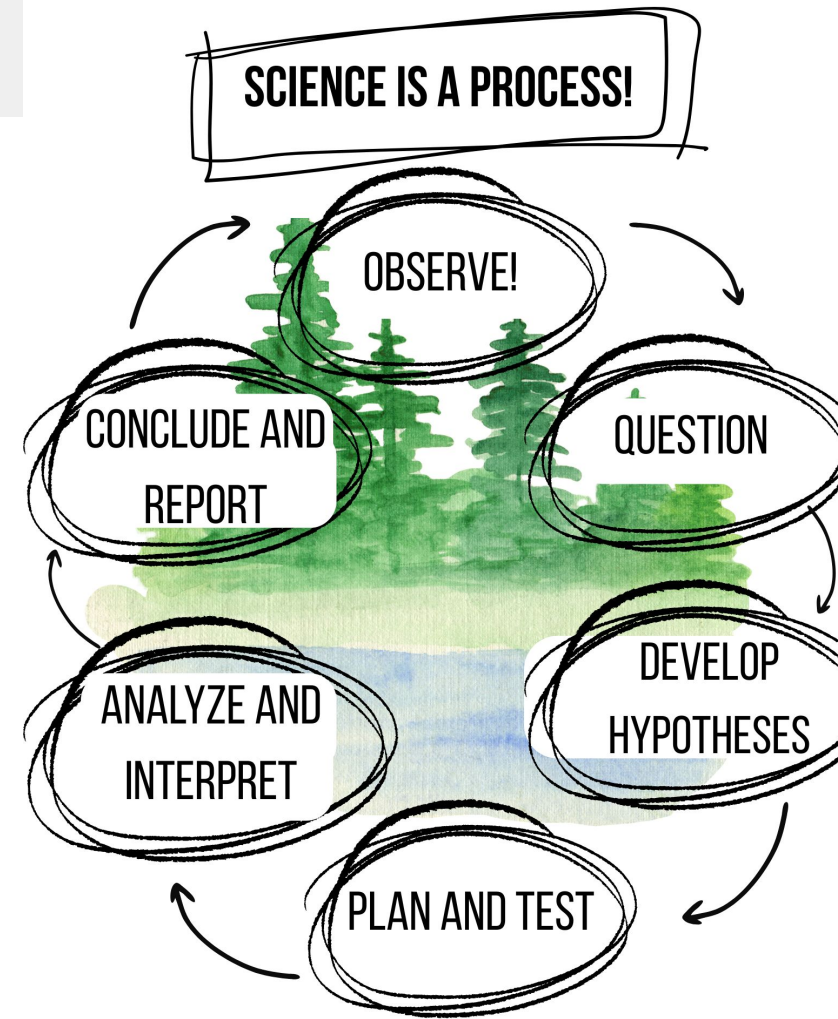
Today you need to:

- 1) Complete the pre-Lab Activity
- 2) Write your hypotheses
- 3) Collect Data from a mock data set
- 4) Analyze your results
- 5) Write a formal conclusion



Step 1: Complete the Pre-Lab

In this investigation you'll conduct a transect survey based on data from the Camp 8 Stand. Before you do that, you need to learn about transects and the Camp-8 stand! Read the background and answer the pre-Lab questions to help you prepare for the investigation.



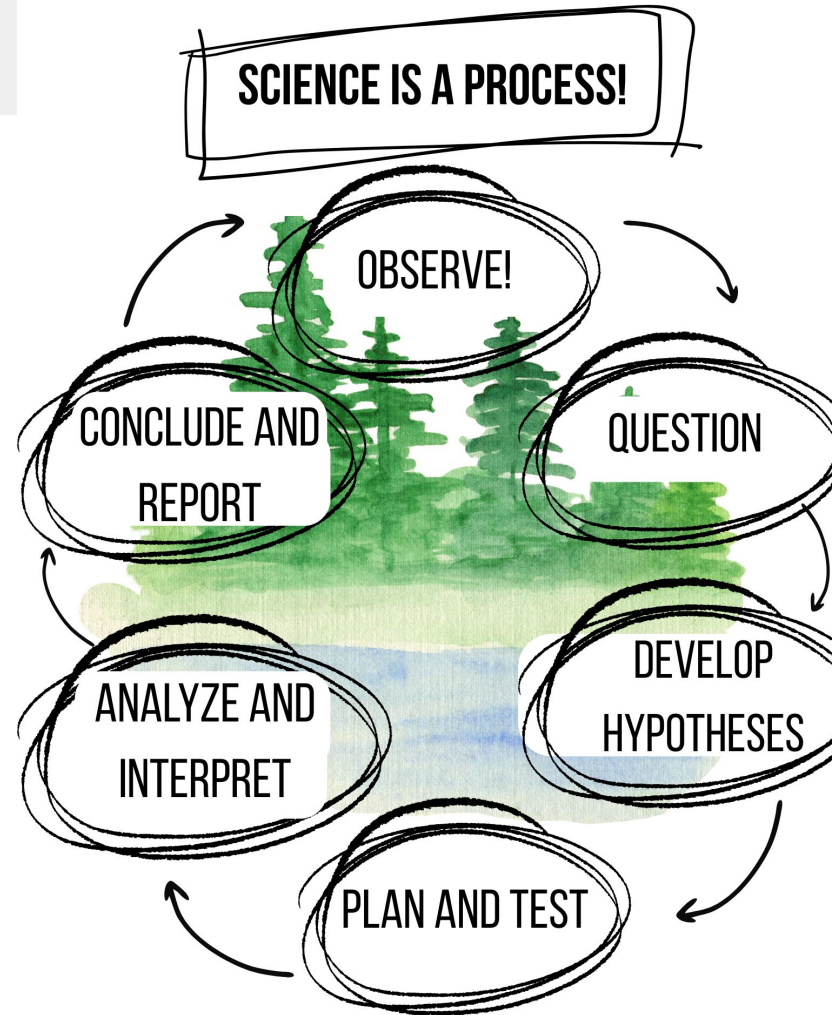
Step 2: Write your Hypotheses

Hypothesis: Possible answer to a scientific question

Why multiple hypotheses? Any experiment we do has more than one possible outcome. By writing multiple hypotheses we are better able to understand our results!

Use the sentence stems to write your hypotheses:

- H1: Fire will increase blueberry and pine growth because
- H2: Fire will increase maple and birch growth because
- HN: Fire will have no effect on species distribution because



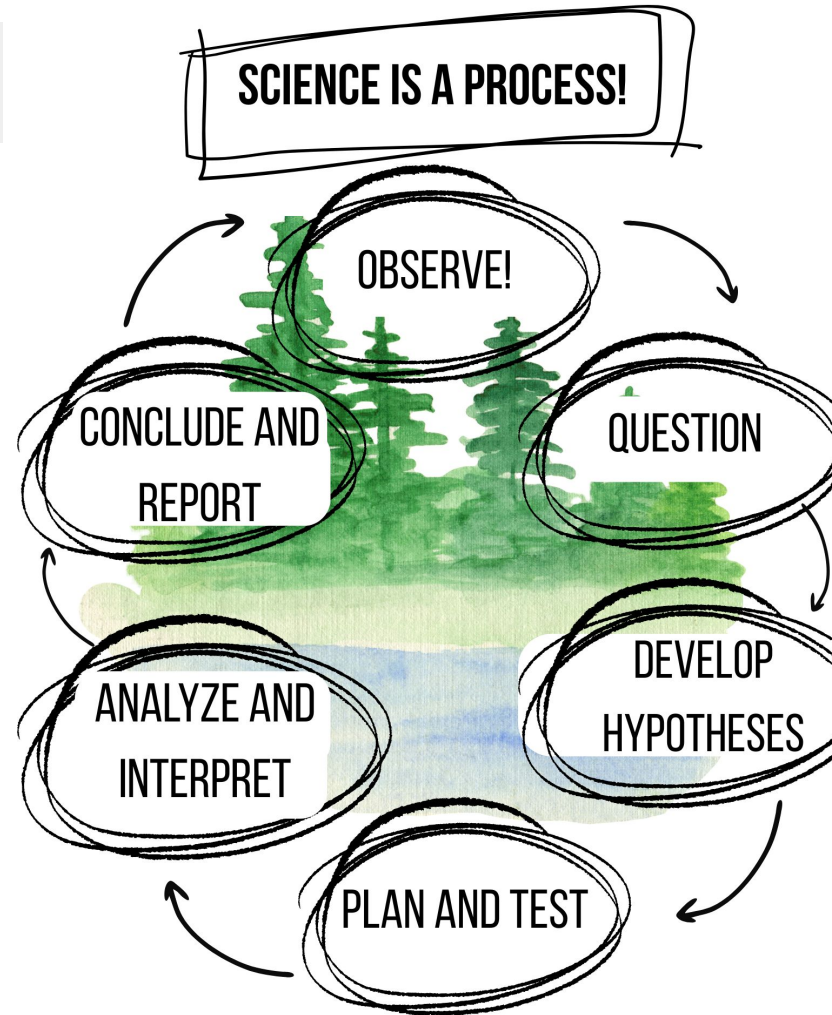
Step 3: Collect your Data

We'll use a quadrat to compare 2 locations. We'll complete 1 quadrat at each of our locations. Each location has data from 2 and 5 years after the initial treatment.

- **Location 1: Prescribed Burn Site.**
 - Scientists conducted a prescribed burn, the data shows you what species were found on the forest floor 2 and 5 years after the burn.
- **Location 2: Control Site**
 - Scientists did not conduct a burn at these sites. The last recorded fire at these sites occurred in 1909. The data shows you what the species distribution was like 2 and 5 years after the prescribed burn site was burned.

Directions:

- 1) Cut out the quadrat square. Be sure to cut out the inside so that it is hollow.
- 2) Randomly lay the square on top of the "Prescribed Burn Site After 2 Years" data sheet.
- 3) Use the species key to identify all of the plants within your quadrat square.
- 4) Record the number and type of plants in the data table below.
- 5) Repeat for each of the sample sites.



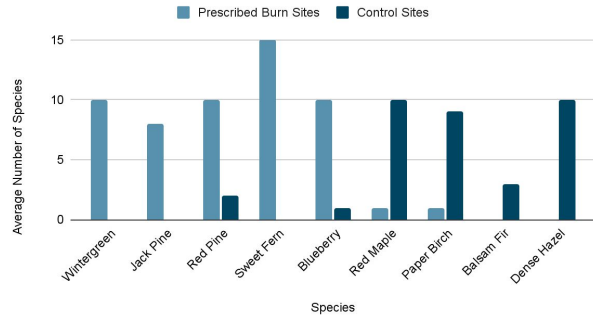
Step 3: Analyze and Graph your Results

To answer our question, we'll compare the number and type of species at the prescribed burn and control sites.

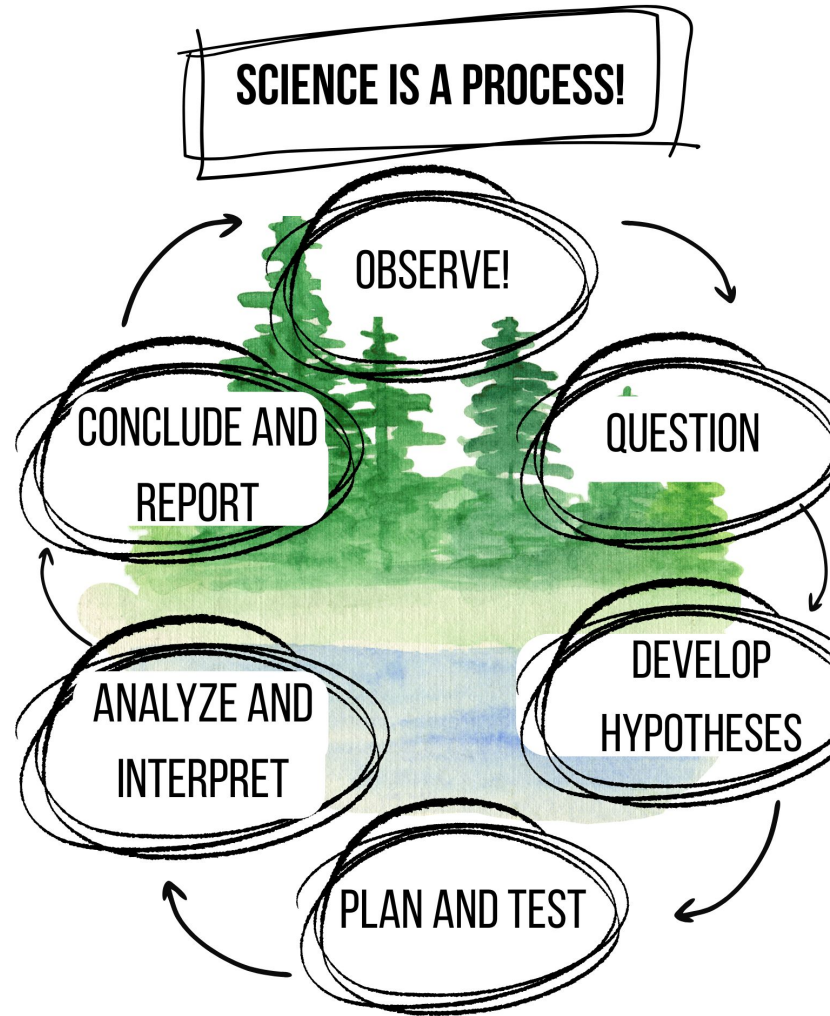
Step 1: Create a *bar graph* comparing the number of each species at controlled and prescribed burn sites. Graphs should include:

- Title
- Scale
- Axis labels!

Species Distribution at Prescribed Burn and Control Sites

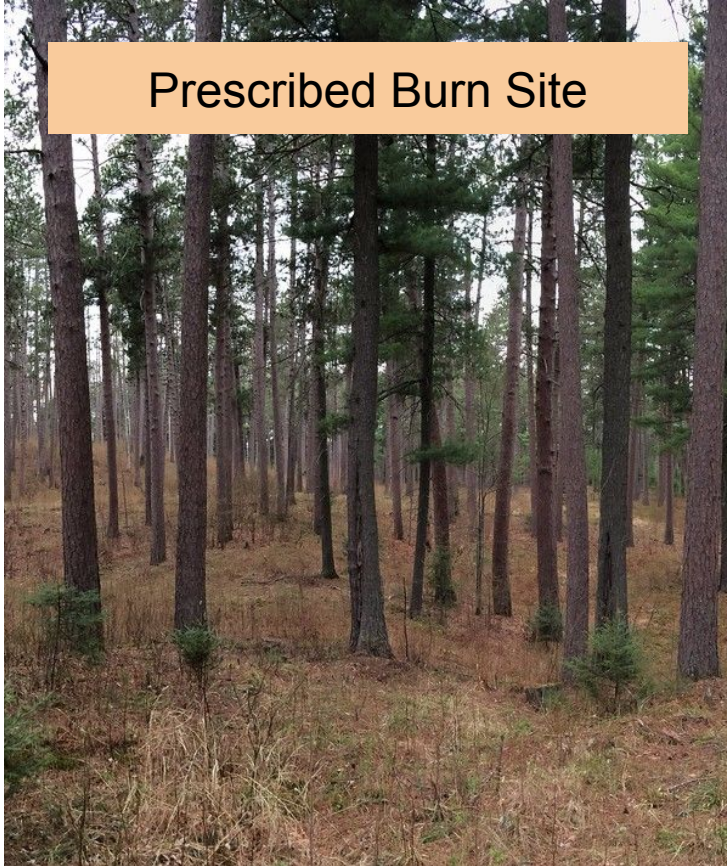


Step 2: Use your graph and your data table to answer the analysis questions.



Check-in: What patterns did you notice in your data? *WHY* do you think these patterns might exist?

Prescribed Burn Site



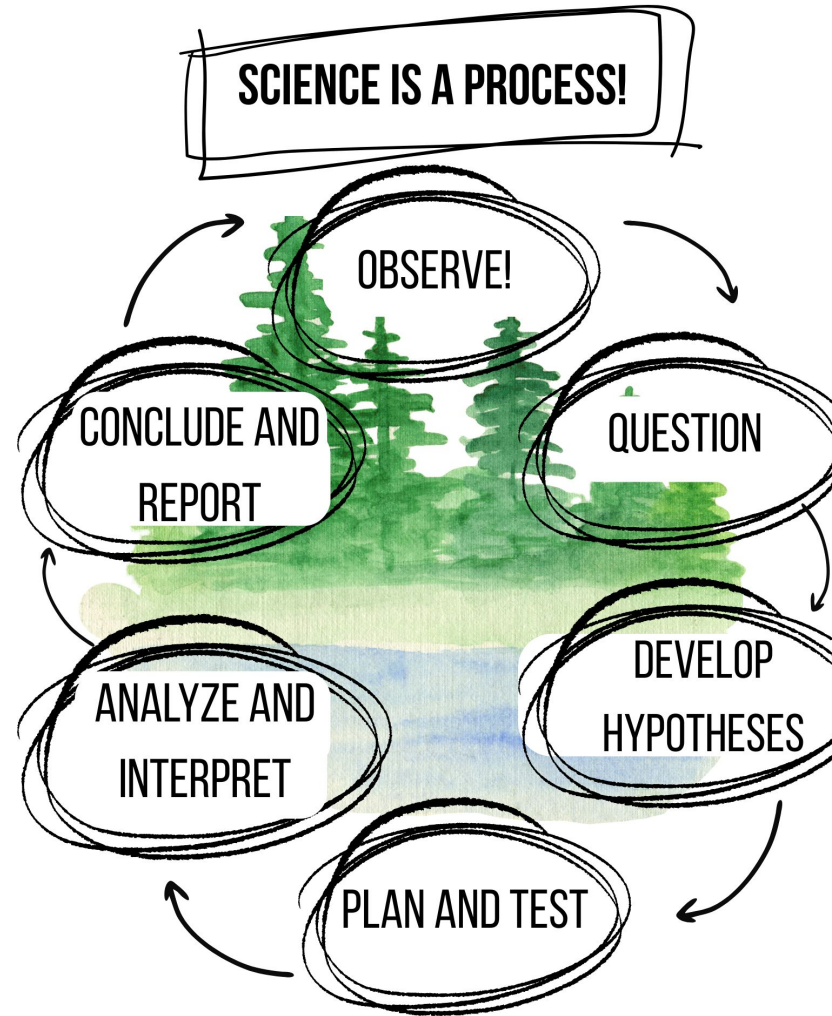
Control Site



Step 4: Write your Conclusion

Look for patterns in your data, use this to write your conclusion using Claim-Evidence-Reasoning format!

- **Claim:** 1 sentence answer to your question:
Fire _____ species distribution.
- **Evidence:** 3-4 sentences that describes your experiment and lists your results.
- **Reasoning:** 1-2 sentences that explains the “why” of your result. This should explain the scientific process that we’re seeing. *Why* does fire have an influence on species distribution?



Check-in/Close Out

Big Ideas:

- The Boundary Waters is a region of wilderness in Northern Minnesota protected under the wilderness act. It is 1.2 million acres of freshwater lakes and boreal forest!
- Succession is the process of ecological change. Fire is a major driver of succession in the BWCA
- Controlled/Prescribed burns have historically been used throughout the BWCA by DNR members and Native communities to maintain ecological diversity and resilience
- Fire affects ecological biodiversity.

Next Steps:

- Evaluate the effect of prescribed burns on ecological species diversity and make a land management recommendation
- Evaluate historical land management plans to refine your recommendation



Fire and BWCA: Transect Investigation

Background Information: Fire has been used throughout northern Minnesota since before colonization. Indigenous peoples set small controlled fires in order to promote the growth of blueberries and clear the forest understory for hunting. However, in the 1900s, government policies prohibited prescribed burns. This policy was put in place to protect timber crops used by the logging industry. Removing prescribed burns from northern Minnesota has changed the plant species that are found throughout this area. To better understand the effects of fire on species diversity, scientists conduct transect surveys. In a transect, scientists count the number and type of species found in small areas (called quadrats) of a forest. The locations are randomly selected and then used to determine the overall species composition of an area. Transects can be done completely randomly or along a designated line. By measuring the plants in a small area, rather than the whole forest, scientists can look for patterns without needing to spend a large amount of time collecting data. In this experiment, you'll use mock-data from a real experiment in northern Minnesota to answer the question *"What is the effect of fire on species distribution?"*

Site Description: In this investigation, you'll look at data based on results from an experiment at the Camp 8 Stand. The Camp 8 stand is part of the University of Minnesota Cloquet Forestry Center. It is an experimental forest on the reserved lands of the Fond du Lac Band of Lake Superior Chippewa and the unceded territory of the Great Lakes Anishinaabeg. Camp 8 is a reserve of the forest that was left unmanaged in order to study red pines. Individual red pines in this forest are as old as 300 years old, and bare evidence of past fire. Since 1911, the forest composition of Camp 8 has dramatically changed. To address this, parts of the forest have undergone controlled burns. The data you'll examine, is based on the results of this experiment. You'll compare data from a site where a prescribed burn was used, and a control site where no burning was done. You can read more about the experiment and their results [here](#).

Pre-Lab Questions: *Use the background information and the site description to answer the questions below.*

- 1) Why was fire used by indigenous communities in Northern Minnesota?

- 2) Why did prescribed burns stop being used in Minnesota? What was one effect of this?

- 3) What is a transect? Why do scientists use them?



4) What question will you investigate in this lab?

5) What is the Camp 8 stand? Why will we use data from it in this lab?

Hypotheses: *Use the background information to help your hypotheses. Remember hypotheses are possible answers to a scientific question, and should be written in statement form with a “because” statement. We write multiple hypotheses because there is more than one possible answer to a scientific question.*

H1: _____

H2: _____

HN: _____

Experiment: *Follow the procedure below to collect and analyze your data!*

Materials

- ☐ Site Data Sheets
- ☐ Species Key
- ☐ Quadrat Square

Procedure

1. Collect your materials: Site Data Sheets, Species Key, and Quadrat Square
2. Cut out the quadrat square. Be sure to cut out the inside so that it is hollow.
3. Randomly lay the square on top of the “Prescribed Burn after 2 years” data sheet.
4. Use the species key to identify all of the plants *inside* your quadrat square.
5. Record the number and type of plants in the data table below.
6. Repeat for each of the sample sites.

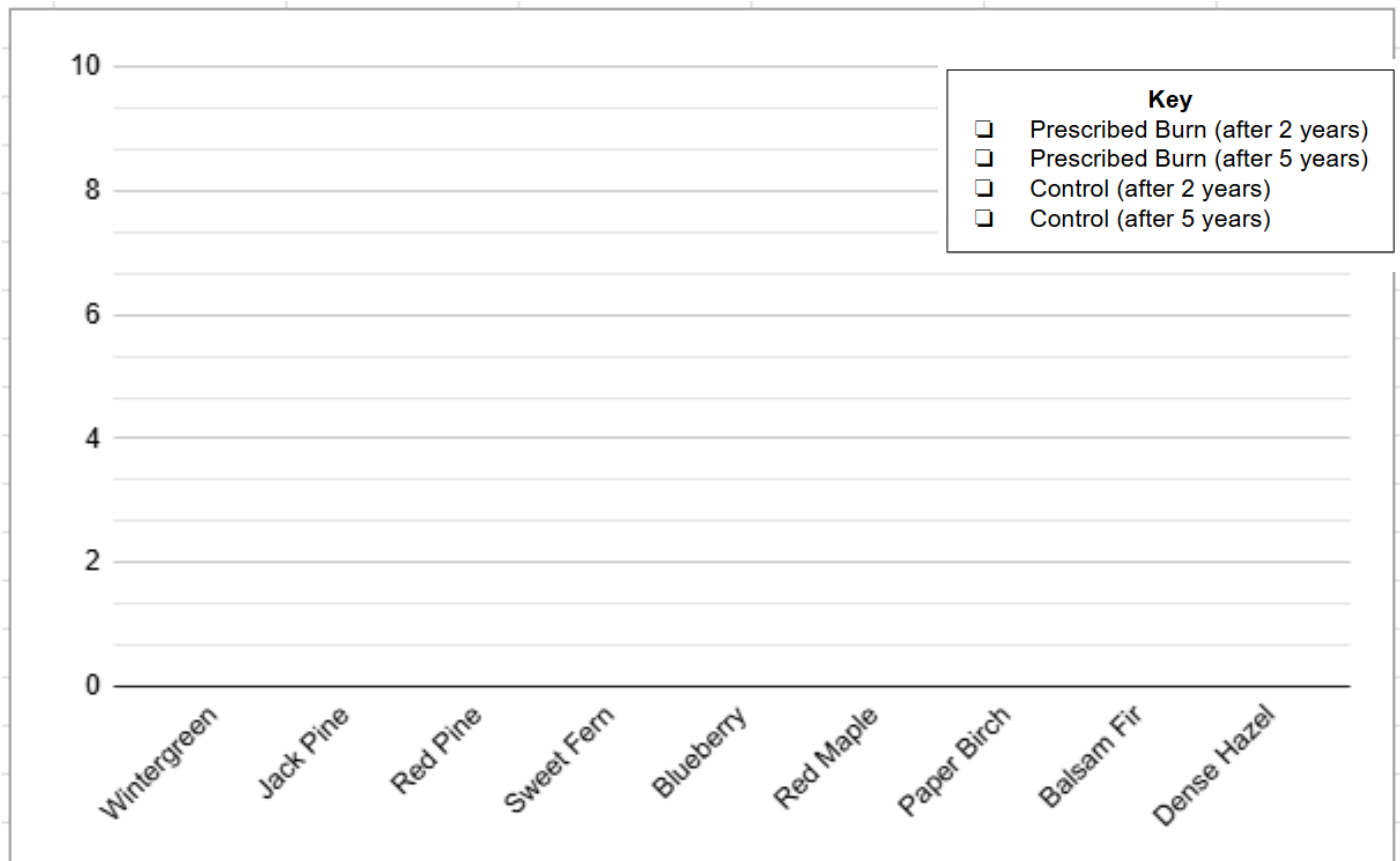


**FRIENDS OF THE
BOUNDARY
WATERS**

Data:

Site	Species								
	Wintergreen	Jack Pine	Red Pine	Sweet Fern	Blueberry	Red Maple	Paper Birch	Balsam Fir	Dense Hazel
Prescribed Burn (2 years)									
Prescribed Burn (5 years)									
Control Burn (2 years)									
Control Burn (5 years)									

Create a graph of your data in the space below. Be sure to include a title and axis labels!



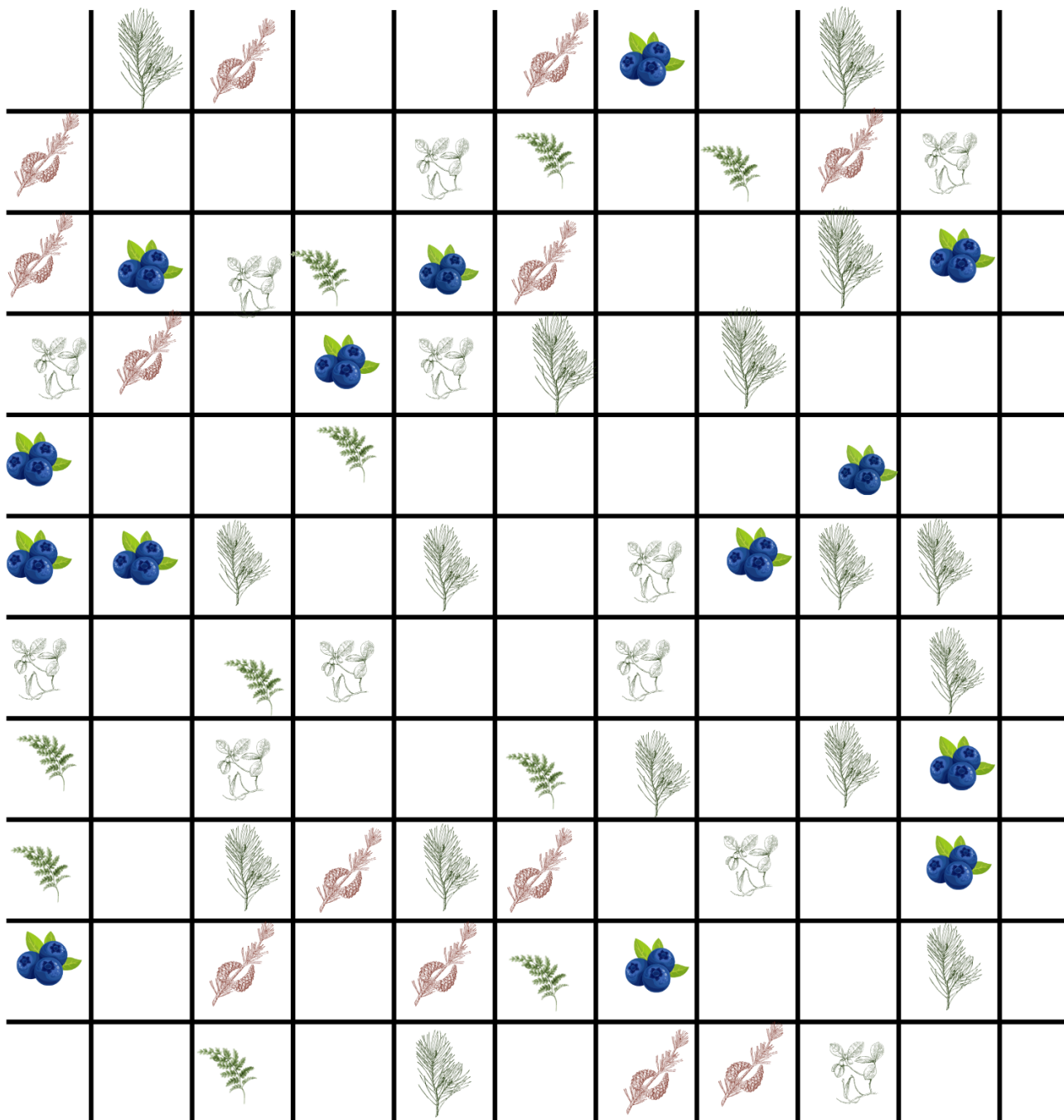
- 1) What species are the most dominant in the prescribed burn sites?
- 2) What species are the most dominant in the control sites?
- 3) How do the sites change between 2 and 5 years? *Why* do you think these changes occur?
- 4) Brainstorm: Why do you think you may see differences in the species distribution between the control and prescribed burn sites?



This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

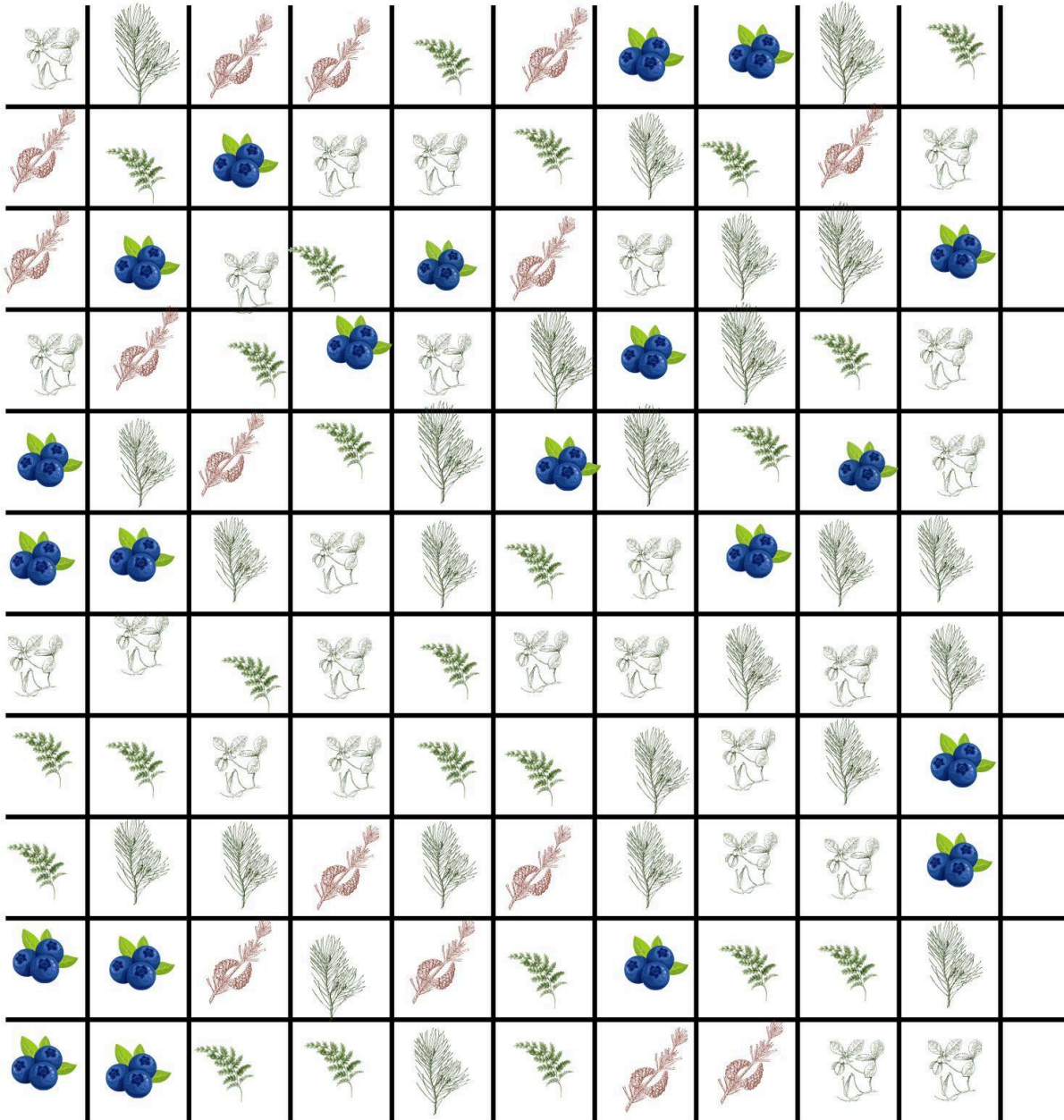
B1: PRESCRIBED BURN SITE

(2 YEARS AFTER BURNING)



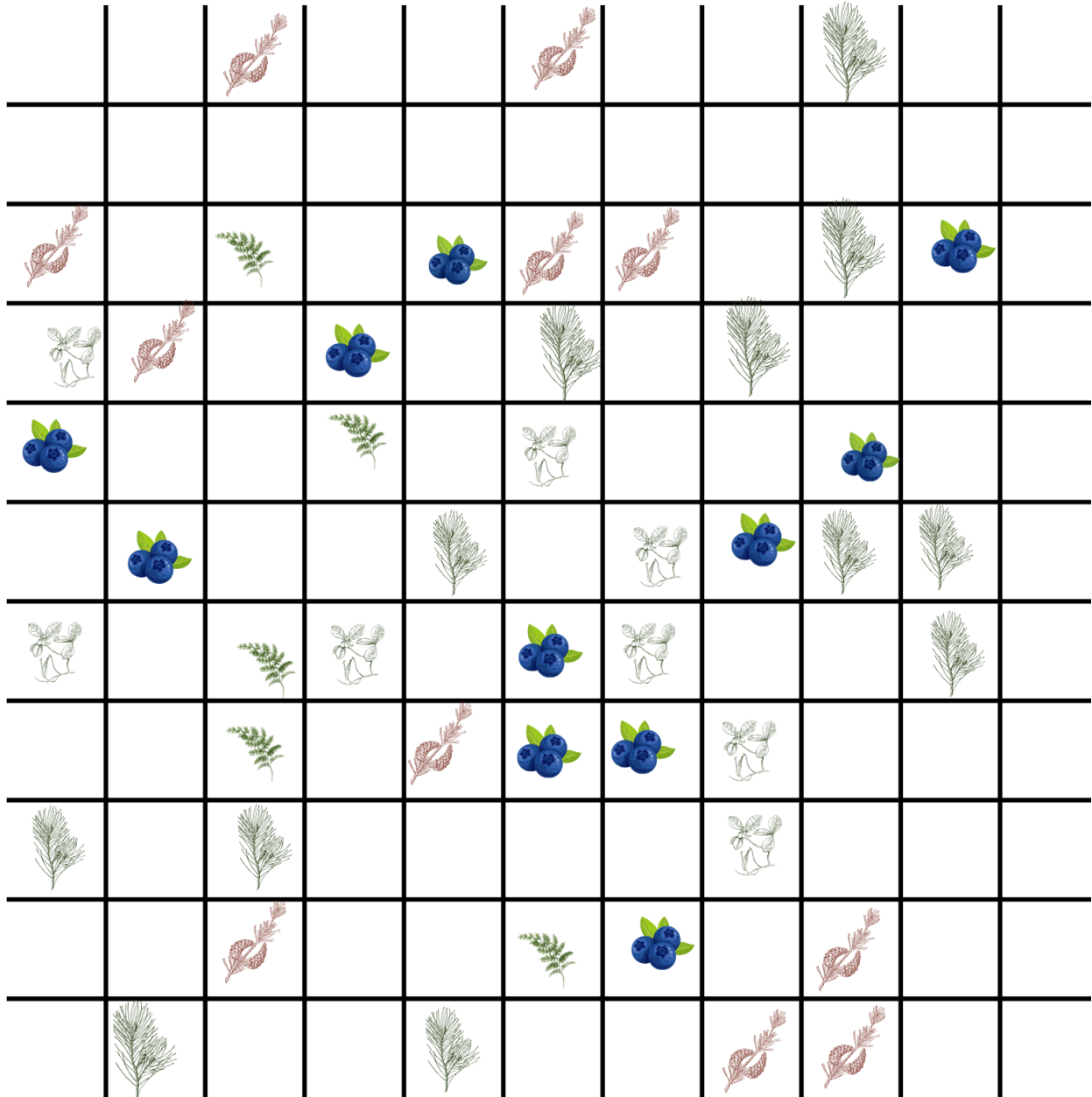
B1: PRESCRIBED BURN SITE

(5 YEARS AFTER BURNING)



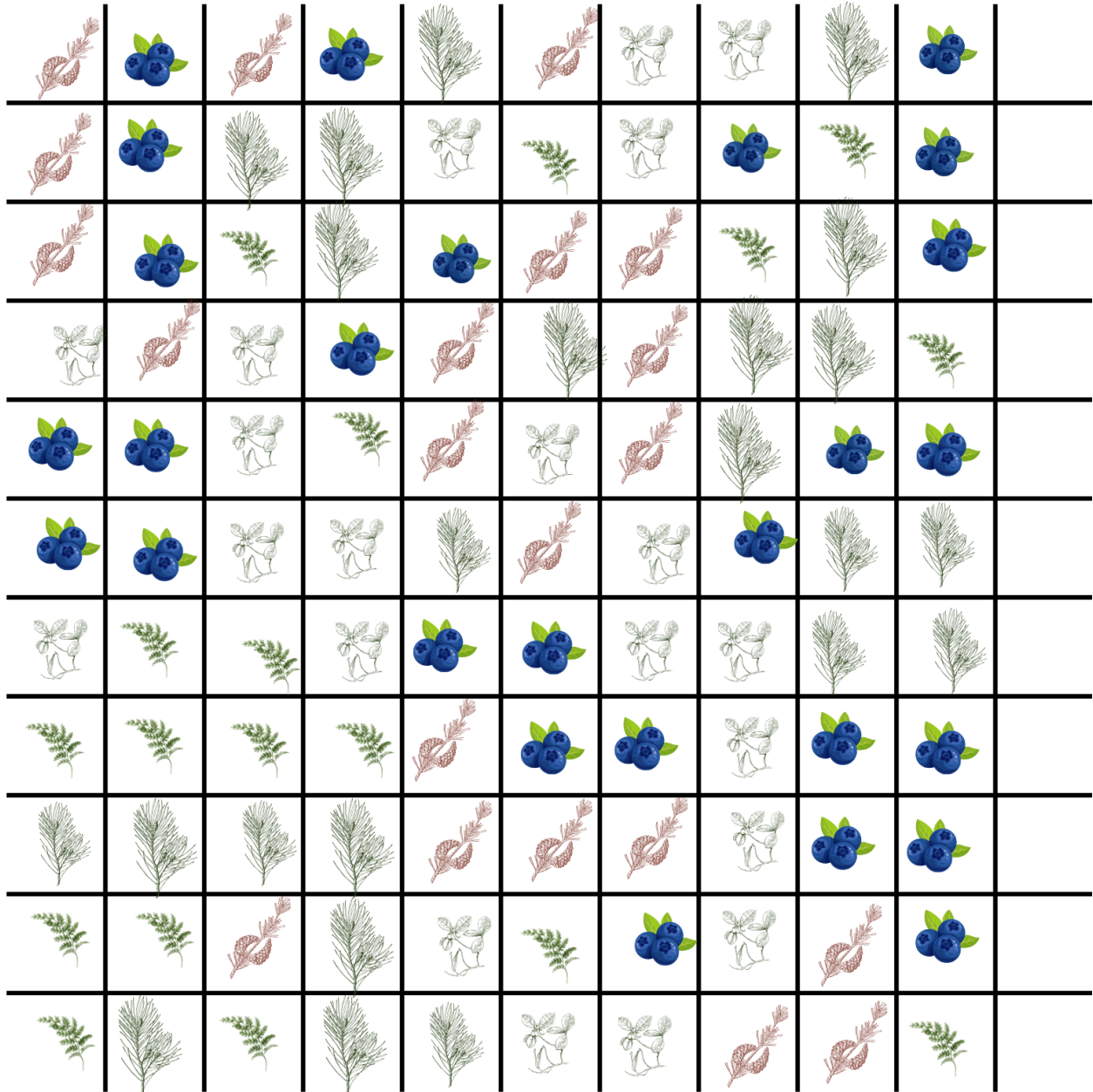
B2: PRESCRIBED BURN SITE

(2 YEARS AFTER BURNING)



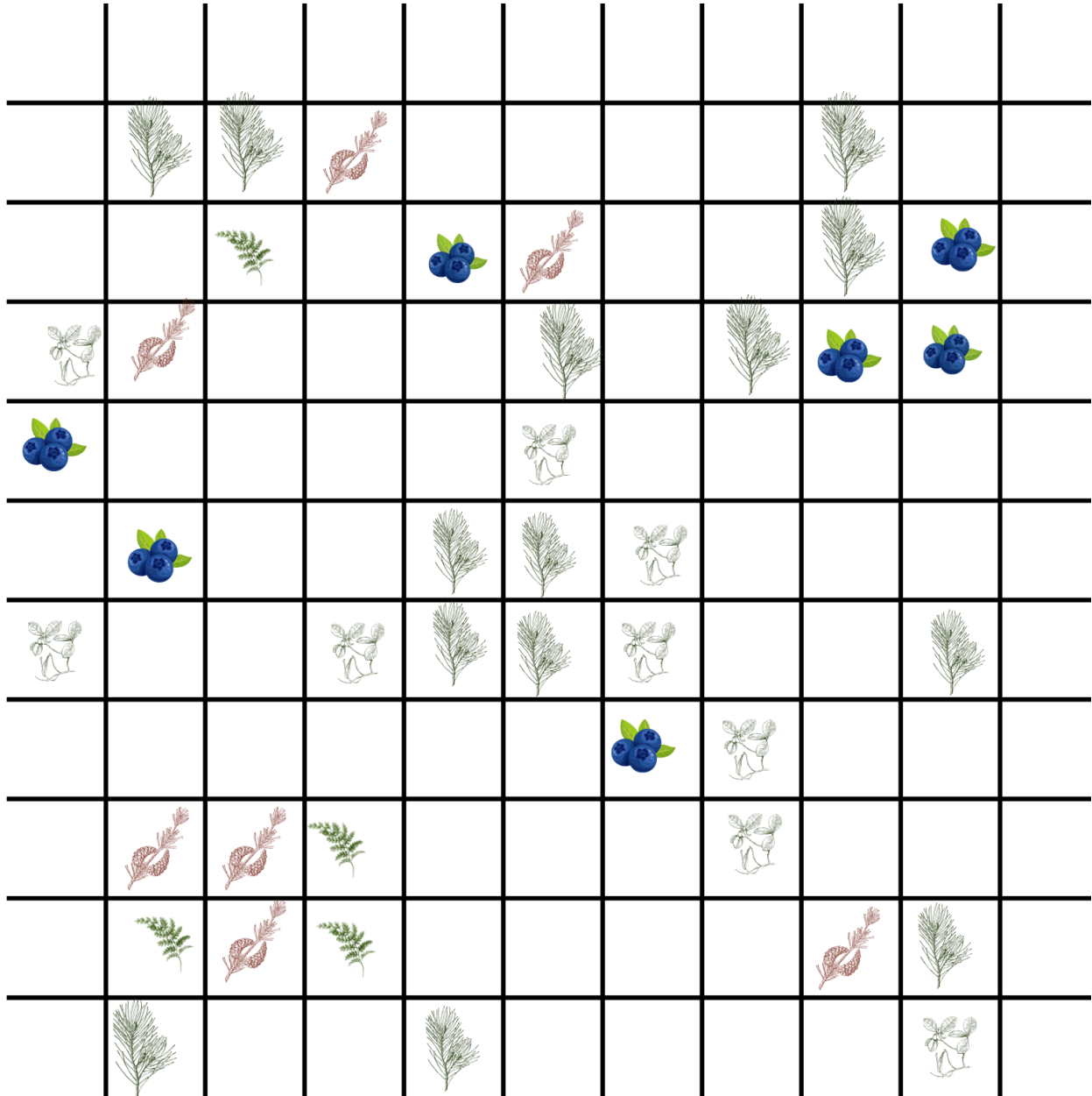
B2: PRESCRIBED BURN SITE

(5 YEARS AFTER BURNING)



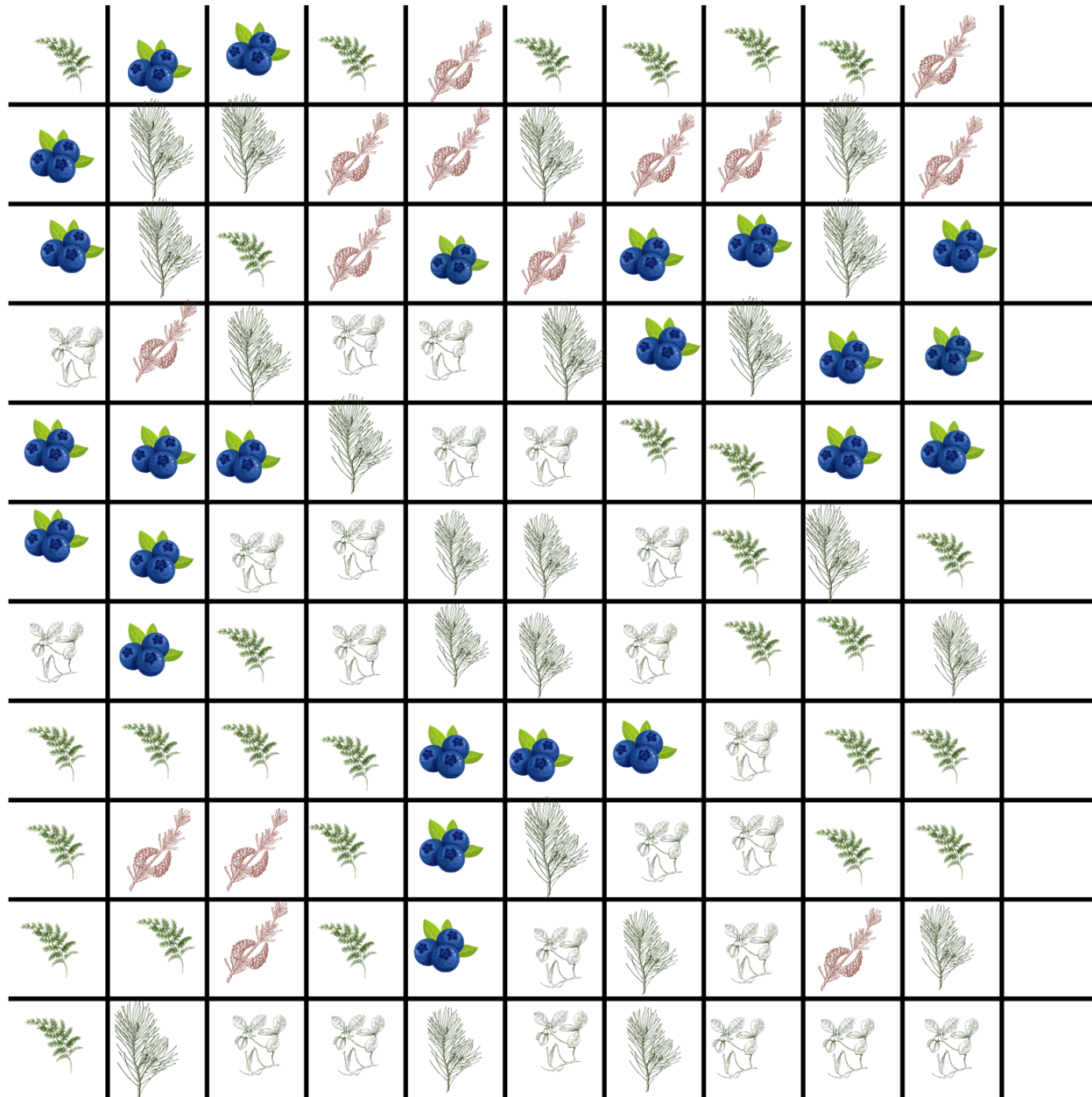
B3: PRESCRIBED BURN SITE

(2 YEARS AFTER BURNING)



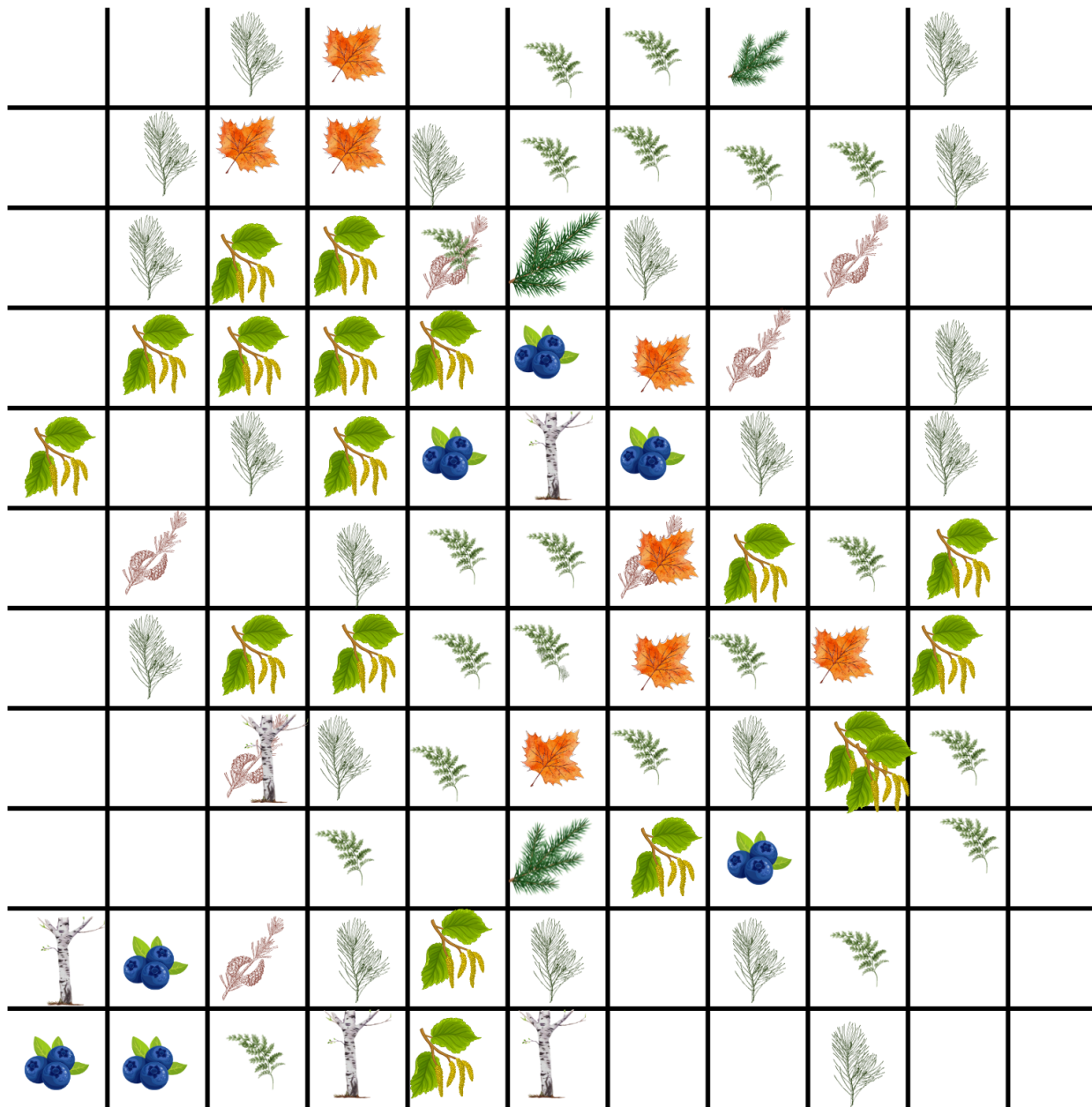
B3: PRESCRIBED BURN SITE

(5 YEARS AFTER BURNING)



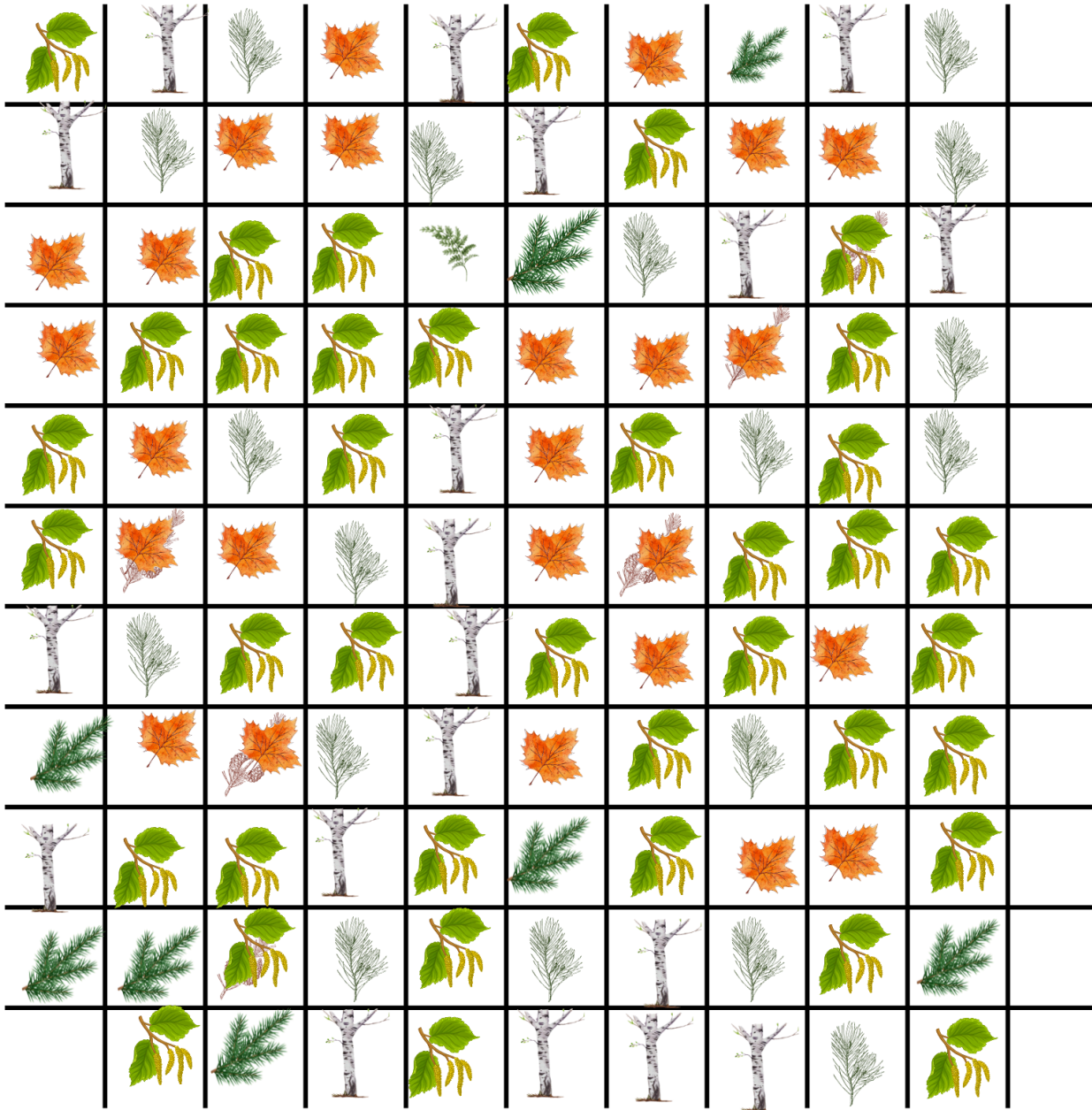
C1: CONTROL SITE

(2 YEARS WITHOUT FIRE)

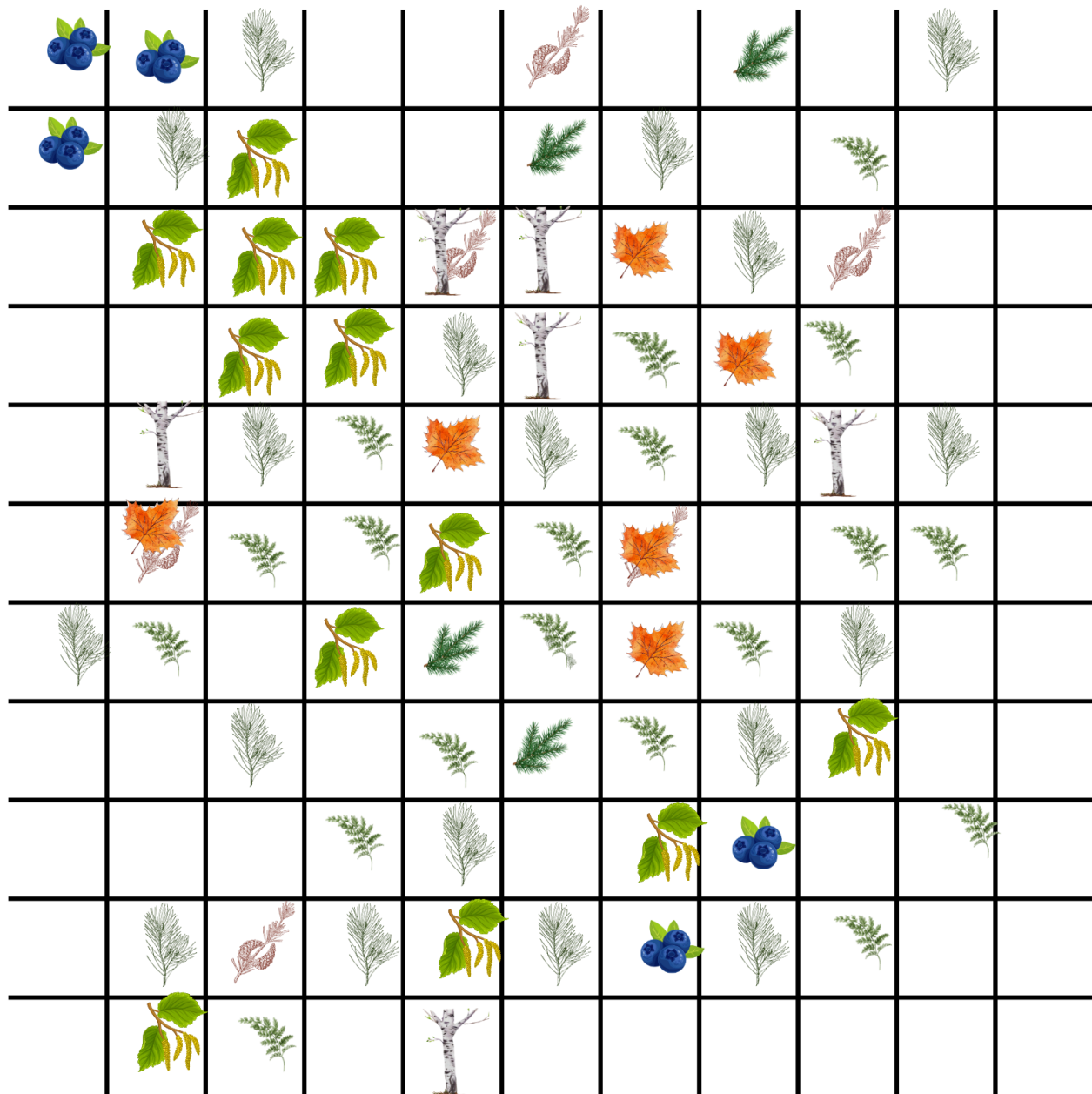


C1: CONTROL SITE

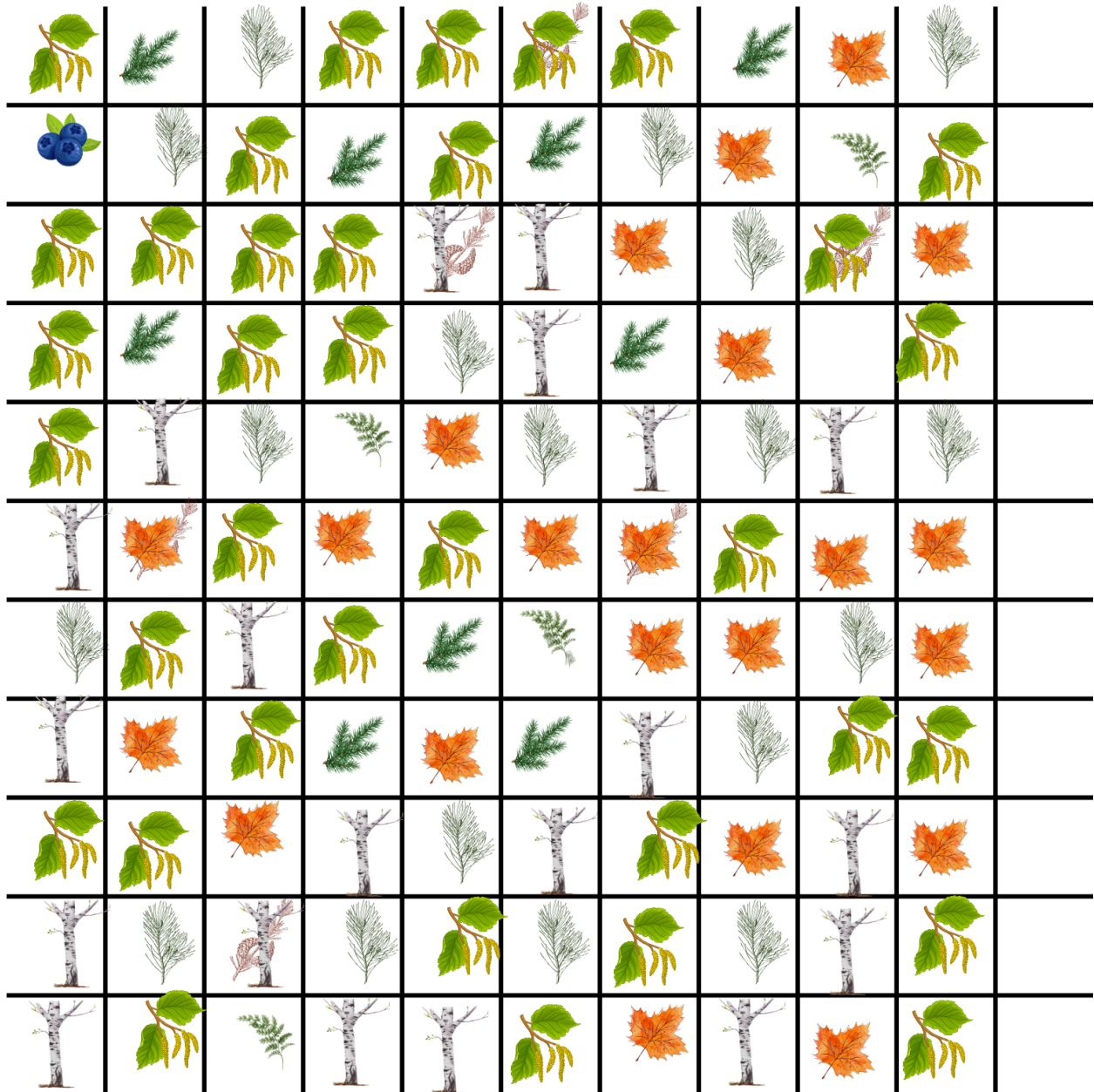
(5 YEARS WITHOUT FIRE)



(2 YEARS WITHOUT FIRE)

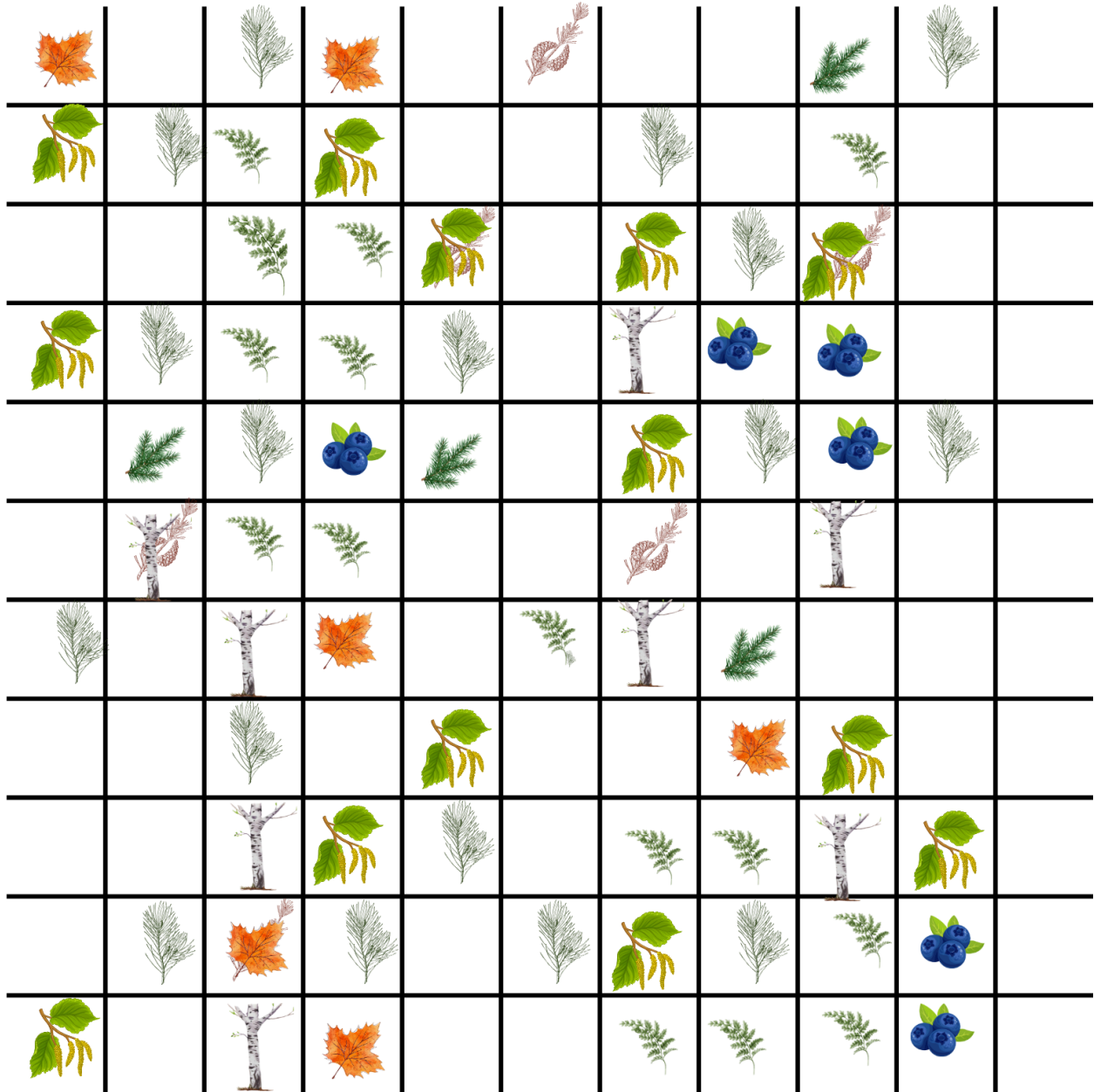


(5 YEARS WITHOUT FIRE)

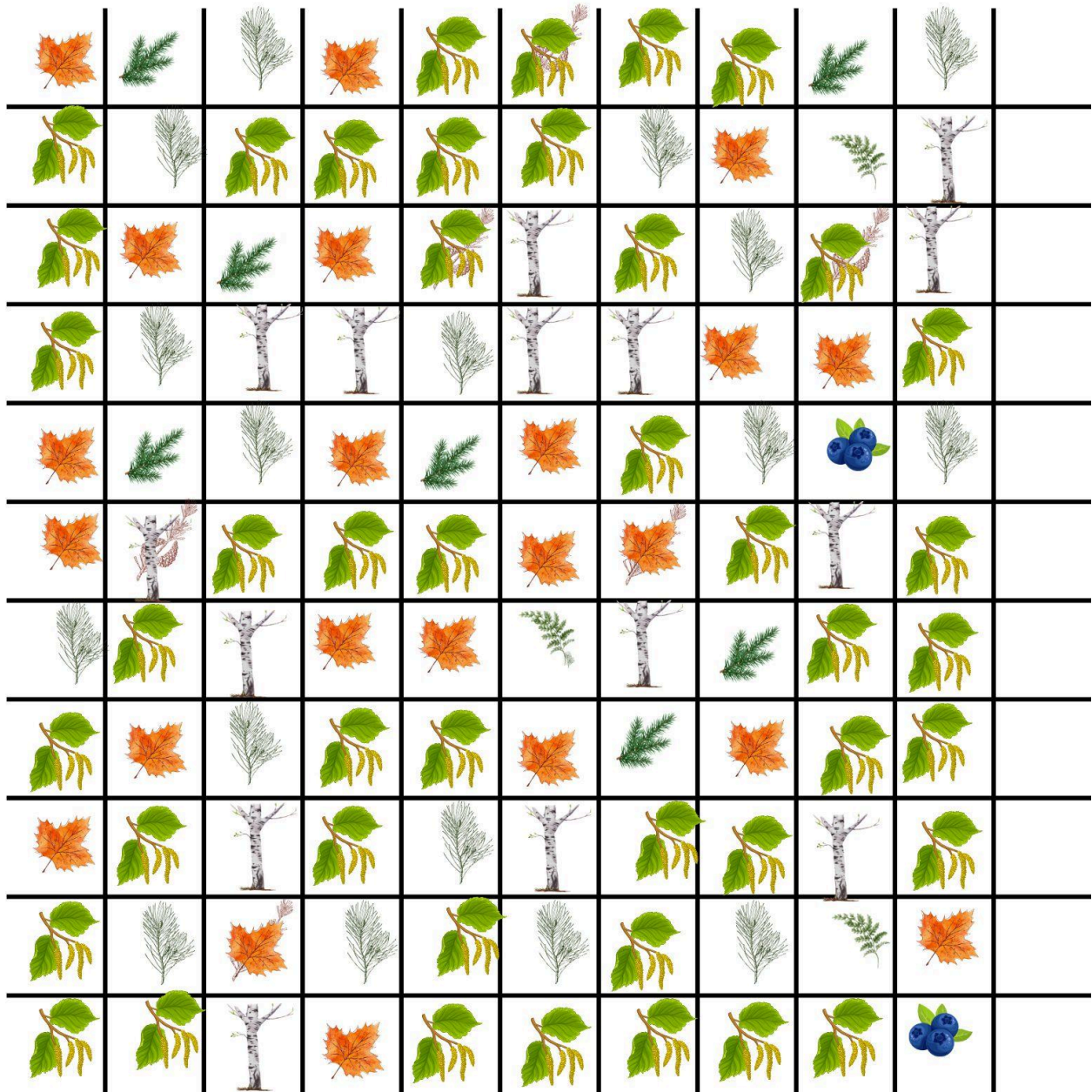


C3: CONTROL SITE

(2 YEARS WITHOUT FIRE)



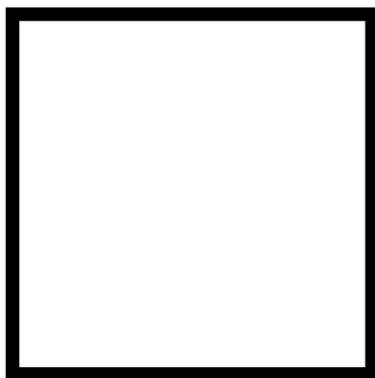
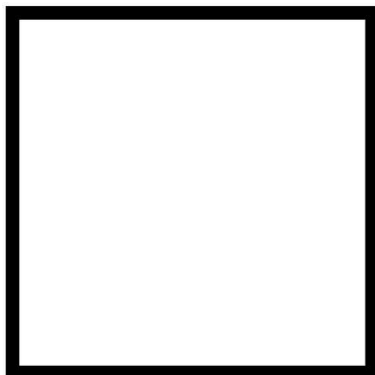
(5 YEARS WITHOUT FIRE)



Species Key			
Image	Common Name	Scientific Name	Anishinaabe Name
	Wintergreen	<i>Gaultheria procumbens</i>	Winisi'bugud
	Jack Pine	<i>Pinus banksiana</i>	okikaandag
	Red Pine	<i>Pinus resinosa</i>	bapakwanagemag
	Sweet Fern	<i>Comptonia peregrina</i>	gabaa'aagemish
	Blueberry	<i>Vaccinium cyanococcus</i>	miinagaawanzh
	Red Maple	<i>Acer rubrum</i>	zhiishiigimewanzh
	Paper Birch	<i>Betula papyrifera</i>	wiigwaas
	Balsam Fir	<i>Abies balsamea</i>	zhingobaandag
	Dense Hazel	<i>Corylus avellana</i>	bagaan

Sampling Directions

- 1) Cut out the quadrat square. Be sure to cut out the inside so that it is hollow.
- 2) Randomly lay the square on top of Prescribed Burn Site after 2 years.
- 3) Use the species key to identify all of the plants within your quadrat.
- 4) Record the number and type of plants in your data table.
- 5) Repeat for each of the sample sites.





FRIENDS OF THE
BOUNDARY
WATERS



Warm-up:

What are some ways that fire can impact an ecosystem?
(Consider how fire might affect plant and animal life, soil health, and other ecosystem functions)

Fire is a major driver of succession
in the Boundary Waters, in this
lesson we'll explore the question:
***What role should prescribed
burns play in BWCA
management?***

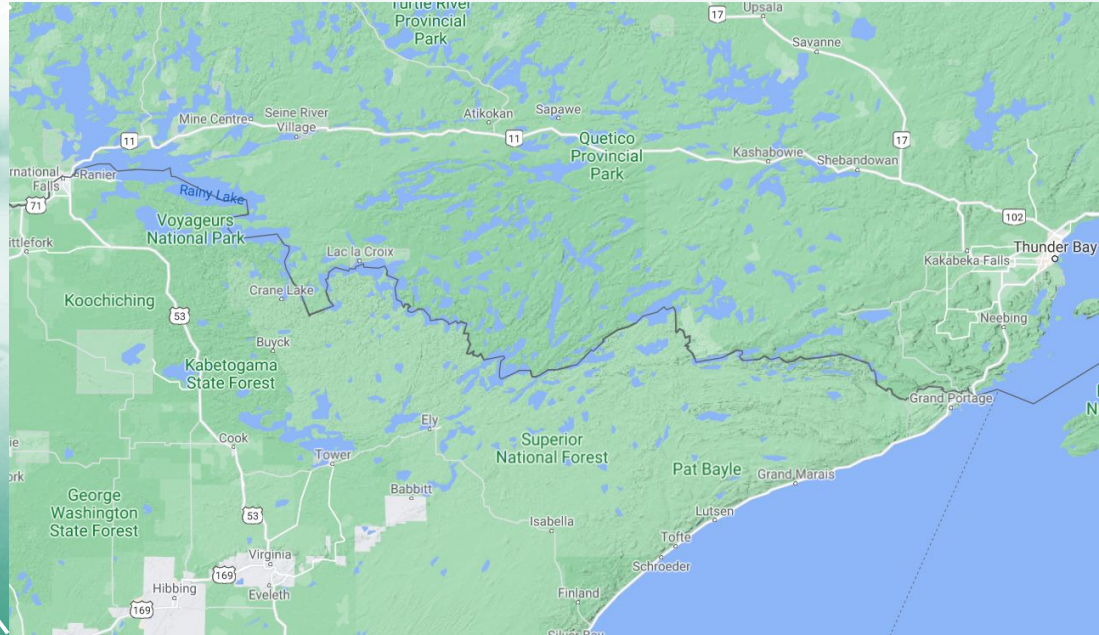
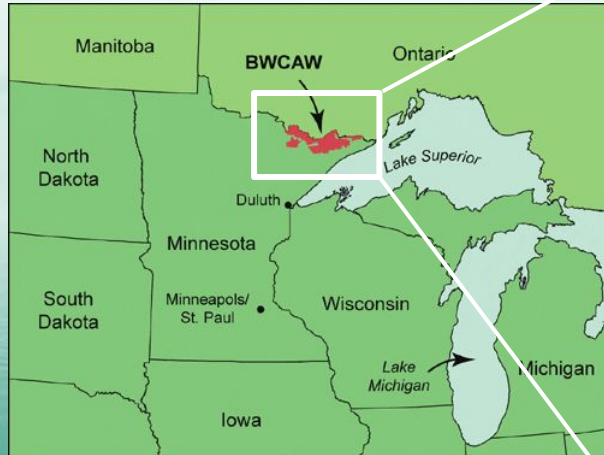
Agenda:

- Boundary Waters and Fire Review
- Lab Data Review
- Stockton Island Fire Management Case Study
- Write a Fire Management Proposal



The Boundary Waters is the region of wilderness separating Canada from the US between Ontario and Minnesota, west of Lake Superior.

The BWCA is 1.2 million acres, and 20% of it is water!



The BWCA is primarily **Boreal (Coniferous) Forest**

- Short, moist summers, long dry winters
- Temperature Range: -65 - 86F
- Thin, Acidic Soils (nutrient poor)
- Dominated by coniferous trees (spruce, fir, pine, and larch)



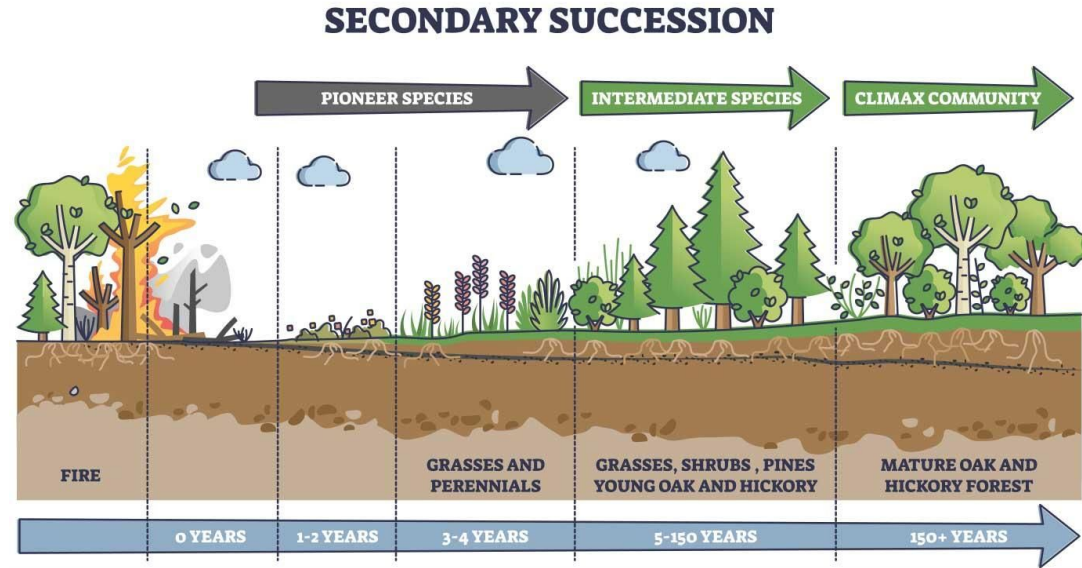
The Boundary Waters ecosystem is constantly changing through the process of **succession**

Succession: a predictable (directional) change in species composition of an area over time. 2 main types:

- 1) Primary Succession
- 2) Secondary Succession

Succession is driven by **disturbance**.
Examples of disturbance:

- Fire
- Windstorms
- Flooding
- Human Activity (logging, urban development)



Succession in the Boundary Waters is driven by **fire**

Succession in the Boundary Waters has historically been driven by **fire**. Tree records show that there have historically been fires every **100 years**, and controlled burns every **5-15 years**. Controlled burns have helped to diversify the forests of the BWCA *and* increase resilience of this unique ecosystem! However, there is disagreement about how fire can and should be used in the BWCA due to its wilderness status.

Frequent Low-intensity Fires can...

- 1) Clear underbrush and open-up forests providing more light
- 2) Add nutrients into soil
- 3) Increase forest species diversity



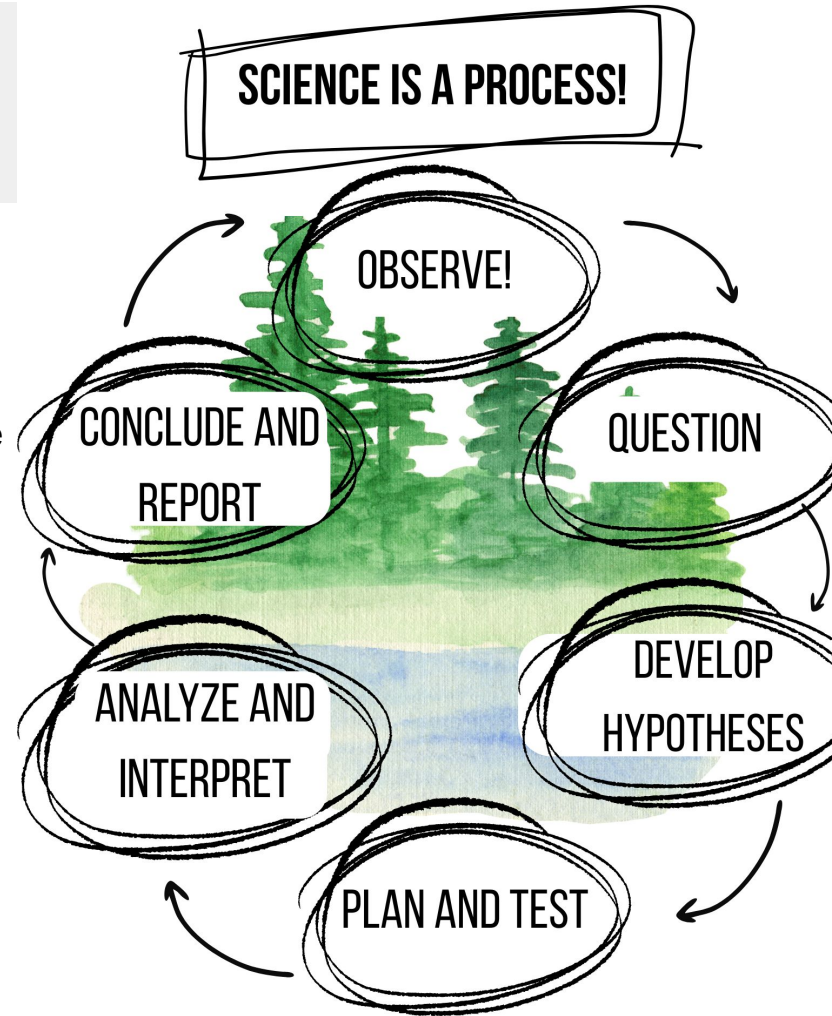
Investigation: What is the effect of fire on species diversity in the BWCA?

Native communities and the Minnesota DNR (Department of Natural Resources) continuously work together to make recommendations for prescribed burns that help prevent wildfires, honor traditional ecological knowledge, and encourage ecological resilience in the BWCA. To do this they need to collect data ecological data to evaluate the effect of wildfire on species biodiversity.

Last Class you collected transect data to answer this question! You worked with a group to:

- 1) Write hypotheses
- 2) Collect Data using the transect method
- 3) Analyzed your results
- 4) Wrote a conclusion using CER format!

Today: we'll dig into our data to look for patterns!

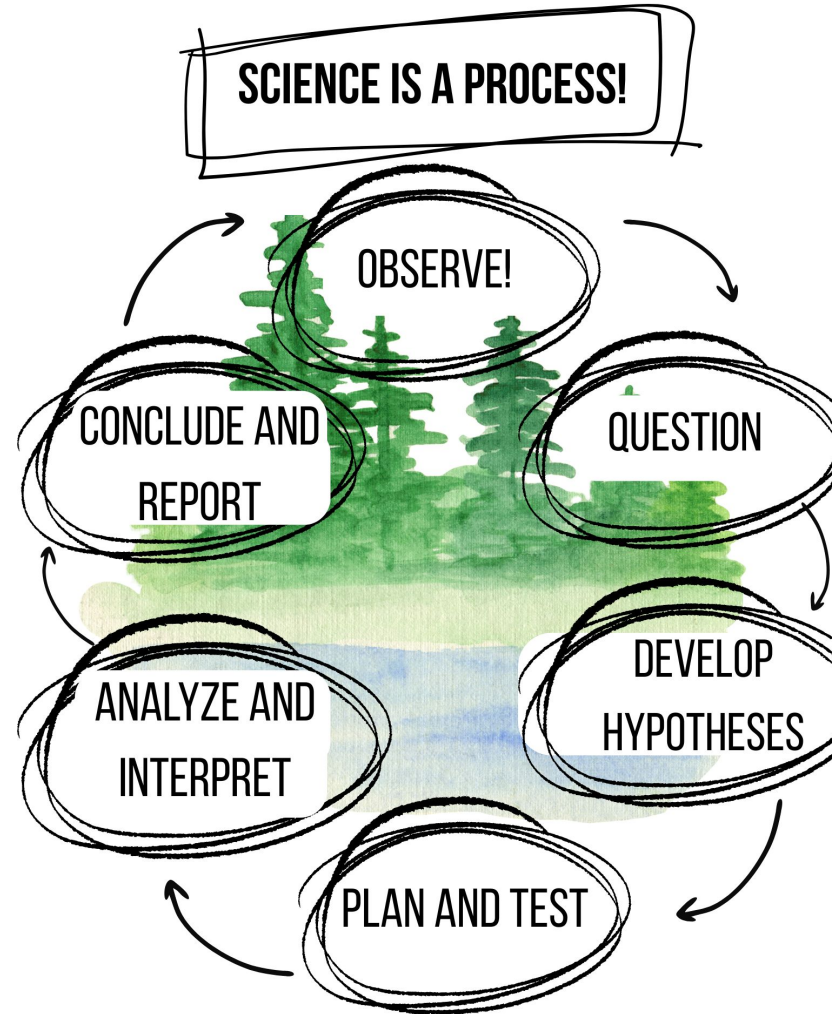
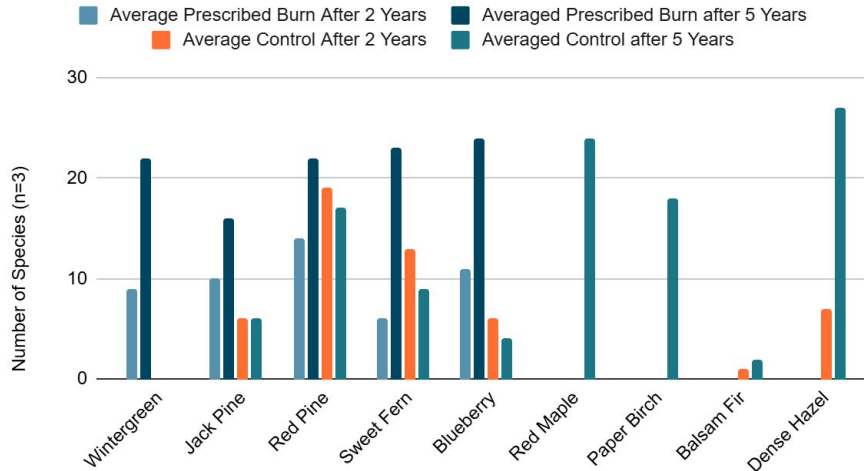


Explore it: Data Dig

Directions:

- 1) Collect a copy of the “Data Dig” handout
- 2) Work with your small group to look at your results and answer the reflection questions
- 3) Be ready to share out your ideas!

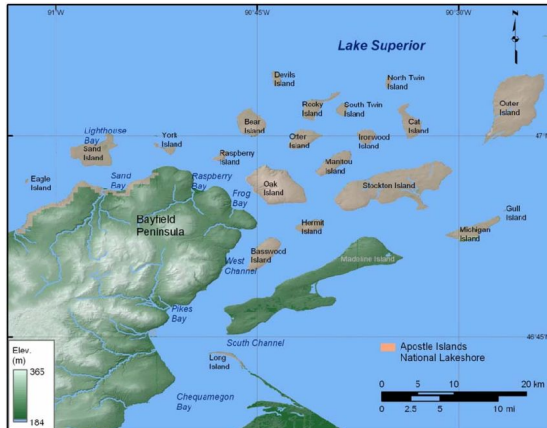
Average Species Distribution after 2 and 5 years



Dive Deeper: Stockton Island Case Study

The Apostle Islands are one area where governmental agencies are working with indigenous communities to reintroduce fire and could be a model for future BWCA fire management.

Directions: Watch the video, then read the case study, and discuss the reflection questions!



Create it: BWCA Fire Management Proposal

Directions:

- 1) Collect a copy of the BWCA Fire Management Proposal Handout
- 2) Read and annotate the example proposal
- 3) Use your knowledge from your field-experiment and the Stockton Island Case Study to write your own management proposal
- 4) Your proposal should include:
 - a) Claim: A clear statement in support or opposition of using prescribed burns in the BWCA
 - b) Evidence: At least 2 pieces of evidence that support your claim.
 - c) Reasoning: An explanation of what you expect the long-term impact of your proposal to be



Check-in/Close Out

Big Ideas:

- The Boundary Waters is a region of wilderness in Northern Minnesota protected under the wilderness act. It is 1.2 million acres of freshwater lakes and boreal forest!
- Succession is the process of ecological change. Fire is a major driver of succession in the BWCA
- Controlled/Prescribed burns have historically been used throughout the BWCA by DNR members and Native communities to maintain ecological diversity and resilience
- Fire affects ecological biodiversity.
- Governmental groups are working with Indigenous communities to reintroduce fire into boreal forests. The Boundary Waters could potentially be a candidate for this type of work!



FRIENDS OF THE
BOUNDARY
WATERS

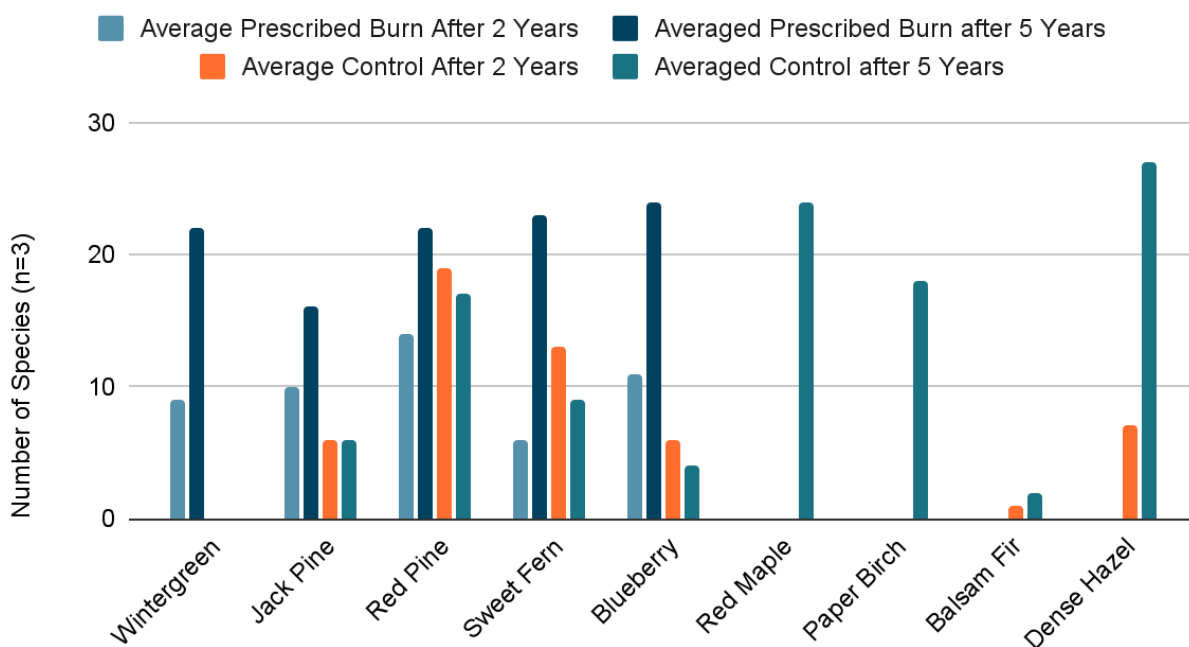
Fire and the BWCA: Data Dig

Directions

- 1) Look through the data you collected in lesson 2 and the data below.
- 2) Work with your small group to identify patterns.
- 3) Use your data to discuss the reflection questions below.

Prescribed Burn Species Data

Average Species Distribution after 2 and 5 years



Site	Average number of Species								
	Wintergreen	Jack Pine	Red Pine	Sweet Fern	Blueberry	Red Maple	Paper Birch	Balsam Fir	Dense Hazel
Prescribed Burn (2 years)	9	10	14	6	11	0	0	0	0
Prescribed Burn (5 years)	22	16	22	23	24	0	0	0	0
Control Site (2 years)	0	6	19	13	6	0	0	1	7
Control Site (5 years)	0	6	17	9	4	24	18	2	27



Reflection Questions:

- 1) What patterns do you notice in your data? How does plant distribution (the number and type of species) differ across each of the different sites?

- 2) Do sites that have experienced fire have different species than the control sites?

- 3) Brainstorm: why do you think you saw the patterns you saw? Why were there differences between the sites?

- 4) If you revisited these sites again in 10 years, what differences would you expect to see? Why would you expect this?



Fire and the BWCA: Stockton Island Case Study

Cultural Burning and the Boreal Forest

The relationship between people and fire in the Great Lakes region is thousands of years old. The Great Lakes Anishinaabeg have used fire to manage the landscapes of North Dakota, Minnesota, Wisconsin, Michigan, and parts of Canada for thousands of years. Fire was intentionally set, through a process now called cultural or prescribed burning, in order to promote the growth of blueberries and red pine, as well as foster suitable environments for hunting (YES! Magazine, 2022). However, with European colonization, the use of fire was abruptly stopped and deemed destructive. As a result, the ecosystems in these regions began to shift, and the frequency and intensity of wildfires increased (Sea Grant Wisconsin, 2023).

Fire suppression has resulted in a shift in these northern ecosystems. The forests of Northern Minnesota and Wisconsin have shifted to be less fire-adapted and dependent. These forests are what Damon Panek—wildland fires operations specialist for the Fond du Lac Band of Lake Superior Chippewa and member of the Mississippi Band of White Earth Ojibwe—calls “colonized” (YES! Magazine, 2022). In the absence of fire, native red pines have been replaced by hardwoods. Forests are denser with more shade-tolerant plants, and sun-loving groundcover species such as blueberries and sweet fern are disappearing. A full rejection of fire has threatened not only the historic ecosystems of this region but the ways of life associated with them.

One proposed solution to this is to reintroduce cultural and prescribed burning into Northern Minnesota and Wisconsin. To enact this, governmental, community, and Indigenous groups all need to collaborate. At Stockton Island, located in the Apostle Islands of Wisconsin, this collaboration has already taken shape (National Park Service, 2023b).

Stockton Island and the Reintroduction of Fire

Stockton Island (Wiisaakodwan-minis) is part of the Apostle Islands National Park. The island is known for its sand beaches and unique plant communities, including bogs, dunes, lagoons, savannahs, and pine forests. These pine forests have been lived in by Indigenous peoples for more than 1,000 years. The forests allowed Indigenous communities to hunt, fish, gather berries, and harvest maple sap. Cultural burning allowed for Indigenous people to promote the growth of pine and blueberry plants (National Park Service, 2023b). However, with colonization and the suppression of fire, these landscapes shifted.

Starting in 2017, the National Park Service began working in collaboration with the Bureau of Indian Affairs, the Red Cliff Band, Bad River Band, and the Great Lakes Indian Fish and Wildlife Commission to reintroduce cultural burning to the island in an effort to restore these culturally significant ecosystems (Friends of the Apostle Islands, 2021). The objective of the burns has been to restore pine forests as well as increase blueberry production. A second set of burns was done in 2021. Both burns have been successful in restoring a more open forest and increasing blueberry production (National Park Service, 2023a).

At the center of this initiative is Indigenous knowledge. Ojibwe nations in the Apostle Islands



maintain Reserved Treaty Rights and have used fire to promote blueberry production on Stockton Island for centuries. Cultural burns at both sites have been done with the consent of and led by Indigenous leaders in the area in an effort to help correct a history of erasure—both of fire and people (National Parks Traveler, 2023).

What's Next? Introducing Fire to the Boundary Waters

The work being done at Stockton Island has been looked to as a possible model for how Traditional Ecological Knowledge (TEK) can guide fire management. The collaboration between National Park Service (NPS), Bureau of Indian Affairs (BIA), and their Tribal partners is a model that many argue could be implemented within the Boundary Waters Canoe Area Wilderness (BWCA) (Sea Grant Wisconsin, 2023).

Using cultural burning in the BWCA is complicated by its wilderness status. The Wilderness Act of 1964 defined wilderness as “an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain... an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation.” Under this act, wilderness is intentionally established as areas where the presence of humans is not seen or felt (National Park Service, 2025). This idea is in direct conflict with the implementation of TEK, and as a result, cultural burning. The U.S. Forest Service is the primary agency responsible for determining BWCA management strategies, and they are actively working with Indigenous communities as well as other organizations to develop and refine management plans. These plans could potentially include the reintroduction of cultural burning to the BWCA (YES! Magazine, 2022).

Sources

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National Park Service. (2023a). *Stockton Island prescribed burn restores cultural landscapes*. <https://www.nps.gov/articles/000/stockton-island-prescribed-burn-restores-cultural-landscapes.htm>

National Park Service. (2023b). *Stockton Island – Apostle Islands National Lakeshore*. <https://www.nps.gov/places/stockton-island-apis.htm>

National Parks Traveler. (2023, September). *Indigenous knowledge to guide prescribed burn in Apostle Islands National Lakeshore*. <https://www.nationalparkstraveler.org/2023/09/indigenous-knowledge-guide-prescribed-burn-apostle-islands-national-lakeshore>

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Sea Grant Wisconsin. (2023, February). *We all gather around the fire [Transcript]*. https://www.seagrant.wisc.edu/wp-content/uploads/2023/02/Transcript_We-all-gather-around-the-fire.pdf



YES! Magazine. (2022, September 20). *Fire is medicine: Indigenous traditional ecological knowledge*. <https://www.yesmagazine.org/environment/2022/09/20/fire-indigenous-traditional-ecological-knowledge>

Reflection Questions

Write your ideas about these questions in the space below, then discuss in your small groups.

- 1) How has the role of fire in Northern Minnesota and Wisconsin changed over time? How is this related to the cultural history of this region?

- 2) What is the effect of prescribed burns on the ecosystems of Northern Minnesota and Wisconsin? (How does fire change the forest structure?)

- 3) What is happening at Stockton Island? How is the National Park Service collaborating with indigenous communities? Why is this significant?

- 4) How could Stockton Island be used as a model for fire management in the BWCA? What are some possible strengths and challenges of this?



Fire and the BWCA: Fire Management Proposal

Overview: The U.S. Forestry Service works in collaboration with a variety of governmental agencies, community organizations, and indigenous tribes to create and implement management plans for wilderness areas including the Boundary Waters Wilderness Canoe Area (BWCA). When creating these plans they need to consider: the constraints of the wilderness act, the ecological impacts of actions, the economic cost, and cultural impacts. In this activity, you'll create a proposal for the role you think prescribed burning should play in the management of the BWCA.

Directions:

- 1) Read and annotate the example proposal
- 2) Use your knowledge from your field-experiment and the Stockton Island Case Study to write your own fire-management proposal for the BWCA.
- 3) Your proposal should include:
 - a) *Claim:* A clear one sentence statement in support or opposition of using prescribed burns in the BWCA.
 - b) *Evidence:* At least two pieces of evidence that support your claim. This could be data from your field experiment, the stockton island case study, or evidence from independent research.
 - c) *Reasoning:* An explanation of what you expect that long-term impact of your proposal to be. This should include a discussion of the ecological impact (how will forest structure change) and the cultural impact.

Example Proposal: *Read and annotate this proposal, use this to help guide your own proposal*

Prescribed burns should be utilized on Stockton Island. Stockton Island has a long history of prescribed burns. These burns were conducted by indigenous people, in particular the Ojibwe, and helped to promote the growth of red pine and blueberry plants. Without prescribed burns the forest structure on Stockton Island has shifted. Red pines have been replaced by hardwoods, and the understory no longer supports sweet fern and blueberry species. Indigenous communities have been unable to hunt and gather in a culturally appropriate manner because of these shifts in ecosystem structure. Prescribed burns have been shown to open up the forest canopy, add nutrients to soil, and support pine and blueberry growth. Reintroducing prescribed burns to Stockton Island would have long term consequences for both the ecological and cultural landscape of Stockton Island. Prescribed burns would help to restore the island's forest to their pre-colonial state, creating a more resilient forest and a culturally significant one. Prescribed burns would foster the growth of pine and blueberries and allow indigenous communities to reconnect and reengage with the landscape after the disenfranchisement of colonization and the resulting fire suppression.



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