CENTRAL QUESTION: WHAT'S KILLING THE LODGEPOLE PINE TREES?

TIME: 2.5-3 hours

OVERVIEW:

- **SECTION 1: GATHER** (50 minutes)
  How many lodgepole pines are dying?
- **SECTION 2: ANALYZE** (70 minutes)
  What is killing the lodgepole pines?
- **SECTION 3: INTERPRET** (50 minutes)
  Why now?
- **SECTION 4: COMMUNICATE** (30-60 minutes)
  And why is it worse now than in the past?

MATERIALS:

- One computer per two students
- One computer with the ability to broadcast material onto a screen visible by the entire class
- Printed or Digital ***Research Assistant Notebooks*** for students to record notes
- White board or other surface for teacher to use while facilitating class discussions
- Additional resources:
  - ***Student Learning Assessment Tool***
  - ***Student Rubric for Presenting Arguments***
  - ***Student Rubric for Assessing Learning Outcomes***

SCIENCE STANDARDS ALIGNMENT:

Utah SEEd Standard

- **6.4.1** - Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

NGSS Standard

- **LS2-1** - Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

ELA Standards

- **Writing Standard 3:** Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.
- **Language Standard 5:** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.

GETTING STARTED

This investigation provides support for teaching the content standards, along with the nature of science/how science is done, developing claims, working with evidence, and using reasoning skills. (**Hint:** Review the documents entitled *Curriculum Alignment* and the *Student Learning Assessment Tool* for other alignments and to assess learning with your students.)

Before class...

- Review this instructional guide and determine your student learning goals, which sections you want students to work on during each class period of the investigation, and the steps where your students will need guided instruction.
- Review the following recommended strategies for optimizing student learning outcomes.
    - Working in pairs ensures that every student has the opportunity to share their ideas. As students progress though the investigation, you may want to combine pairs of students into small groups to provide more practice sharing and responding to the ideas of their peers.
    - Build a shared vocabulary for the learning tasks by identifying key vocabulary beforehand and encouraging students to use these words often. Model correct usage if needed.
        - **Key Vocabulary:** phenomenon, natural resources, pathogen, predation/predator, natural disturbances, drought, correlation, causation, precipitation, historic average, data set, average, strong evidence, weak evidence, disconfirming evidence
    - Think about places you can activate prior knowledge by prompting students to relate new concepts to a familiar context.
    - Think about how to integrate the *Research Quest* investigations with other curriculum-aligned activities.
    - Create and engage student interest in the program by expressing your enthusiasm and/or describing your personal interest in this investigation. You may also want to emphasize that students will be working with authentic materials on research questions that scientists actually address in their own work.
    - Introduce students to sentence stems that reinforce flexible thinking and help students verbalize their thought processes:
        - "I see..."
        - "I think..."
        - "I wonder..."

Set Up...

- Make copies of the Research Assistant Notebook (RAN) for each of your students, or use the PDF with your desired digital classroom platform (ie. Google Classroom, Canvas, etc).
- Navigate to www.researchquest.org and login using the email address and password you used to create your *Research Quest* account. Then, navigate to the "My Account" tab at the far right of the navigation bar. You will find your **Student Access Code**.
- Have your unique Student Access Code and URL link [www.researchquest.org/student/] ready for students. **It is important you have students use this particular URL and access code to get into the investigations for FERPA.**

In class...

- Introduce the daily objectives and provide a brief overview of the investigation to the class.
- Provide each student with a copy of the *Research Assistant Notebook* (RAN).
- Arrange students into pairs, one pair per computer. Instruct them to navigate to the URL [www.researchquest.org/student/] and enter your unique Student Access Code.
- Students will find themselves on a landing page with the option to go into one of two investigation modules. They should choose, "Change in the Uinta Mountains: Normal or Not?" Then, they should click on investigation #1 "What's Killing the Lodgepole Pine Trees?"
- Once logged in, students will be on the introduction page for this investigation. They can read the overview and start at your direction.

SECTION 1: GATHER - HOW MANY LODGEPOLE PINES ARE DYING? *(50 minutes)*

OVERVIEW

Students will define the problem by identifying dead pine trees in aerial images of the Uinta Mountains. Determine whether the amount of dead trees found this year is significantly different than the historic average. Identify the resources a tree needs to survive and clues that can tell you which resources they may not be getting.

ASSESSMENT

In this section, the instructor may find it useful to focus on the following critical thinking skills, defined in more detail in the *Student Learning Assessment Tool* which can be found through the "Teacher Support" tab and by clicking on the *What's killing the lodgepole pines*? link.

- **Observation:** Make detailed, sense-based observations about the trees in the study sites.
- **Comparisons:** Identify patterns in the data to discriminate between study sites.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 1 *(3 minutes)*	• Watch the video on Step 1 of the investigation. (2:59 min.)	• As you introduce the research question, facilitate a brief class discussion to assess prior knowledge students have for the kinds of factors that cause trees to die. • Direct students' attention to the following before beginning the video: *In this video, Isabel, from the Natural History Museum of Utah, will introduce students to the phenomenon, visibly dead or dying lodgepole pines, and how these observations can be measured to quantify what is happening. Listen for Isabel's explanation of what we can learn from this investigation and how to get started on the first task.* • **Key Vocabulary:** phenomenon
STEP 2 *(15 minutes)*	• Click on each sample site (Site 1-6) to view and process the data. • In the pop-up, click on all squares that have more than 50% dead or dying trees. Repeat for each sample site then click "I'm done" to continue.	• Initiate a brief discussion about collecting data and aerial photos. Give examples of a 'bird's eye view' and ask students why they think aerial photos might be useful when studying large areas, like a forest. • You may elect to collect data from the first site as a class, then have students complete the rest with their partner(s). Students can move on to Step 3 when they finish.

SECTION 1: GATHER - HOW MANY LODGEPOLE PINES ARE DYING? *(Continued)*

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 3 *(5 minutes)*	**REFLECT** • Compare the data that you've gathered from recent flyovers to the larger data set and to flyovers in the past (historical average for the area). Use the information links for data set definitions. • Answer the reflection question: **How does tree death now compare to tree death in the past?** ***a.*** What do you notice about the number of dead trees across the sites? ***b.*** What does this tell you?	• Prompt student thought and connections to the question: Do you think the recent tree death is normal or something we should be concerned about or different from what we've seen in the past? • **Key Vocabulary** • Larger data set is data that has been collected this past summer from dozens of other sites in this section of the Uinta Mountains. • Historical data is data from other aerial studies that have been done in this section of the Uintas over the last 50 years. By comparing their data to "historical data," students can reason about whether the current outbreak is normal or an increase/decrease from what has been seen in the past.
STEP 4 *(5 minutes)*	• Watch the video on Step 4 of the investigation. (1:40 min.)	• Direct students' attention to the following before beginning the video: *In this video Dr. Mitch and Isabel will discuss how to explore the phenomenon of dying trees further. Listen for the two types of information you should gather in order to figure out what might cause a tree to die.* 1 - The resources a tree needs to survive. 2 - The signs that tell us a tree isn't getting enough of those resources.
STEP 5 *(15 minutes)*	• Click on each hotspot (+) on the tree to learn what a lodgepole pine trees needs to survive. *Be sure to click on all of the hotspots.* • With your partner, list the resources, pathogens, predators, and natural hazards that impact the lodgepole pine. *RESEARCH ASSISTANT NOTEBOOK (RAN): page 1*	• Consider doing a jigsaw activity for this step. Have partner groups of four students look for evidence from each of the given categories. Then share with others, so all students learn the information gathered by other groups and take notes on what they learn. • **Key Vocabulary:** natural resources, pathogen, predation/predator, natural disturbances

SECTION 1: GATHER - HOW MANY LODGEPOLE PINES ARE DYING? *(Continued)*

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 6 *(5 minutes)*	**PREDICT** • Based on the information you've gathered explain why you think the trees are dying. • Answer the reflection questions: **1.** Which resources does a lodgepole pine tree need to survive? **2.** Which pathogens are often deadly for lodgepole pine trees? **3.** When is a predator more likely to kill a tree? **4.** Which natural hazard can be deadly to lodgepole pines? • How did your thinking compare with Isabel and Dr. Mitch? *RESEARCH ASSISTANT NOTEBOOK (RAN): page 1*	• Prompt students to look for patterns in the data they collected about the lodgepole pine trees in order to answer their reflection questions. • If needed, • 1) Use the reflection questions (Online and in the column to the right) to guide classroom discussion, • 2) Have student pairs who are effectively interpreting their data to answer these questions to model their thinking for the class, or • 3) Provide modeling for the class on how to use their evidence to identify patterns that can help us to identify what may be killing the trees. (**Hint:** Use Step 5 of the RAN to help guide students through recognizing patterns.) • You can view your students' responses by navigating (while logged into your Research Quest account) to My Account>View Answers for this investigation.

SECTION 2: ANALYZE - WHAT IS KILLING THE LODGEPOLE PINES? *(70 minutes)*

OVERVIEW

Students will look for evidence of known tree killers (drought, pathogens, predators, and wildfire) in museum specimens and images of lodgepole pine trees from the Uinta Mountains. They will also analyze precipitation and temperature data to look for relationships that could explain this phenomenon.

ASSESSMENT

- **Evaluations:** Students use multiple forms of evidence to evaluate an idea or hypothesis.
- **Interpretation:** Draw graphs to visualize precipitation and temperature data. Use graphs to discern a trend to make evidence supported inferences.
- **Flexible Thinking**: Keep mind open to multiple ideas until all data is evaluated.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 7 *(5 minutes)*	• Watch the video on Step 7 of the investigation. (2:20min.)	• Direct students' attention to the following before beginning the video: *In this video Dr. Mitch and Isabel discuss what types of things might be killing the trees. Listen for why it is important to keep your mind open to multiple ideas as you analyze your data for this phenomenon.*

SECTION 2: ANALYZE - WHAT IS KILLING THE LODGEPOLE PINES? *(Continued)*

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 8 *(20 minutes)*	• Click on each of the 6 tree samples to make observations and use those observations to identify or rule out potential causes of tree death. Repeat the process for all samples (1-6).	• Have a short class discussion about why scientists collect data from multiple sources.
STEP 9 *(5 minutes)*	• Review the chart of your collected data. Look for patterns. What cause(s) of tree death does your evidence point to?	• Guide students in looking for patterns; Ask: Which categories have the most check marks? • *Note:* Students can download their data summaries to use in a final presentation of their findings (during the "Communicate" section) or to add to a science journal to document their path through the investigation.

STEP 10 & STEP 11 *(15 minutes)*	**REVIEW**
	• Compare your data set with the larger data set. Does the larger data set point to the same tree killer(s) as your data?
	• Use Step 10-11 in your *Research Assistant Notebook* to create a bar graph of your data. You will use this evidence later when you communicate your findings.
	• Then, evaluate the evidence you collected to determine: What is killing the lodgepole pines in the Uinta Mountains?
	RESEARCH ASSISTANT NOTEBOOK (RAN): page 2
		• Model how to draw a bar graph. You may elect to do Step 10 as a class. Then, have students work with their partners to do the second one using the Combined data set in Step 11. Drawing these graphs will help them visualize the patterns created by the data.
		• Scientists combine their data with larger data sets to see if patterns they see in smaller amounts of data sets are also present in larger data sets. However, in this scenario percentages might be easier to work with because it helps students quantify the change that is happening and compare their data set to the larger data set.
		  • Percentages are good for showing change over time or comparisons, but not as much detail as raw data can provide. When doing data analysis using raw data is almost always the better option.
		• *Note:* At this point, students are using their data, the evidence, to determine what is causing lodgepole pine trees to die. Their bar graphs can help them with this analysis.
		• Conduct a brief class discussion about strong, weak and disconfirming evidence. *See definitions below:*
		• **Support Vocabulary**
		  • **Raw data** is the total number of data points.
		  • **Percentage** is the ratio of the whole data set.
		  • **Strong evidence** supports one explanation.
		  • **Weak evidence** supports several explanations.
		  • **Disconfirming evidence** rules out explanations.

SECTION 2: ANALYZE - WHAT IS KILLING THE LODGEPOLE PINES? *(Continued)*

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 12 *(5 minutes)*	• Watch the video on Step 4 of the investigation. (2:16 min.)	• Direct students' attention to the following before beginning the video: *In this video Isabel and Dr. Mitch will talk about what they observed in the samples. Listen for the difference between correlation and causation. And, listen for what you will analyze next as you work to answer our research question: What's killing the lodgepole pines? And, what could explain why it is so much worse now than in the past?* • This is an opportunity to discuss *causation vs. correlation.* Depending on your learning goals you may encourage students to use this vocabulary as they communicate their findings. • **Key Vocabulary:** causation, correlation
STEP 13 *(10 minutes)*	• With your partner, examine the precipitation data. What do you notice? *RESEARCH ASSISTANT NOTEBOOK (RAN): page 2*	• If needed explain to students how to read the precipitation (rainfall/snow) totals from these graphs. • Students will make observations to discern whether precipitation has increased, decreased or stayed about the same over the last 100 years. Depending on your learning goals students can discuss before they download or record their responses in their RAN.
STEP 14 *(10 minutes)*	• With your partner, examine the temperature data. What do you notice? *RESEARCH ASSISTANT NOTEBOOK (RAN): page 2*	• If needed explain to students how to read the temperature graphs the same way they read the precipitation graphs. • They will make observations to discern whether temperature has increased, decreased or stayed about the same over the last 100 years. Depending on your learning goals students can discuss before they download or record their responses in their RAN.

SECTION 3: INTERPRET - WHY NOW? *(50 minutes)*

OVERVIEW

Students will discuss and interpret evidence collected in previous sections to construct an explanation, supported by evidence, for why lodgepole pine trees are dying in the Uintas.

ASSESSMENT

- **Interpretations:** Use information from multiple sources to construct an evidence-based explanation.
- **Evaluations**: Consider the strength of each piece of evidence.
- **Flexible Thinking**: Keep mind open to multiple ideas until all data is evaluated.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 15 *(10 minutes)*	• Discuss these questions with your partner: *a.* Why are the lodgepole deaths are so bad this time? *b.* What effect does increasing temperatures and decreased precipitation have on beetles?	• Model how to use evidence to discuss these questions: • Why is the beetle predation so bad this time? • What affect does increasing temperatures have on beetles?
STEP 16 *(20 minutes)*	• Read the facts about bark beetles. Take notes in Step 16 of your *Research Assistant Notebook*. *RESEARCH ASSISTANT NOTEBOOK (RAN): page 3*	• As needed, provide modeling for evaluating text for relevant, useful information and how to reason with that information. Students should take notes they can use to develop a response to their research question.
STEP 17 *(20 minutes)*	• Use the data you gathered during the investigation to answer: • What is killing the lodgepole pine trees and why is this outbreak worse than past outbreaks? • Use the chart in your *Research Assistant Notebook* Step 17 to help you construct an evidence-based explanation. *RESEARCH ASSISTANT NOTEBOOK (RAN): page 3*	• Provide support, as needed, to help students use the data from Step 3, 10, 11, 13, 14 and 16 to develop their claim, evidence and reasoning for the phenomenon/research question. • *Note:* Students can use their *Research Assistant Notebooks* to help them formulate a rough draft. Or, they can type their final draft in the provided sections on the computer, which they can download and print or add to their digital files (for classes that use Google Classroom or Drive).

SECTION 4: COMMUNICATE - SHARE YOUR EXPLANATION. *(20-60 minutes)*

OVERVIEW

Students will construct an explanation, supported by evidence, for why lodgepole pine trees are dying at an accelerated rate in the Uinta Mountains.

ASSESSMENT

- **Interpretations:** Use information from multiple sources to construct an evidence-based explanation.
- **Evaluation:** Consider the strength of each piece of evidence.
- **Flexible Thinking**: Keep mind open to multiple ideas until all data is evaluated.

	STUDENT ACTION	TIPS FOR SUPPORTING CRITICAL THINKING
STEP 18 *(Varies)*	• Write a one act play to communicate your explanation for what is killing the lodgepole pine trees and why it is happening at a faster rate than we've seen in the past. Use personification to develop characters from this ecosystem. For example, the lodgepole pine tree may be visiting a doctor. It may describe its symptoms (the evidence you observed). Its doctor may off a diagnosis (the cause your evidence points to) and why it is happening (the reasons it is so much worse now compared with the past). Be creative! Use the "Script Template" to help. *RESEARCH ASSISTANT NOTEBOOK (RAN): page 4*	• Have students work in pairs to write their one act play. Depending on your learning goals, this is a good opportunity to build collaboration and creativity skills. • As a way to extend their learning and keep them engaged as active listeners, students could act these out with/for their class. The other students can be critics (evaluators) to listen for the claim and evidence that backs the claim. • *Note:* This is just one suggestion for the communication section and is closely aligned with the ELA Speaking and Listening standards. Select a communication strategy that best aligns with your learning goals. Regardless of your approach we recommend using the "Student Rubric for Presenting Arguments" located under the "Teacher Support" tab of the website.
STEP 19 *(4 minutes)*	• Watch the video on Step 19 of the investigation. (1:49 min.)	• Direct students' attention to the following before beginning the video: *In this video Isabel and Dr. Mitch will summarize their findings. Compare their findings with yours. Did you come to the same conclusions? Why or why not?*