11. Recipe for a Lodgepole Pine Forest: Serotinous Cones

Lesson Overview: In this activity students extract seeds from serotinous cones of Rocky Mountain lodgepole pine (also called "closed cones"), count the seeds, report their results, and analyze their pooled data. Then they calculate the number of seeds from serotinous cones that might germinate in a small forest after a crown fire has swept through.

Subjects: Science, Mathematics, Writing, Speaking and Listening
Duration: two half hour sessions
Group size: Whole class, possibly working in teams
Setting: Classroom
Vocabulary: *embryo, filled seed, seed wing, seed bank, serotiny/serotinous*


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Lesson Goal: Students will understand that many lodgepole pine trees have serotinous cones, which means that wildland fire helps them reproduce: Heat from a fire opens their cones, and their seeds drop onto a perfect seedbed. Students will understand that lodgepole pine seeds and subsequent seedlings may be amazingly abundant after a severe fire.

Objectives:

- Students can explain how seeds can get out of a serotinous lodgepole pine cone.
- Students can identify filled versus empty seeds.
- Students can count the number of filled seeds in a cone and record their data on a chart.
- Students can combine the class's data with other information to estimate the abundance of lodgepole pine regeneration after fire.

ABOUT STUDENT PRESENTATIONS: If you assigned lodgepole pine to a student in **Activity E08-2. Who Lives Here? Adopting a Plant, Animal, or Fungus**, this would be a great time for that presentation. If you did not do that activity or did not assign lodgepole pine, we recommend that you either

- have students read the essay on lodgepole pine in the *FireWorks Encyclopedia* (**Elem_FireWorksEncyclopedia_NRM-NC.pdf** in **Activity E08-2**) or
- teach some of the information provided in the **Teacher Background** below.

*The only trunk items needed for this activity are closed serotinous lodgepole pine cones, pie tins, and the histogram poster (also available in **E11_SeedHistogram.pdf**).

Standards:		1st	2nd	3rd	4th	5th
CCSS	Writing	2, 7, 8	2, 7, 8	2, 7, 10	2, 7, 9, 10	2, 7, 9, 10
	Speaking/Listening	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6
	Language	1, 2, 4, 6	1, 2, 4, 6	1, 2, 3, 4, 6	1, 2, 3, 4, 6	1, 2, 3, 4, 6
	Math	MP.2, MP.5, 1.NBT.4	MP.2, MP.4, MP.5, 2.MD.10	MP.2, MP.4, MP.5, 3.NBT, 3.MD.2	MP.2, MP.4, MP.5	MP.2, MP.4, MP.5
NGSS	From Molecules to Organisms: Structures and Processes	LS1.D		LS1.B	LS1.A	
	Biological Evolution: Unity and Diversity			LS4.C		
EEEGL	Strand 1	A, B, C, E, F, G				A, B, C, E, F, G

Teacher Background: Forests of Rocky Mountain lodgepole pine[1] cover very large areas in the West. Most of these forests were established after fire sometime during the past 150 to 300 years. Many of the fires were severe, torching and crowning - at least in patches. These forests will probably burn again in the next century or two, just as they have for thousands of years.

A few years after fire, burned areas in lodgepole pine forests can be home to millions of lodgepole pine seedlings. Why? Some lodgepole pine trees store their seeds in resin-sealed cones that stay on the tree for decades. These serotinous cones – also called "closed cones" - open when heat melts the resin. This frees the seeds, and they fall to the ground in perfect conditions for establishing a new forest: lots of sunlight, bare soil, little shade from overstory trees, and lots of nutrition in the soil for at least a few years.

In this activity, students extract the seeds from serotinous lodgepole pine cones, count them, pool their data, and determine the median and other descriptive statistics. Then they use multiplication and division to estimate the number of seedlings that might germinate in a small forest of burned lodgepole pine trees after a crown fire has occurred.

You can complete this activity in 1 day or 2. See the **Procedure** section below.

Materials and Preparation:

For Day 1:

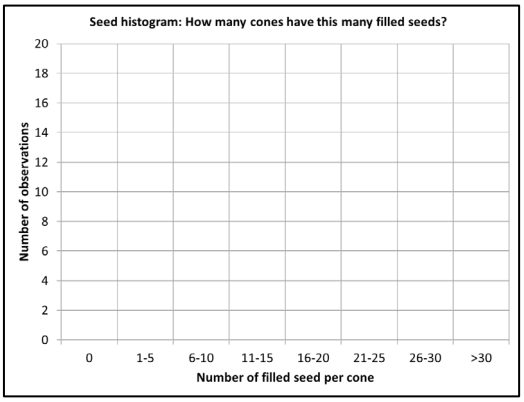
- 1 lodgepole pine cone/student (in trunk)

[1] Rocky Mountain lodgepole pine is just one variety of the species. The biology and reproductive patterns of the other two varieties, Sierra lodgepole pine and shore pine, are very different from those of the Rocky Mountain variety.

- 1 Dixie cup/student or similar non-meltable container. You will heat the cones in aluminum pie tins with hot water to melt the resin, then place the cones in the cups, which will prevent the seeds from falling out as the cones open.
- Set up 3-4 stations, each with an aluminum pie tin, 8- or 9-inch diameter.
- Boiling or nearly boiling water

For Day 2:

- 1 sticky note/student (7.5 cm wide)
- 1 paper plate/student
- Display the poster **E11_SeedHistogram.pdf** (in trunk and also available for download). Note that its columns are 7.5 cm wide, the same width as the sticky notes.
- Look at Step 14 below to decide how deeply you want to get into the statistics. To finish the activity, you only need to discuss the median.
- Download ***E11_LotsaTrees.pptx*** to display at the start of the **Assessment.**



Procedure: This activity has two parts (Day 1 and Day 2). On Day 1, students see what happens when hot water is poured on serotinous lodgepole pine cones. This is a quiet, observational activity, and it doesn't take very long. On Day 2, students examine the cones that have been opened by heat and count the seeds that come out, then pool their data and analyze it extensively with descriptive statistics and calculations. Day 2 is a busier, longer activity.

If you prefer to do this activity in one day, skip the Day 1 procedure and heat the closed cones ahead of time (see the **NOTE** that follows step 8), saving some closed cones for students to compare with the opened ones. Begin the Day 2 procedure with Step 9.

Day 1 Procedure… melting the resin and opening the cones:

1. Distribute the closed lodgepole pine cones and cups, 1/student. Ask: These cones have lots of seeds inside. How can they get out? Students will observe that the cones are closed up tight, and it seems there is no way to get the seeds out. They may try pounding or poking or picking at the cone scales… don't let them hurt themselves!

2. Ask: Is that a problem for the tree? If the tree is ever going to reproduce, the seeds have to get out somehow.

3. Ask: How might the tree solve this problem? Welcome any ideas from the students. Fire is likely to be mentioned. That would be great.

4. Explain: The cones are from a lodgepole pine tree. They are sealed tight by resin, which is like hardened glue. Not all lodgepole pines produce this special kind of cone, but many do. This sealed-up-cone property is called serotiny. Let's use heat to try to melt the resin and

help the seeds get out. We'll use boiling water. The cones will cool off and dry out, and then we'll examine them to see if they've opened up.

5. Explain: Students at each pie-tin station, place your cone in the pie tin. I will pour boiling-hot water over the cones. Don't reach into the water until it cools off. Just observe. **You must be very quiet to listen, smell, and watch** for signs of the resin melting.
6. Pour boiling or very hot water into the pie tins.
7. After a minute, ask for observations. Students may <u>see</u> little bubbles coming from between the cone scales as the resin is melted and the air inside expands and escapes; they may <u>hear</u> the bubbles hiss as they come out of the cones; and they may <u>smell</u> the resin as it melts.
8. After the water has cooled, tell students to label their cups with their names, take their cones out of the water, and placed them in the cups. Then collect the cups for drying.

   NOTE: It may take several days for the cones to open if you air-dry them. You can dry them quickly by heating them as follows; then the seeds will begin falling out in a few hours or the next day. Leave the cones in their cups to do this so the seeds from various cups won't get mixed up.

   - Microwave: 1 minute on high. If the cones do not open well with this much heat, try another minute. Let them cool before handling them.
   - Oven: Place the cones (in cups) on foil on a cookie sheet and heat them in a conventional oven at 300º F for at least 30 minutes. The foil will catch any wax that melts off the cups.

<u>Day 2 Procedure… after the cones are dry and at least partly open:</u>

9. Give students their cone-filled cups, with cones that are now dry and at least partly open.
10. Give each student a paper plate for collecting the seeds when they are extracted from the cones.
11. Explain:

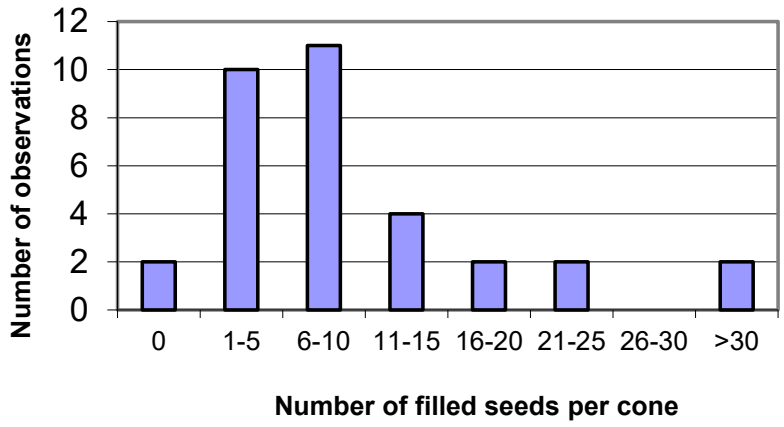
    - From the open cone in the cup, extract as many seeds as you can. You can shake, bang (carefully), and pull – but don't hurt yourselves! Some seeds may have already fallen out into the cup. Some cones may not have any seeds. That is not a problem. In fact, it is very important information to record.
    - Look for **filled seeds**. Explain: Each seed has two parts – a papery "wing" and the actual seed. If the seed has an embryo in it (that is, a baby tree), it will be a dark oval, 1-2 mm across; this is called a filled seed. Ignore any seeds that are smaller; they do not contain an embryo.
    - Count the filled seeds and write that number with big print on your sticky note.

- Place your sticky note in the correct column of the frequency diagram (i.e., **E11_SeedHistogram.pdf** poster), building up from the bottom. This way we can see how many cones have various numbers of seeds.

12. Ask: What does the frequency diagram show? Cones vary a lot in the number of seeds they contain, from zero to (perhaps) a large number. Some columns of the graph seem more common than others.

13. Together with the class (or individually for advanced students), figure out any or all of the following descriptive statistics. **The MEDIAN is the only statistic that you MUST have to complete the Assessment.** Explain: We use statistics to describe the patterns we see in data like the those we just collected – the numbers of seeds in lodgepole pine cones.

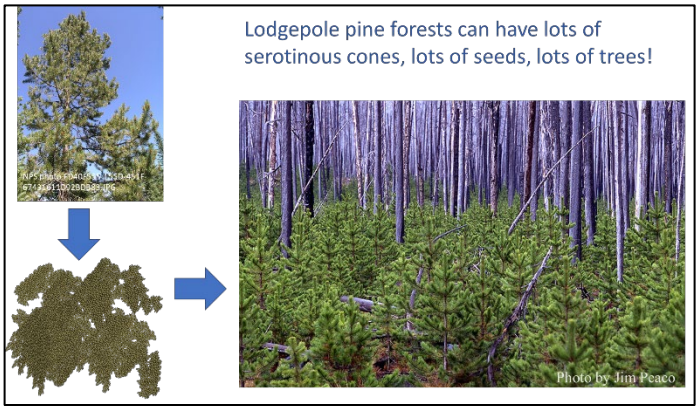
Sample of frequency diagram (histogram): Data were collected by an 8th grade class.



- What is the minimum number of filled seeds per cone? Smallest number – probably zero.
- What is the maximum number of filled seeds per cone? Greatest number counted – in the right-most column of the histogram.
- What is the range of our data? Our data range from the minimum to the maximum.
- What is the mode? In other words, what is the most "popular" number? This is the number with the tallest column, the most sticky notes. It could be zero.
- What is the median? Have two students help, one at the left side of the frequency diagram and one on the right. With a pencil, have them circle the number on each sticky note – one at a time – until they meet in the middle. That is the midpoint of the data set, the median.
- What is the average or mean? With students' help, add the values on all the sticky notes and divide by the number of notes.

Assessment:

1. Project ***E11_LotsaTrees.pptx***. Explain: Lodgepole pine forests in the northern Rocky Mountains and North Cascades sometimes have LOTS of tree seedlings, especially after a fire. Just how many is "lots"? For example, how many seedlings might we find in an area as big as a football field? Write some guesses on the board.



2. Explain: We can use our data to estimate how many seedlings might come up in a forest as big as a football field the year after a fire.
3. Give each student a copy of **Handout E11-1. From cone to forest.** Read through the introduction with them as needed. Have them all answer Question 1 together – that is the **median number of filled seeds/cone** (from the data gathered by the class). Have students complete the rest of the handout.
4. After the students finish, compare their answers with the guesses they made in Step 1. Discussion.

Evaluation: Refer to Answer Guidelines for Handout E11-1. From cone to forest below.

Note that the correct answer for each question after #1 depends on the previous answer. If one answer is incorrect, you'll need to calculate all subsequent answers based on that incorrect one in order to figure out if the later calculations were done correctly.

	Excellent	Good	Fair	Poor
Number correct	6	5	4	<4

Handout E11-1. From cone to forest

Name: _____

Use the class's data to estimate how many baby lodgepole pine trees you might find in a forest the summer after a crown fire[2]:

Suppose we have a small lodgepole pine forest near our school. It is about as big as a football field. It contains 500 trees, and most of the trees produce serotinous cones.

1. Suppose the **median number of filled seeds per cone** in our forest is the same as what we observed in class: _____ **seeds/cone.**

2. Suppose each of the trees in our forest produces about 800 cones in a typical year. **How many filled seeds is it likely to produce in 1 year?**

3. Suppose most of the cones and their seeds stay healthy for at least 20 years.[3] This means that they contain embryos that can grow into healthy trees. The stored seeds are called a seed bank. **How many seeds are in an average tree's seed bank?**

4. Recall that our small forest has 500 lodgepole pines in it. **How many seeds are in the seed bank for the whole forest?**

5. Suppose a crown fire burns through our little forest, releasing about half of the seeds in its seed bank. **How many seeds fall to the ground?**

6. Suppose about 1/3 of the seeds that fall to the ground produce baby lodgepole pines the next spring. **How many baby trees will be in our football-field-sized forest?**

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[2] The numbers in this handout (cones/tree, trees/unit area, etc.) are not just made up; they came from a literature review of fire effects on Rocky Mountain lodgepole pine (www.fs.usda.gov/database/feis/plants/tree/pinconl/all.html).

[3] Once a serotinous cone produces seeds, it will not produce any more seeds in future years, but the tree can produce more cones in future years.

Answer Guidelines for Handout E11-1. From cone to forest

Use the class's data to estimate how many baby lodgepole pine trees you might find in a forest the summer after a crown fire:

Suppose we have a small lodgepole pine forest near our school. It is about as big as a football field. It contains 500 trees, and most of the trees produce serotinous cones.

1. Suppose the **median number of filled seeds per cone** in our forest is the same as what we observed in class: _____ **seeds/cone.**

2. Suppose each of the trees in our forest produces about 800 cones in a typical year. **How many filled seeds is it likely to produce in 1 year?** Multiply the median from the class's data * 800. Example: If the median was 6 filled seeds/cone: 6 filled seeds/cone * 800 cones/tree = 4,800 seeds/tree in 1 year

3. Suppose most of the cones and their seeds stay healthy for at least 20 years. This means that they contain embryos that can grow into healthy trees. The stored seeds are called a seed bank. **How many seeds are in an average tree's seed bank?** Multiply the answer from (2) * 20. Example: 4,800 seeds/tree/year * 20 years = at least 96,000 seeds in that tree's seed bank

4. Recall that our small forest has 500 lodgepole pines in it. **How many seeds are in the seed bank for the whole forest?** Multiply the answer for (3) * 500. Example: 96,000 seeds/tree * 500 trees = 48,000,000 seeds in the forest's seed bank

5. Suppose a crown fire burns through our little forest, releasing about half of the seeds in its seed bank. **How many seeds fall to the ground**? Divide the answer for (4) by 2. Example: 48,000,000 seeds in the forest's seedbank/2 = 24,000,000 seeds on the ground

6. Suppose about 1/3 of the seeds that fall to the ground produce baby lodgepole pines the next spring. **How many baby trees will be in our football-field-sized forest?** Divide the answer for (5) by 3. Example: 24,000,000 seeds on the ground/3 = 8,000,000 baby trees!