11. Recipe for a Baker cypress grove: Serotinous Cones

Lesson Overview: In this activity, students extract seeds from *serotinous* cones, count them, and estimate the number of seeds that might fall in an area after a large, severe fire.

Lesson Goal: Students will understand that Baker cypress and knobcone pine cones are *serotinous* and need wildland fire to open their cones and release their seeds. Thus they can establish a new forest after fire.

Subjects: Science, Mathematics, Writing, Speaking and Listening

Duration: two half hour sessions

Group size: Whole class, possibly working in teams

Setting: Classroom

New FireWorks Vocabulary: *embryo, filled seed, seed wing, serotiny/serotinous*

Objectives:

- Students can identify filled vs. empty seeds.
- Students can explain the importance of fire and serotiny for regeneration of knobcone pine and Baker cypress.

ABOUT STUDENT PRESENTATIONS: If you assigned Baker cypress to a student in **Activity E08. 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 Baker cypress, we recommend that you either

- have students read the essay on Baker cypress in the *FireWorks Encyclopedia* (pp. 5-6 in either **FireWorksEncyclopedia_YoungerGrades.pdf** or **FireWorksEncyclopedia_OlderGrades.pdf**) or
- teach some of the information provided in the **Teacher Background** below.

Standards:		1st	2nd	3rd	4th	5th
Common Core Math	Operations/Algebraic Thinking	1,2,3,7	1,2,3	1,3,5,8		
	Number and Operations Base Ten	1,2	1,2,3,4,5,6,7,8	1,3		
	Measurement and Data	1				
	Represent and Interpret Data		10	3		
NGSS	Structure, Function, and Information Processing	LS1.A, B				
	Interdependent Relationships in Ecosystems		LS2.A	LS2.C, LS4.C		
EEEGL	Strand 1	C,E,F,G				C,E,F,G

Teacher Background:
Children, as well as adults, often assume that fire is a catastrophe for all living things. Throughout Unit V of FireWorks, students learn that many native species in the Sierra Nevada can survive fire and/or reproduce well afterward. This activity demonstrates that 2 tree species in California – knobcone pine and Baker cypress – actually NEED fire to reproduce well, and the hotter the fire, the better.

In this activity, boiling water is used to open the cone of a knobcone pine. These cones are *serotinous* – that is, remaining closed on the tree with seed dissemination delayed (from the Latin *sero,* meaning "late). Students will observe the cone gradually opening and then count the number of *filled seeds* that fall out. Filled seeds are those that contain an *embryo*; they are larger and more solid than unfilled seeds, which have not matured (possibly because they were not pollinated) and cannot produce a new plant. Filled knobcone pine seeds are about a half centimeter across.

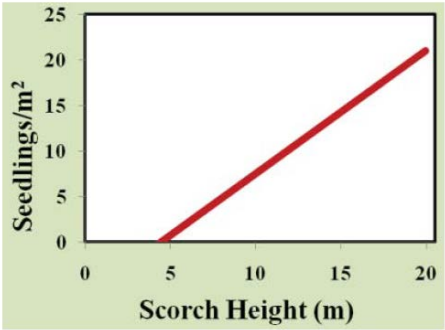
While this activity uses knobcone pine cones to demonstrate serotiny, knobcone pines are a foothills species rather than a montane species, so they are not included in the rest of this curriculum. We use them to demonstrate serotiny because the serotinous species that does occur in montane forests of the Sierra Nevada – the Baker cypress – is very rare and its seeds are too precious to be collected for classroom demonstrations.

About Baker cypress: Baker cypress stands are only found in 11 locations northern California and southern Oregon. They grow in dry places on mountains from about 1,000 to 2,200 meters.

Baker cypress trees evolved to burn; that is, they are adapted to fire, and they depend on fire. Baker cypress cones are *serotinous*. That means that the cones remain sealed shut until the heat from a fire melts the cones' resinous coating. Once the coating is melted, cones open and release their seeds. The seeds fall to the ground in perfect conditions for establishing a new grove: lots of sunlight, few overstory trees, and lots of nutrition in the soil for at least a few years.

Not just any fire is hot enough to melt the resinous coating on Baker cypress cones. Intense crown fires kill the mature trees, but they are exactly what Baker cypresses need to release their seeds. In fact, crown fires are more likely to occur in Baker cypress groves than in many Sierra forests because the trees grow in dense thickets and retain their dead lower branches – perfect ladder fuels for a crown fire.

In recent years, land managers have noticed that Baker cypress trees are dying and groves are not regenerating. Although Baker cypress is adapted to wildland fire, fire has been excluded from their groves for almost a century. Wildland fires, such as the 2007 Moonlight Fire in the Plumas National Forest, may help these old groves regenerate. After the Moonlight Fire, scientists found that Baker cypress seedling density was highest in areas where the fire was most severe (as indicated by the height of scorch on trees).[1]



Materials (<u>not provided</u> in FireWorks trunks)

- One or two knobcone pine cones
- Boiling water
- Jar that is large enough to fit 1 or more knobcone pine cones and cover them with water

Procedure: This activity has two parts (Day 1 and Following Days). In Day 1, teachers place the cone(s) in a transparent jar of boiling water, and students observe sights, sounds, and smells of the resin melting and possibly of cones beginning to open. In the following days, students witness the cone(s) opening and seeds falling out.

Procedure - Day 1:

1. Pass around the knobcone pine cone(s) for students to examine. Ask: These cones have lots of seeds inside. How can they get out? Have the students 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 picking at the cone scales… don't let them hurt themselves!

2. Ask: Is that a problem for the tree? Discussion – 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: This kind of tree and a few others have unusual cones. They are sealed tight by a resin, which is like hardened glue. This property is called *serotiny.* If we heat the cones, the resin will melt and the seeds will fall out. Another kind of tree with serotinous cones is Baker cypress, but we will not use them in this lesson because Baker cypress groves are rare and precious, so we don't want to take any of their cones.

5. Explain: Let's use boiling water to melt the resin and open the cones in our jar. **Tell students to be very quiet and to listen and look** for signs of the resin melting. Poor boiling or very hot water into the cone-filled jar.

[1] https://www.firescience.gov/projects/briefs/06-2-1-17_FSBrief126.pdf

6. After a minute, ask for observations. They may include seeing little bubble of gas coming from between the cones scales as the resin melts and the air inside expands and escapes; seeing the melted resin as an oily or waxy layer on top of the water; hearing the bubbles hiss as they come out of the cones; smelling the resin as it melts. **NOTE:** It may take several days for the cones to dry out and open. You can dry them more quickly by heating them. If you do this, seeds will begin to fall out the next day.

   - 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 cone on foil on a cookie sheet and heat them in a conventional oven at 300º F for about 30 minutes.

7. Hang the cones upside-down from somewhere in your classroom where they will not be disturbed for a few days. Place a white cloth or large sheet of paper below them to catch the seeds.

Procedure - Following Days … after the cones are dry and open:

8. Observe any seeds that have fallen out.

9. Shake the cones over your sheet/paper to get any remaining seeds out.

10. Have the students examine the seeds.

11. Explain: Each seed has two parts – a long papery *wing* and the actual seed. Seeds that have *embryos* inside (baby trees) will be 5-7 mm long; these are called *filled seeds*. Seeds that are much smaller are empty (containing no embryo), and students should not count them.

12. Have students count the filled seeds.

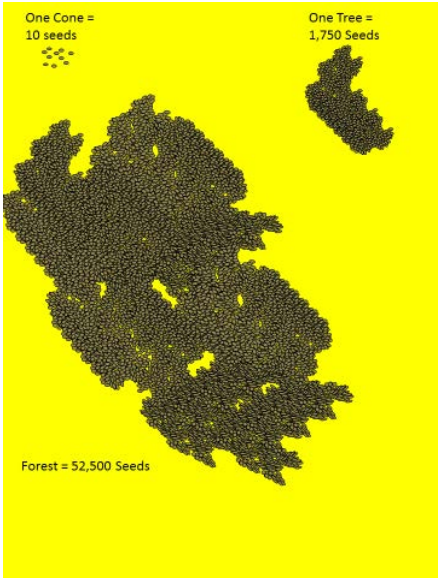
13. Explain: We can use our data to estimate how many seeds a whole tree produces in a year and how many seeds might be stored in a whole tree, ready for the next fire to open the cones.

    a. Suppose the tree that produced these seeds makes 175 cones its lifetime. How many filled seeds is it likely to produce? Multiply the filled seed count from your demonstration by 175. If you opened more than 1 cone, use the average seed count from all of them.

    b. Suppose our tree is in a forest about the size of a football field with 30 knobcone pines in it. How many seeds might be in the seed bank for that whole forest? Multiply the answer from (a) by 30.

    14. Have a couple of students make a poster containing all of this information. Glue the seeds to the poster or put them in a bag nearby. Display the poster and seeds next to

the cone. (In case you would like to show them an example, this graphic – using 10 seeds/cone - is available in the FireWorks files, entitled **Lotsa_seeds)**



Assessment:
Have each student write a short paragraph that answers this question: **What would happen to knobcone pine and Baker cypress forests if fires never visited their homes?**

Evaluation: Answers should include this information:

- Knobcone pines and Baker cypress trees are serotinous, which means that their cones will not open without heat.
- If fires do not burn these trees, very few of their cones will open up – perhaps none will open. So they will not be able to release their seeds, and no baby knobcone pine or Baker cypress trees will grow.
- Without fire, the old trees will eventually die, and new young trees will not take their place.