



18. Fire History 3: Fire Regime across a Sierra Nevada Landscape

Lesson Overview: Students learn about mixed-severity fire and the complexity of actual historical fire regimes. They study information from a published research project, model results, and maps showing present patterns of fire severity. Then they use their understanding to create a stand age diagram for a hypothetical forest in the Sierra Nevada with a mixed-severity fire regime and decide if their imagined forest has a fire regime that is substantially different from its historical fire regime.

Subjects: Reading, Writing, Speaking and Listening, Math, Science

Duration: 1-2 30-minute sessions

Group size: Whole class, working singly

Setting: Classroom

FireWorks vocabulary: *landscape-level diversity, mixed-severity fire*

Lesson Goals: Students understand the nature of mixed-severity fire regimes and their contribution to landscape-level diversity in the Sierra Nevada. Students can use a quantitative method to describe a hypothetical concept. Students can make a judgment call based on quantitative information.

Objectives:

- Students can draw a hypothetical stand age diagram that depicts a history of mixed-severity fire and shows how it influenced the distribution of two or more tree species in the forest.
- Students can judge whether their hypothetical forest shows a pattern of fire now that is substantially different from its historical fire regime.
- Students can state some potential ecological consequences of a changed fire regime.

Standards:		9th	10th	11th	12th
Common Core ELA	Reading Informational Texts		1,2,4,		1,2,4
	Speaking and Listening		1,4,		1,4
	Reading Science/Technical Subjects		3,5,7,10		3,5,7,10
	Writing Science/Technical Subjects		7,10		7,10
	Science/Technical Subjects		2,4,5,6,7,8,9,10		2,4,5,6,7,8,9,10
NGSS	Structure and Function			LS1.A	
	Interdependent Relationships in Ecosystems			LS2.A, LS2.C,LS2.D, LS4.C	
	Natural Selection and Evolution			LS4.B, LS4.C	
	History of Earth			ESS1.C, ESS1.A	
	Earth's Systems			ESS2.A	
EEEGL	Strand 1			C,E,F,G	

Teacher Background: In the previous two lessons, students learned that low-severity fires were characteristic of some forest stands in centuries past (including California oak woodlands, mixed-conifer forests, and Jeffrey pine forests), and stand-replacement fires were characteristic of others (mainly Baker cypress, in the Sierra Nevada). However, ecosystems are not this simple in reality. Ponderosa pine forests did experience stand-replacing fire, and fire scars can be found on some of the trees that seem most vulnerable to fire, such as Sierra lodgepole pine. When a single fire has a variety of effects – some mortality in overstory trees, some trees only scarred or not even touched by fire – we call it a *mixed-severity fire*. When an ecosystem has a history of mixed-severity fires or experiences fires of different severities over time, we say it has a *mixed-severity fire regime*.

The fire regime for most of the montane forests in the Sierra Nevada was dominated by low-severity fire, but the pattern was far from uniform, especially when variation in fire severity was superimposed on a landscape with varying topography and vegetation. Students used a summary of fire history for mixed-conifer forests in the Assessment in the previous activity (**H18. Fire History 2: History of Stand Replacing Fire**):

The majority of the landscape burned fairly often, and the majority of fires were of low severity. However, there were definitely patches that seldom burned, and there were definitely patches that burned with high (stand-replacement) severity. The authors call this landscape pattern a “relatively fine scale” that contained a lot of large, old trees and had an open structure – but that also had a variety of stand ages and combinations of species, all contributing to high diversity across the landscape.

In this activity, they learn about mixed-severity fire, and then they study evidence for the mixture of fire severities that characterized historical montane forests of the Sierra Nevada. Finally, they apply their understanding of fire regimes to judge whether the patterns of fire in current forests is substantially different from the historical fire regime – that is, are current forests “out of whack”? And if they are, what might be some consequences?

For more background, view the presentation and notes for the activity:

H18_MixedSeverityFireRegime.pptx.

Materials and preparation:

1. Download ***H18_MixedSeverityFireRegime.pptx***
2. Make 1 copy/student or team: **Handout H18-1: Imagine a forest with a mixed-severity fire regime.**

Procedure:

1. Explain: In the last two activities, we learned how low-severity fires and stand-replacing fires shape a forest stand, and we learned how to determine a stand’s fire history. But we have focused on one kind of fire at a time, and that oversimplifies the real historical pattern

of fire across a landscape – its complete fire regime. In historical times, Sierra Nevada ecosystems often had a mixture of fire severities. Land managers want to know what the mixture was, and they want to know if today’s fire regimes are “out of whack.” Why do these things matter? **The fire regime now could be so different from historical times that some native plant and animal species don’t have the habitat they need anymore. It is managers’ responsibility to make sure they provide for healthy populations of all native species – that is, to protect the land’s biodiversity. To do that, they need to provide landscape-level diversity in habitat.**

2. Explain: We’re going to look at stand history diagrams from another location with a complicated historical fire regime – the Pumice Plateau in central Oregon. That will help us understand how diverse a fire regime can be. Then we’ll compare data on the past and present fire severities in the area of the Plumas National Forest to help answer this question: “Is the current fire regime in California montane ecosystems out of whack?”
3. Go through the presentation **H18_MixedSeverityFireRegime.pptx**:

Slides and notes for H18_MixedSeverityFireRegime.pptx

Slide 1

Is the current fire regime in California montane ecosystems out of whack?

- First, information on a complex fire regime in central Oregon
- Then, maps and data for comparing current fire patterns with historical ones
- Third, your answer!

Photo by Sara Abrahamson. Used with permission.

Slide 2

ARTICLE

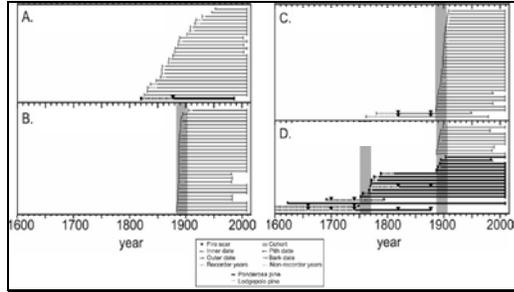
Oregon
study area

Mixed-severity fire in lodgepole pine dominated forests: are historical regimes sustainable on Oregon's Pumice Plateau, USA?
Emily K. Heyerdahl, Rachel A. Luskman, and Donald A. Falk

Heyerdahl, Emily K., Luskman, Rachel A., Falk, Donald A. 2016. Mixed-severity fire in lodgepole pine dominated forests: are historical regimes sustainable on Oregon's Pumice Plateau, USA? Canadian Journal of Forestry 44(5): 593-603.

Some fire regimes are very complex. Here is information on a place in central Oregon where the historical fire regime had some low-severity fire and some severe fire – a *mixed-severity* fire regime. The study was conducted on the Deschutes National Forest. The ecosystem is unique because the forest has developed on pumice soil, which was formed by the eruption of the Newberry Crater 1300 years ago. The pumice is poor in nutrients for plant growth, and the site is prone to unusual summer frosts.

Slide 3



The researchers collected increment cores and samples of fire scars from 30 plots. The variety was amazing! Here are stand history diagrams from 4 of the plots. Let's make sure we can interpret these diagrams.

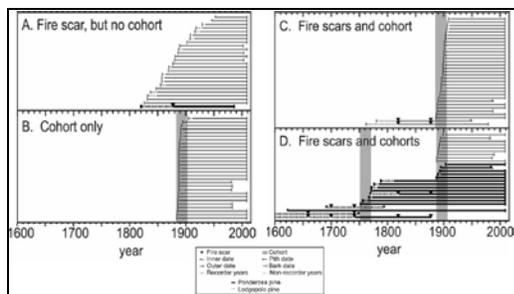
(Go through the key. The only new terms here are *recorder years* – the years after the first scar – and *nonrecorder years* – the years before the first scar or when the margin of the catface could be dated.)

Why are all those early years excluded from the data? It takes more heat to create the first scar than to create subsequent ones (because of the insulation from the thick bark). Several surface fires may have burned around the tree before one of them was intense enough to kill the cambium. So, if you included those first years, the average fire interval would seem longer than it truly was.

How would you describe the fire pattern in each of these stands?

- Graph A shows a stand that has recorded only 1 surface fire (on a ponderosa pine that is now dead) and has no cohorts to indicate any history of stand-replacing fire. The lodgepole pines in this plot have become established gradually over the past 200 years.
- Graph B shows 1 cohort, all lodgepole pines, and no fire scars; it is likely that every tree in this stand established after a stand-replacing fire, which killed the previous forest and provided lots of sunshine and nutrients for new trees.
- Graphs C and D show a mixed-severity fire history. In C, most of the trees (all lodgepole pines) are in a cohort that probably established after fire – perhaps the same fire that scarred 2 trees (now dead) on the plot. In D, there is evidence of stand-replacing fire in the mid 1700s and late 1800s, and there is also evidence of many low-severity fires that scarred ponderosa pines.

Slide 4



Here is how the scientists described the evidence for fire in each stand.

Slide 5

Mixed-severity fire regime

A mixed-severity fire regime is a pattern in which fires tend to cause selective mortality in the upper canopy layer (depending on different species' susceptibility to fire), or vary in time or space between low-severity and stand-replacement...
<http://www.fs.fed.us/database/feis/glossary2.html>

When an individual fire causes some stand replacement and some fire scarring, it's called a *mixed-severity fire*. This is a fairly new term in fire research. Scientists have also used "moderate-severity fire" and "mosaic fire" to describe complicated patterns of fire on the landscape. When the fire pattern over a big landscape and over a long time period is a mixture of stand replacement and low severity, it's called a *mixed-severity fire regime*.

Slide 6

How important was each fire severity historically in the Sierra Nevada?

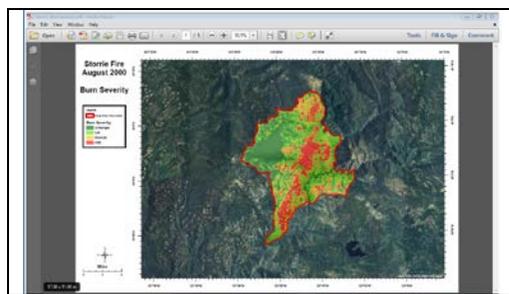
Historical Fire Severities in Mixed-conifer Forests of the Sierra Nevada*

Midpoint of estimated fire intervals (yr)	% of fires		
	Low severity	Mixed or "Moderate"***	Stand replacement
16 yr	68%	24%	8%

*Based on a search for fire regime descriptions provided by LANDFIRE for Biophysical Settings in the Plumas National Forest, CA, as summarized by The Fire Effects Information System (ffis.org/ffis).
 **Based on the midpoint between the lowest and highest percentage of fires of this severity shown for the Biophysical Settings included in the plant community type, as modeled for LANDFIRE. (More information on LANDFIRE modeling is available at <http://www.landfire.gov/summary.html>).
 ***The meaning of "Moderate severity" is very similar to the meaning of "mixed severity." "Moderate" is often used in positive monitoring, while the LANDFIRE models use "mixed."

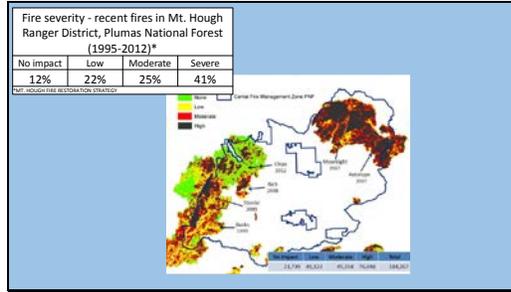
How important was each kind of fire (low-severity, moderate or mixed, and stand-replacement) in the area of the Plumas National Forest? Here are some estimates calculated by LANDFIRE modeling of fire and forest succession after fire in mixed-conifer forest of the Sierra Nevada. **This forest type had lots of low-severity fire, but it also had moderate-severity fires and occasional patches of stand-replacement fire.**

Slide 7



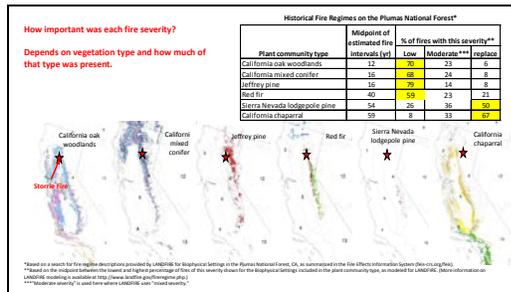
After a big wildland fire like the Storrie Fire of 2000, scientists use satellite imagery to create maps like this one. It shows a lot of variety in fire severity, including a large patch in the western part of the fire that was not burned but was surrounded by burned area. Managers use fire severity maps to decide where there might be high risk of erosion.

Slide 8



Do montane mixed-conifer forests in the Sierra Nevada still have a fire regime like the historical one? Recall: That was mostly low-severity fire, some mixed-severity, and occasional or small areas of stand replacement. **The data from these 18 years show much more severe fire and much less low-severity fire than occurred in past centuries.**

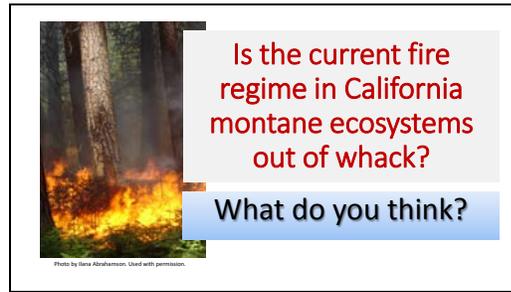
Slide 9



How important was each kind of fire (low-severity, mixed-severity, stand-replacement severity) in the variety of forests types on the Plumas National Forest? Here are some estimates calculated by modeling fire and succession.

We can see that the first 3 types (dominated by oaks, mixed-conifer forest, and Jeffrey pine) had lots of low-severity fire and were very prevalent in the area of the Storrie Fire. Red fir forests also had plenty of low-severity fire, but they had substantial amounts of the other severities too. Only the lodgepole pine and chaparral types showed more stand-replacement than low- or mixed-severity fire.

Slide 10



Assessment:

1. Give each student a copy of **Handout H18-1: Imagine a forest with a mixed-severity fire regime.**
2. Explain: This activity will challenge both your imagination and your quantitative skills. You will “make up” a forest with a mixed-severity fire regime, and you will describe it *quantitatively* – using a stand history diagram like the ones we’ve been creating from data in previous activities and the ones we’ve looked at in the presentation for this activity.

- Go through the directions in the handout. Answer questions. Provide suggestions and help as needed while students draft their stand history diagrams.

Evaluation: See **Teacher's example solution for Handout H18-1: Imagine a forest with a mixed-severity fire regime** for an example of a stand history diagram that meets the requirements listed on the handout.

Excellent	Good	Fair	Poor
<p>~Student included all 6 required features listed on Handout H18-1.</p> <p>~Narrative and/or labeling was clear.</p> <p>~Student selected appropriate fire-resistant species (most likely ponderosa pine or Jeffrey pine) and fire-vulnerable species (most likely white fir or Sierra lodgepole pine).</p> <p>~Student answered the final question and gave a logical explanation.</p>	<p>~Student included 5 of required features</p> <p style="text-align: center;"><u>or</u></p> <p>~Narrative/labeling was unclear</p> <p style="text-align: center;"><u>or</u></p> <p>~Species selections were not ecologically appropriate.</p> <p style="text-align: center;"><u>or</u></p> <p>~Student did not answer the final question with a logical explanation.</p>	<p>~Student included 3-4 of required features</p> <p style="text-align: center;"><u>or</u></p> <p>~narrative/labeling was incorrect</p> <p style="text-align: center;"><u>or</u></p> <p>~Species selections were not ecologically appropriate.</p> <p style="text-align: center;"><u>or</u></p> <p>~Student did not answer the final question with a logical explanation.</p>	<p>~Student included less than 3 of required features</p> <p style="text-align: center;"><u>or</u></p> <p>~narrative/labeling was incorrect</p> <p style="text-align: center;"><u>or</u></p> <p>~Species selections were not ecologically appropriate.</p> <p style="text-align: center;"><u>or</u></p> <p>~Student did not answer the final question.</p>

Handout H18-1: Imagine a forest with a mixed-severity fire regime.

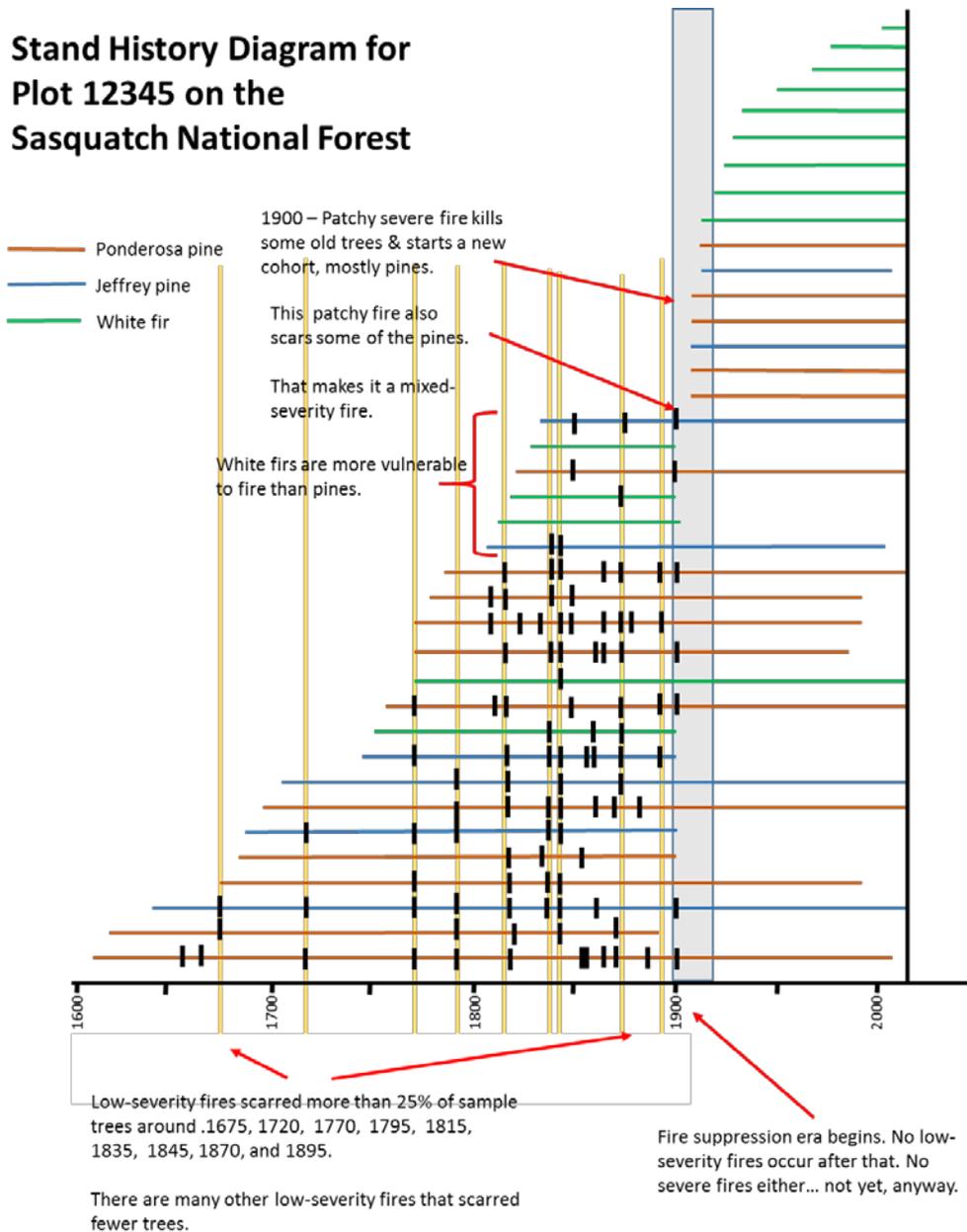
For this assignment, you will use what you know about historical fire regimes to imagine and describe a montane forest in the Sierra Nevada. Your description will be quantitative – that is, based on numbers and displayed as a *stand history diagram* – rather than qualitative, like the forests described for Activity H17.

Create a stand history diagram that describes a forest in a California montane ecosystem that had a history of mixed-severity fire before the fire suppression period. You can draw the stand history diagram by hand or use a computer program. No matter what medium you use, you may find it easiest to sketch the diagram in pencil before creating a finished product. Make it as complex as you like, but you must include at least the following:

- a) A timeline at the bottom that goes back at least 400 years
- b) Timelines for trees of at least two different species – one that grows thick bark at an early age so it can survive low-severity fires, and another that has less resistance to fire. Label each tree's timeline with its species or use a color key to show the species of each tree.
- c) At least 1 severe fire – that is, one that initiated a new cohort
- d) At least 4 low-severity fires – that is, they scarred some trees
- e) The start of the fire suppression period
- f) Either labels on the diagram or a separate paragraph that identifies all of these features
- g) Answer these questions: **Is the fire regime of your imagined forest out of whack? How do you know it is (or isn't)? If it is, what are some possible ecological consequences?**

Teacher's example solution for Handout H18-1: Imagine a forest with a mixed-severity fire regime.

Stand History Diagram for Plot 12345 on the Sasquatch National Forest



The forest looks out of whack because there have been no low-severity fires since 1900, there have been more and more white firs growing in, and there have been no ponderosa pines or Jeffrey pines establishing. The loss of the pines – and the closure of the forest due to white fir regeneration – alter the habitat for understory plants and for animals that rely on open habitat with big, old trees.