Lesson Overview: Students use the stand history diagrams that they assembled in the 2 previous activities to learn about mixed-severity fire regimes. They apply this understanding as they learn about the historical fire regimes in 3 forest communities of the northern Rocky Mountains and North Cascades – forests dominated by ponderosa, lodgepole, and whitebark pines. In the Assessment, they read articles about fire regimes in these forest types and summarize an article in a news blog.

Lesson Goals: Understand the nature of low-severity, stand-replacing, and mixed-severity fire regimes. Recognize the most prevalent fire regime in 3 forest community types. From technical articles, learn how fire regimes may have changed over the past century and explain why changes in a fire regime matter.

Objectives:

- Students can recognize low-severity, mixed-severity, and stand-replacing fire regimes from stand history diagrams.
- Students can understand a 1-page technical article on a fire regime.
- Students can write a concise blog that summarizes information on a fire regime, how it may have changed over the past century, and why that matters.
- Students can identify strengths and weaknesses in blogs written by other students.

### Standards

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Teacher Background: In the 2 previous activities, students used data from a published research study to assemble stand history diagrams that showed low-severity and stand-replacing fire regimes. Both of these patterns were common historically in forests of the western United States. In this activity, they learn about a third common pattern, the mixed-severity fire regime.

A forest with a mixed-severity fire regime has some places where fires were severe enough to replace old stands with young ones... and other places where some of the big trees were killed but others survived (probably with fire scars)... and yet other places that have not burned at all in a long time. A forest with a mixed-severity fire regime may also experience low-severity fires that alternate over time with stand-replacing fires. In other words, its fire history is all mixed up – and that history produces very complex forests with a mixture of tree species and ages.

In this activity, students also learn about the fire regimes that were most prevalent historically in the 3 forest communities they have been studying:

- Most ponderosa pine/Douglas-fir forests from the northern Rocky Mountains to the North Cascades had fire regimes of frequent, low-severity fire in past centuries, but they also had occasional mixed-severity fires, and sometimes they also had stand-replacing fires.
- Most lodgepole pine/subalpine fir forests in the region had historical regimes of either stand-replacing or mixed-severity fire, depending on fuels, topography, and weather patterns.
- Most whitebark pine forests had mixed-severity fire regimes.

For more details on these forest types and their fire regimes, how they have changed in the past century, and why the changes are important, see the technical readings that students summarize in the Assessment for this activity (in the Appendix and available for download from 3FireRegimes_TechnicalReadings.docx) and the related Evaluation section below.

Materials and preparation:

- Note that the PotholesStudyArea.pptx projection from Activity M18andH17_High-sevFireHist should still be on display.

- Take the stand history diagrams from the previous 2 activities and move them so the one showing stand-replacing fire is above the one showing low-severity fire. Tuck the “Dot Diagram” information on the stand-replacement diagram under the top of the low-severity diagram to make them look more continuous. IF YOU DON’T HAVE THESE DIAGRAMS, YOU CAN JUST START WITH THE PRESENTATION BELOW.

- Download M20_MixedSeverity&3ForestTypes.pptx.
• Make 1 copy/student of Handout M20-1. News blog.

• Print 1 copy/3-student team of the technical readings in the Appendix or make them available electronically from M17andH16_DendroForFireHist.docx.

Procedure:

1. Explain: The increment cores and tree cookies that we’ve studied were sampled in different ways, but all of them came from the same research study in the same area of central Oregon. Let’s combine the information from the two of them to see if we can learn more about the fire history of the area.

2. Go through M20_MixedSeverity&3ForestTypes.pptx:

   Slide 1
   All of the increment cores and fire- scarred tree cookies that we’ve looked at came from the same study area in central Oregon. Let’s see what happens when you have a mixture of low-severity and stand-replacing fire over time and space.

   Slide 2
   The top diagrams here are like the ones we constructed in class. The diagram based on fire scars – showing a history of low-severity fires - is on the left. The diagram based on increment cores – showing a history of stand-replacing fire - is on the right. When we combine them to describe the whole area and all of the variety it contains, what can we say about the history of the whole, big area? Over the past 500 years, the area has experienced both low-severity and stand-replacing fire. The cohort that started in the late 1800s (mostly lodgepole pine) probably started after the 1877 fire. This fire also scarred 5 ponderosa pines, and 3 of them died the next year. So the 1877 fire must have had some low-severity areas and some stand-replacing areas. When we put all of our data together – from fire scars and increment cores - what can we say about the area’s fire regime? Perhaps the area has had a mixed-severity fire regime. Or perhaps the fire regime changed from low-severity to stand-replacing in the early 1900s.

   Slide 3
   Let’s look at more information about mixed-severity fire regimes. They are pretty common. Here’s an example from a stand with ponderosa pines, Douglas-firs, and other firs. The design of this diagram is just a little different from the ones we put together: First, the fire scars in this diagram are shown with black triangles rather than straight lines... and second, the different tree species are shown with different colors.
So... what is the story of this forest? The forest had a lot of low-severity fires until around 1900 but has had none since then. There was a stand-replacing fire in the early 1700s. It didn’t scar any trees that we know of, but it led to establishment of the oldest Douglas-fir tree on the site. There was another stand-replacing fire around 1900, which led to the establishment of lots of Douglas-firs and other firs but no ponderosa pines.

If we draw a line through the year 1910, can you picture what that forest probably looked like then? There were a lot of big old ponderosa pines and a couple of big Douglas-firs. There may have been a lot of dead Douglas-firs too, killed by a recent stand-replacing fire. There were probably also a lot of tiny Douglas-firs and other firs, the beginning of that new cohort.

If we draw a line through the year 2010, can you picture that forest? There were just a couple of big old ponderosa pines, and there were a lot of Douglas-firs and other firs. They were be grown-up but not nearly as big as the old pines. There would probably be a lot of smaller firs too, since they can reproduce well in shade – unlike ponderosa pines.

Here’s another example of a forest with a history of mixed-severity fire. This diagram shows the history of a stand of whitebark pines in a high-elevation forest. What is the story of this forest? There are 2 cohorts – one from the early 1600s and one from the mid 1700s. There seem to be just 3 years with low-severity fire until around 1815, when a fire scarred nearly every tree on the site. That same fire may have helped the 3 youngest whitebark pines (at the top of the diagram) start growing. A few whitebarks died in the 1800s, and then mortality increased dramatically through the 1900s. By the year 2000, every whitebark pine was dead. Based on student presentations and other things we’ve learned, can you guess why they died? Many of the trees were probably killed by mountain pine beetles, and many others by white pine blister rust. In addition, the trees may have been too weak to resist beetles and rust because low-severity fire had not killed off the competing fir trees over the past 100 years or so.
Now we know about 3 historical fire regimes: low-severity, mixed-severity, and stand replacement. Let’s return to the 3 types of forest we’ve been studying and learn about their historical fire regimes – and the way they’ve changed through the past 100 years or so. First, a review: What are these 3 forest communities? Forests dominated by ponderosa pine (on the left), lodgepole pine (upper right), and whitebark pine (lower right). Keep in mind that we’re talking about COMMUNITY TYPES, not individual tree species. The community types are named for the tree species that was most plentiful there in past centuries, but many other tree species can occur in each type. Review: What other tree species occur in the ponderosa pine type? Douglas-fir, other fir species, western larch, lodgepole pine…. What other tree species occur in the lodgepole pine type? Douglas-fir, subalpine fir, western larch, Engelmann spruce, whitebark pine…. What other tree species occur in the whitebark pine type? Subalpine fir, Engelmann spruce, lodgepole pine…. 

Where do the 3 forest types occur? Discuss locations of the communities on the map relative to your location. Note that all of the plants and animals we’ve been studying – and the fire weather we have studied and the smoke data we’ve studied – come from ponderosa pine, lodgepole pine, or whitebark pine communities in this region. What fire regime do you think was most prevalent in each of these types?

This table summarizes information for our 3 forest types from dozens of research studies. Let’s read it carefully. [Go through the caption at the top, then the row and column titles.] Let’s answer some questions with this information. What is the most common fire severity for ponderosa pine forests? Low-severity, at 68% of fires. What is the most common fire severity for lodgepole pine forests? Stand replacement, at 75% of fires. What is the most common fire severity for whitebark pine forests? Mixed severity, since about 41% of fires were of mixed severity. But low-severity and stand-replacement fire occurred a lot too (31% and 28%). How would you describe the historical fire regime for the whitebark pine type? It looks like whitebark pine communities in general have a mixed severity fire regime... they’re all mixed up!

3. Summarize: Now we’ll read more about the fire regimes in our 3 forest communities (ponderosa pine, lodgepole pine, and whitebark pine), determine if the forests and fire regimes have changed in the last 100 years, and decide if the changes have important
consequences. In other words, we will answer the questions that we asked at the beginning of this unit (Activity M17andH16_DendroForFireHist.docx): Are our forests OK, or are today’s wildfires destroying them? Are today’s wildfires too big or too small? Are they too severe? Are the forests we’ve been studying threatened because of fire or lack of fire? [The articles are reprinted at the end of the lesson.]

**Assessment:**

1. Divide the class into groups of 3. One member of each group will write a short blog about the historical fire regime in ponderosa pine communities, one about lodgepole pine communities, and one about whitebark pine communities.

2. Give a copy of the 3 technical readings to each group or arrange for them to do the readings electronically. The readings are printed in the Appendix below and available electronically in 3FireRegimes_TechnicalReadings.pdf.

3. Assign – or have students choose – who in each group will write about each forest type. Each group must cover all 3 forest types.

4. Give each student a copy of Handout M20-1. News blog. Explain that news articles should get the reader’s attention, be very clear, and be as short as possible while still getting the point across. An Illustration can be very helpful.

5. Go through the directions in the handout. When you get to 1(d), explain that the article will not give you much information on this issue. Here are a few sources you can use: what you learned about fuels and fire spread in the unit on fire behavior, what we learned about smoke, and what we learned from student presentations on individual species.

6. Have them do the assignment. When the writing is completed, post the blogs on a school website, if possible, and encourage students in other classes to read them.
### Evaluation:

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<th>Excellent</th>
<th>Good</th>
<th>Poor</th>
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<tbody>
<tr>
<td>Headline is 8 words or less, accurate, and interesting.</td>
<td>Headline is accurate but more than 8 words or dull.</td>
<td>No headline is included, or headline is inaccurate.</td>
</tr>
<tr>
<td>Article is 150 words or less.</td>
<td>Article is too long.</td>
<td>Article is too long.</td>
</tr>
<tr>
<td>Article is accurate.</td>
<td>Article has minor inaccuracies.</td>
<td>Article has major inaccuracies.</td>
</tr>
<tr>
<td>Article accurately describes historical fire frequency and severity.</td>
<td>Article accurately describes historical fire frequency or severity but not both.</td>
<td>Article includes inaccurate information.</td>
</tr>
<tr>
<td>Article correctly describes 2 or more changes in last 100 years.</td>
<td>Article correctly describes 1 change in last 100 years.</td>
<td>Description of change is inaccurate or missing.</td>
</tr>
<tr>
<td>Article gives 1 or more valid reasons why change(s) matter.</td>
<td>Article gives 1 valid reason why change(s) matter.</td>
<td>Article gives no reason or incorrect reasons why change(s) matter.</td>
</tr>
<tr>
<td>Article includes appropriate illustration with accurate caption, credited appropriately.</td>
<td>Article includes illustration with caption.</td>
<td>Article includes irrelevant illustration or no illustration, or caption/credit is incorrect.</td>
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### Suggested content for essays on each of the 3 forest types:

<table>
<thead>
<tr>
<th>Forest type:</th>
<th>Northern Rocky Mountain ponderosa pine</th>
<th>Rocky Mountain lodgepole pine</th>
<th>Whitebark pine</th>
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<tbody>
<tr>
<td>General fire regime:</td>
<td>Mostly frequent, low-to moderate-severity surface fires. Fires often burned in a patchy/mosaic pattern.</td>
<td>Infrequent stand replacement or mixed-severity fires were most common. Sometimes low-severity fires occurred.</td>
<td>Mixed-severity fire regime, that is, fires of severities that varied in space and time, creating complex patterns of tree survival and mortality.</td>
</tr>
<tr>
<td>Fire intervals:</td>
<td>6-50 years... most studies report 6-15 years.</td>
<td>100-300 years, but with intervals as short as 25 years and as long as 400 years</td>
<td>60-300 years, sometimes as long as 500 years. Stand-replacing fires occurred at 250-year intervals or longer.</td>
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How vegetation and fire regime have changed:

| Fuel loads, particularly ladder fuels, have increased. Forest patches have become denser. Fire exclusion may cause larger, more severe fires than what occurred historically. | Some studies indicate little change over the past century. However, fire exclusion could gradually make the landscape more uniform, since fewer new patches of burned forest are created by fire. | It is hard to say how fire suppression has affected these forests. It may lead to further loss of whitebark pine (in addition to loss from white pine blister rust) and replacement by fir and spruce. |

Why changes matter:

| Native plants and animals may not survive in the changed environment. Many people have homes and live in this forest type; increased fire severity increases risks to watersheds, people, and property. | Native plants and animals may not survive in the changed environment. Many people have homes and live in this forest type, often in areas remote from fire control resources. Increased uniformity of vegetation could increase the possibility of larger fires. | Native plants and animals may not survive in the changed environment. Establishment of rust-resistant whitebark pine may fail if fire has not prepared a seedbed. If rust-resistant whitebark pines do become established, they may be shaded out by already-established subalpine firs and spruces. Large, uncontrollable, more severe fires at lower elevations could spread into whitebark stands and kill the remaining rust-resistant trees. |

| THIS INFORMATION IS NOT IN THE READINGS. (For possible information sources, see Assessment, Step 5 above.) | | |
Handout M20-1. News blog.

Name: ____________________________________________

My forest community type: ____________________________________________

1. Write a short blog about your forest community type and its fire regime for a high-school science website. It should be no more than 150 words long.
   a) Describe your forest community type (what are the most important trees?).
   b) Describe the forest type’s historical fire regime (how often fires occurred and how severe they were).
   c) Describe 1 major change in your forest type’s vegetation and fire regime during the past 100 years.
   d) Tell your readers why that change matters. Use information from other sources, such as student presentations and your ideas about smoke and people’s safety.
   e) Write a headline no more than 8 words long. Make it catchy but also accurate.
   f) You may include 1 photo or other illustration. If you do, include a caption and credit the source.

2. Exchange papers with 2 students who wrote about the OTHER two forest community types. Have them write their suggestions for your article in the spaces below.

3. Read their papers and write your suggestions on their handouts, then give them back.

4. Use comments from your reviewers to improve your blog. Then hand it in with this handout.

Suggestions from student writing on ANOTHER forest type:
Name: ____________________________________________

Write at least 1 strength and 1 way to improve the article. You may write on the back too.

Suggestions from student writing on YET ANOTHER forest type:
Name: ____________________________________________

Write at least 1 strength and 1 way to improve the article. You may write on the back too.
Appendix. Technical readings on historical fire regimes in northern Rocky Mountain ponderosa pine, Rocky Mountain lodgepole pine, and whitebark pine forests.
Ponderosa pine dominates low-elevation forests and savannas from the northern Rocky Mountains to the North Cascades. Douglas-firs and other fir trees are also common among the large, old trees. Historically, ponderosa pine forests were a mosaic of open stands, dense patches of young trees, and areas without any trees at all. Frequent fires maintained ponderosa pines as the biggest, oldest trees, even in places where firs trees would probably take over without fire.

Before the time when fires were kept out of the forests (the early 1930s), there was plenty of litter and undergrowth in ponderosa pine forests, but there were not many young trees or woody fuels. Lightning fires occurred in summer, and American Indians set fires in spring and fall.

Most of the fires were surface fires of low to moderate severity that burned in a patchwork pattern. Stand-replacement fires were infrequent, but they were an important part of the fire regime.

Results from fire history studies show that average fire intervals in ponderosa pine forests of the northern Rocky Mountains ranged from 6 years to 50 years. Most studies report averages of 6 to 15 years. Fires were less frequent but more severe at higher elevations, in moist sites, and on north-facing slopes.

As fires have been kept out of ponderosa pine forests in the northern Rocky Mountains, fuel loads have increased - particularly ladder fuels. Many ponderosa pine forests have a lot of Douglas-firs and other fir species in the understory, and not many ponderosa pines. Many forests are denser than they were in the past. Cheatgrass has invaded some ponderosa pine forests, increasing the fine fuels.

Many ponderosa pine forests of the northern Rocky Mountains have changed over the past century. They now have longer fire intervals, but when fires occur they tend to be more severe and possibly larger than what occurred historically. The size and frequency of severe fires are likely to continue to increase with climate change. Large, severe fires threaten the integrity of ponderosa pine ecosystems.

Wildland fires usually occurred at intervals from about 100 years to 300 years in lodgepole pine/subalpine fir forests, although sometimes fires were more frequent. Most fires were either stand-replacing or mixed-severity, but low-severity fires occurred occasionally. Where there are a lot of ladder fuels, fallen logs and branches, and dense tree crowns, these forests are likely to have stand-replacing fires. They can be crown fires or severe surface fires – or a combination of crown and surface fire. In dry locations where fuels are sparse, fires are likely to be a patchwork of mixed severities.

In forests dominated by Rocky Mountain lodgepole pine, the amount of fuel is related to stand age. If a young stand is very dense, with interlocking crowns, sparse lower limbs, and few understory plants, it is unlikely to burn at all unless the wind is very strong; then it may burn in a crown fire. As the forest gets older, the trees may be killed by bark beetles or dwarf mistletoe, and young fir trees may grow in, increasing the ladder fuels. Then the stand becomes likely to burn in either stand-replacing or mixed-severity fire.

Research from two national parks shows how fire regimes in lodgepole pine forests can vary:

- A study in forests containing western larch and Rocky Mountain lodgepole pine in Glacier National Park showed that forests with a dry climate and gentle topography experienced mixed-severity fires about every 25 to 75 years. Forests on wetter, steeper, sites experienced stand-replacing fires at longer average intervals, ranging from 140 to 340 years.
- A study in Yellowstone National Park showed that low-elevation lodgepole pine forests experienced mixed-severity fires about every 25-150 years; higher-elevation forests experienced stand-replacing fires at longer intervals, ranging from 300-400 years.

Because fire intervals are long in most Rocky Mountain lodgepole pine forests, it is hard to say for sure whether fire suppression efforts have changed these forests substantially. Where these forests had some low-severity fires in the past, they now have almost none. Lack of fire may be making forests more uniform and therefore more susceptible to epidemics of bark beetles. In addition, the uniform fuels could mean that future fires will be mostly stand-replacing; there will be little mixed-severity fire.


Whitebark pine fire regimes vary a lot in space and time. The most common kind of fire is of mixed-severity. A history of mixed-severity fire creates a complex pattern of tree survival and mortality on the landscape. Mixed severity fires occurred in the past at 60- to 300-year intervals; sometimes they occurred at intervals longer than 500 years!

Some fires in whitebark pine stands burn in sparse surface fuels and have low severity, killing only the smallest trees and the thinnest-barked overstory trees, such as subalpine fir. Fires are likely to be more severe if they burn in areas with heavy fuel loads or when the weather is especially dry and windy. These conditions help fire spread into the tree crowns and kill large patches of whitebark pines that may be hundreds of years old. Burned openings in whitebark pine stands provide good locations for Clark’s nutcrackers to cache the heavy, nutrient-rich seeds of whitebark pine.

Many whitebark pine forests from the northern Rockies to the North Cascades have had occasional large, stand-replacing fires. These fires occurred at intervals of 250 years or even longer. The fires were usually driven by strong winds. They often originated in dense forests at lower elevations. Whitebark pines were often the first trees to become established on these large burns because their seeds were brought in by Clark’s nutcrackers. Fir, spruce, and lodgepole pine trees seeded in more gradually from the edges, since they did not get any help from birds!

Because fire intervals are very long in whitebark pine forests, it is hard to say how fire suppression has changed them. In some areas, lack of fire could be leading to loss of whitebark pine and replacement by more shade-tolerant trees, such as spruce and fir. Even if whitebark pine seedlings are resistant to infection from white pine blister rust, they could have trouble getting a start on life if fire has not first cleared the soil and killed the small trees of competing species.