SVS Evaluation Presentation
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Slide 1. The longer we live among Colorado's forests, the more we understand how forests change over time.

More time means more and bigger trees.

But does the pattern hold indefinitely?

Slide 2. No, because Colorado's forests burn. In fact, we know that these forests have burned regularly since the Ice Age, nearly 10,000 years ago.

Slide 3. Considering that forests can change in many ways, how can we predict what'll happen in the next 50 years?

Slide 4. Can we influence our future?

Tonight, I'd like to share with you how scientists are developing ways to manage the forests along Colorado's Front Range –the forests dominated by ponderosa pine--and fire.

Slide 5. We'll use a mathematical model to help us. Mathematical models are tools that help us understand and manage the land. This particular model can help us figure out how forests change through time– a process called "succession," how much burnable vegetation is in a forest stand– which we'll call "fuels," and how severe a fire is likely to be.

Slide 6. We'll look at historical data to understand changes in forest stands, fuels, and fires… and to make predictions.

If you live in the mountains or own property there, you can use the ideas we discuss to understand and manage forests on your own property or in your neighborhood. Also, these ideas can help you play a more active role in planning for the management of public lands. You can be an informed participant, helping set goals and ensuring that management directions reflect your values.

Slide 7. For few minutes, let's explore the idea of a model.

Here's a mechanical model of the human knee. It helps us understand how a knee works and predicts how it will react after an injury.

When you look at a real knee, it is hard to understand these concepts because all the working parts are covered by skin.

Slide 8. Now let's explore the idea of a mathematical model.

We create a mathematical model with data from the past. The model is based on patterns in the data that help us understand what has happened before-- how we "got to the present." Then we use the model to project those same patterns into the future, to make predictions.

Slide 9. Here's a mathematical model showing rain and snowfall patterns in the Front Range. It's based on 100 years of data.

The precipitation patterns represented by this graph explain why ski areas make snow in November and December… and why you don't put your snow shovels away until mid-summer.

Now we'll look at our mathematical model for forest change and fire behavior.

Slide 10. To guide our discussion, let's consider 3 questions:

1. How do forests change over time? Not just "more time, more trees." Let's look in detail at what the patterns mean.
2. How do fires influence forests… and forests influence fires? Again, we won't look just at the obvious ("fires kill trees") … we'll use the model to increase our understanding.
3. How do our choices influence the relationship between forests and fire? This is a very practical question. Here we'll use our understanding of 1 & 2 to consider the future.

Slide 11. While Colorado's forests represent many ecosystems, we'll focus only on ponderosa pine forests. They're represented by light green on this map. You can see how they're inter-woven with the state's population more than any other kind of forest in Colorado. That's why the practical question of "how do our choices influence forest change and fires?" – is so compelling in the Front Range.

Slide 12. The data we'll use and the historical photos we'll see come from the Cheesman Lake area — about 100 miles south of here. For the past century, the Cheesman landscape has developed "naturally"– following historic patterns-- except for one departure: The Denver Water Department has successfully put out every forest fire there except one small one.

The data we'll use come from researchers Merrill Kaufmann, Paula Fornwalt, Laurie Huckaby, and Jason Stoker, from the Rocky Mountain Research Station in Fort Collins. They've studied the area for more than 7 years. We'll use their data because the forests and fire history in the forests between Redfeather Lakes and Fort Collins are similar to what occurred at Cheeseman.

Slide 13. So… How do forests change over time?

Slide 14. First, let’s take a quick look at ponderosa pine and Douglas-fir—the two “main players” in our drama of Front Range forest change.

Ponderosa pine thrives on dry landscapes. Its crown– the portion that has branches with needles– is often high above the forest floor. It has golden bark and big, oval cones.

Its long, thick needles protect the thick, half-inch buds from fire.

Slide 15. Ponderosa pine’s bark, sometimes more than 3 inches thick, protects it from fire. The bark grows quickly. A 7-year old seedling can often withstand a forest fire.

Look closely at this cross-section, and you’ll see markings from 3 different fires, ranging from 10 to 40 years apart. Each fire left a scar but did not kill the tree.

Slide 16. Douglas-fir, the second important player in Front Range forests, has short needles and brown, papery cones with 3-pointed wings sticking out from under their scales.

Slide 17. If not damaged by fire, Douglas-firs germinate easily and grow well in the shade. In contrast, ponderosa pine does not.

Slide 18. Now let’s take a landscape view of how forests have changed in the Cheesman area. Here’s an 1899 photo of hillsides there. Notice that there are several patches without trees, and the patches with tree cover are still quite open. And here’s a 2000 photo. It shows fewer open patches and a lot more tree cover.

Slide 19. But along with forests come fires. Fires differ in the way they behave and the damage they do to forests. The most powerful and dangerous kind of fire is the active crown fire, in which fire spreads rapidly through the treetops, or tree “crowns.”

There has been only one fire on the Cheesman landscape in the past century, but before that fires occurred more frequently. Data reaching back to the year 1197 show that fires occurred every 20 to 50 years until 1900.

Slide 20. After this long history of fire, the Cheesman landscape was quite open.

Slide 21. Researchers Kaufmann and his team used old photos and tree growth rings to get data describing the forest in 1900. Their results graphically show that, in 1900, nearly all (more than 90%) of the Cheesman Area consisted of patches with open forest. “Open” means that treetops– also called tree “crowns”– covered less than one-third of most patches.

In 2000, only about half of the area was still in open patches. About two-fifths had patches of “medium” tree cover, and a few patches had dense cover.

The model helps us picture what these forest patches looked like in an overhead view: “open,” “medium,” and “dense.”

A pattern of forest change over time is called *succession.* Why is succession important? Because in Colorado’s Front Range, that means increasing tree cover, which increases the chances of an active crown fire– the most powerful kind of fire, the most difficult to control.

Slide 22. We’ll use both data and modeling to look at forest change over time. I used data to build the graph of the 1900 and 2000 stands. Then I adjusted the mathematical model, so it could start with the 1900 data and accurately predict the forest of 2000. That means we can use the 2000 data to understand how forests change, and the 2000 model results– which are nearly identical-- to “picture” how the change has occurred.

Slide 23. Let’s look again at succession across the landscape. Viewed from above, this picture illustrates a forest with mostly open patches, like Cheesman in 1900.

In 2000, the same hillside has fewer open patches and some very dense patches. Active crown fires can spread much more easily in today’s forest than they could a hundred years ago.

Let’s zoom in on this patch to look more closely at succession.

Slide 24. Succession occurs because trees grow and reproduce more quickly than they die out– until fire (or some other disturbance) intervenes.

In 1900, this patch had 170 trees and 33% crown cover.

By 2000, it had more than twice as many trees and 55% crown cover.

Slide 25. Look again. We see that the trees are growing, new trees are taking hold, and some are dying and eventually falling.

Slide 26. Here’s a little more detail about the 1900 and 2000 conditions in that patch.

In 1900, there were about 130 small trees/acre (less than 6” diameter). In 2000, we see more than twice as many– 330 small trees/acre.

In 1900, large trees (greater than 6” diameter) numbered about 40/acre. Compare this to the year 2000, where their numbers doubled.

Slide 27. Now let’s come down from our bird’s-eye view and look at this forest patch at human-eye level. Watch the large trees. Notice how they grow taller at each step, and then two of the biggest die toward the end.

Slide 28. As we watch this *succession* again, notice how young trees fill the "understory"– the area below the big tree crowns.   Fire specialists call these seedlings and saplings "ladder fuels," because they provide a path for fire to move from the ground into treetops.

Slide 29. Young trees determine a forest's future, so let's look carefully at the small trees– mostly young– in 1900.

The ponderosa pines are orange-red, and the Douglas-firs are dark green. In 1900, neither species had more than 100 small trees.

In 2000, there are many more– especially Douglas-firs. A few spruces have come in– indicated by dark gray. There are also many young aspens, indicated by light green. Small firs outnumber everything else and will probably dominate this patch of forest in the future-- unless it burns.

Slide 30. At this point, let's briefly review. We've used data and a model to see how a Front Range ponderosa pine forest has changed over the past century: •Crown cover has increased

•Trees have increased number–especially small trees

•Small Douglas-firs outnumber every other species and size group.

This is a typical successional pattern for many patches at Cheesman.

Now let's look more at fire.

Slide 31. Earlier we noted that fires have influenced Front Range forests. But how?

Slide 32. You'll remember that all fires are not equal. They differ in the way they behave and the damage they can do. Some move slowly, some move several miles per hour. Some have short flames, some long.

Consider three kinds of fire behavior. Surface fires burn only in the fuels on the forest floor, not in the tree crowns.

Passive crown fires burns tree crowns, but fire is not jumping from tree to tree. Instead, ground conditions still control fire spread.

Active crown fires spread from one tree crown to the next. They move very fast, create strong winds and produce "spot fires," making control nearly impossible.   All three kinds of fire kill trees, but surface fires may leave many trees alive, especially the larger ones and those with thick bark. And active crown fires seldom occur in open forests.

Slide 33. Now we'll use our mathematical model to predict fire behavior in the 1900 and 2000 forests.

Slide 34. You remember that, before 1900, fires occurred 1 to 5 times a century on the Cheesman landscape. What kinds of fires were they? They were patchy and varied a lot. In some patches, surface fires killed only small trees, reducing the numbers of Douglas-fir and favoring ponderosa pine.

In other patches, passive crown fire made openings where new forest grew.

Slide 35. Let's look again at an illustration of fires in the 1900 landscape, with mostly open forest.

Active crown fires were probably rare in this forest 100 years ago– for 2 reasons:

Slide 36. First, few forest patches had enough crown cover to start active crowning in most summers.

Second, the dense patches were islands within the more open forest. If active crowning started, it could not continue far. Remember 1900? This was a patchy, low-density forest so active crowning was unlikely.

Slide 37. Not only has crown cover increased in the landscape, but ladder fuels– the small trees and shrubs that carry fire into tree crowns– have increased too.

Slide 38. Let's zoom in on our single forest patch and model fire behavior under very dry weather conditions in 1900, when the forest was open, and again in 2000, when it had much greater crown cover.

Let's look at the likelihood of active crown fire.

Slide 39. How much wind is needed to change a fire that may be in surface fuels or passively crowning… to an active crown fire?

Slide 40. Watch the fire that the our model predicts with a 5 mph wind.

In the open stand, the flames stay on the forest floor.

When the stand is dense, the flames spread into the tree crowns creative passive crown fire.

Slide 41. Let's watch the time-lapse again.

In 1900, with 5 mph winds, the model shows that the fire kills mostly small trees.

But in the dense stand of 2000, the passive crown fire consumes much more vegetation.

With 5 mph winds, neither stand supports active crown fire.

Slide 42. Let's turn to the model to describe see how much wind is needed to start active crowning.

The yellow band represents the range of winds in which a fire will probably remain a surface or passive crown fire.

The transition from yellow to red marks the wind speed at which active crowning can begin. In the 1900 stand, active crowning was unlikely until the wind reached 50 mph.

The dense stand of 2000, however, can carry a crown fire at wind around 35 mph. That is not unusual in the Front Range in summer.

Slide 43. At low wind speeds, fire would kill few large trees in either the 1900 or the 2000 stand. But hundreds of small trees burn, especially in the dense 2000 stand. Note the large number of charcoal-colored tree crowns, representing fire-killed trees.

At high winds, the model predicts few trees would survive in either 1900 or 2000. But the 2000 fire consumes a lot more total vegetation. Does that matter?

Slide 44. The model describes burned vegetation as "fuel consumed." It calculates that the 1900 fires– under both 5 mph and 40 mph winds-- would consume less fuel than the 2000 fires.

Burning more fuel creates more smoke and can damage the soil.

Slide 45. Some of the fuel consumed by fire goes into smoke. This graph shows the smoke you are likely to see from the different fires we've been looking at. Smoke is measured in tons/acre of tiny particulates.

The dense 2000 forest would produce more smoke than the 1900 forest at 5 mph winds… and at 40 mph winds too.

Slide 46. Burning more fuel can damage the soil. The more fuel consumed, the more heat there is, and the more roots and plant materials are burned. This can change the soil structure and leave less protection on top, so it is easily eroded by rain.

Slide 47. So how do Front Range forests influence fire behavior?

Increasing numbers of trees– especially small trees– increase the risk of active crown fires, which are more dangerous and harder to control than surface or passive crown fires.

Active crown fires create more smoke.

They can also damage the soil or leave it unprotected, more vulnerable to erosion.

Slide 48. Active crown fires, with high fuel consumption, have probably always occurred in occasional patches in Front Range forests.

Many plants and animals can cope with this habitat change.

But people saw the power of crown fires in the late 1800s and early 1900s– when thousands of people were killed and whole towns burned over– and demanded that fires be stopped.

Slide 49. Now, after 100 years of succession without fire, the potential for active crown fire over large areas has increased. In Colorado's Front Range, it is probably greater today than at any time in thousands of years.

Slide 50. So what choices do we have to manage our forests and reduce the likelihood of large, severe fires?

What can we do as individual homeowners, or working together in neighborhood groups, to make crown fires less likely?

Can we work together with managers of public lands to choose goals, plan ahead, and ensure that management efforts reflect our collective values?

Slide 51. We'll use the model to consider some possibilities, to predict what the forest will be like 50 years from now.

Up to this point, we've used the model to *understand* succession and to *model* fire behavior. Since we obviously can't have data from the future, we'll use the model now to *predict* future conditions. We'll *model* succession in the Cheesman forest and fire behavior. How reliable will the predictions be?

If conditions like soil composition and climate remain the same over the next 50 years, the adjusted model should be pretty accurate. But if future patterns differ from the patterns used in the model, or if we missed some crucial pattern when the model was constructed, then the predictions may be wrong.

Slide 52. With that caution in mind, let's consider some possibilities. We could do nothing and deal with fires as they come along. We could cut a few trees… or a lot. We could remove only small trees or a mixture of little and big ones. We could use prescribed fire– in combination with cutting, or by itself.

Let's look at two possibilities– one very "hands-off" and one very proactive.

First, we'll use the model to anticipate what will happen if we do nothing-- let the Front Range ponderosa pine forests develop for another 50 years and assume we can keep fire out.

Second, we'll look at one prescription for thinning trees and using prescribed fire.

Slide 53. Consider the "big picture" first– an overhead view of the forest in 1900. In the century between 1900 and 2000, crown cover increased about 30% in most patches. If this rate continued, most patches will have 10 to 20% more cover by 2050.

If we take no management action and are successful in keeping fire out, by 2050 forests will be even more dense and more susceptible to active crown fire.

If we remove trees and prescribed burn on about a quarter of the patches in this landscape, we break up the continuous dense tree crowns and reduce the crown fire potential.

Slide 54. Now let's zoom in again on a single patch of forest.

Slide 55. Again, consider the patch that had 170 trees and an open crown in 1900.

In 2000, it had more than 400 trees and medium-dense crown cover.

In 50 years, our model says it will have more than 500 trees. Here's how succession will progress.

Slide 56. We've been following a forested area that had 170 trees in 1900, 409 now. In 50 years, the model says, it will have more than 500 trees. Here's a depiction of the successional change.

Slide 57. Here's an overhead view of the same pattern. Crown cover will increase to about 80% in 50 years.

Slide 58. Will more trees and greater cover increase the likelihood of severe fires?

Slide 59. And that is what the model says will happen.

You remember that we used the model to estimate how much wind would be needed to cause active crowning. In the 1900 stand, the model predicted this transition, where the yellow bar meets the red bar, at about 50 mph.

In the dense stand of 2000, the transition to active crowning can occur at lower– and more common– wind speeds, around 35 mph.

50 years from now, the model predicts active crowning at 23 mph winds, which are quite common here in the summer.

Slide 60. Now let's look at our second possibility– a very proactive approach. What happens if, in the next 5 years, we harvest 1/3 of the large trees and use prescribed fire to remove most of the small trees? How would the forest look? How would the treatment affect fire risk?

Slide 61. Let's go through a time-lapse showing the treatment… and the results.

First, consider the current stand.

After logging, the large trees– that have been cut-- can be sold. A prescribed fire the next year reduces the small debris.

Now the stand is more open. It resembles historic stands in the Front Range, with its patchy forest cover intermingled with an open area.

Watch the change our model predicts after we reduce tree cover. Aspens are prevalent because they sprout from their roots. Ponderosa pines and Douglas-firs come in from seed, but the firs are not as numerous as they were in 2000. (Pines look more bulky and less pointy in this picture than firs.)

Slide 62. Let's look at the whole process one more time.

Slide 63. How will this treatment affect fire behavior?

In 2000, you remember that active crowning can occur with 35 mph winds.

The model tells us that, right after our treatment, active crowning is much less likely in this forest patch. It is even less likely than in the conditions of 1900. There are few ladder fuels, and the tree crowns are open. Only very high winds could trigger active crowning.

Even 40 years after treatment, crown fire remains unlikely– though the wind needed for crowning is gradually decreasing. Another treatment could be needed to reduce fire potential again.

Slide 64. We've only looked at 2 possible choices for management of one kind of forest patch at Cheesman. I chose very different options so we could see the contrast in results. If you investigate management possibilities on your own property or work with neighborhood groups or public land managers, you will be shaping possible choices– there are hundreds of possibilities.

Slide 65. Tonight, we've looked at how a mathematical model can help us answer 3 questions about Front Range ponderosa pine forests:

•How do forests change over time?
•How do fires influence forests, and forests influence fires?
•How do different management choices influence forests and the potential for severe fire?

Slide 66.

1.How do forests change over time? We used our mathematical model to look at succession, and we've seen that•The forest has more trees, especially small ones, greater crown cover, and fewer open patches
•Douglas-firs do a little better than pines

Slide 67.

2. How do fires influence forests, and forests influence fires? We learned that, historically,
•Most fires were surface or passive crown fires
•As forests grew, their crowns became dense enough to support active crown fire
•And the patches coalesced so crown fires could spread more easily
•More severe fires produce more smoke and increase the risk of serious erosion

Slide 68.

3. How can mathematical models inform us so our management choices positively influence forests and fires? We learned that
•We could change some forest patches to resemble their condition 100 years ago
•So when we do have fires, they would be less likely to spread through the tree crowns—
•Making them less dangerous to control, and less likely to produce heavy smoke or severe erosion

Slide 69. Throughout our discussion tonight, we have used mathematical modeling to understand data and make predictions. Our model focused on forest change and fires. Other models are available– and being used by land managers– to look at the effects of our choices on other aspects of the ecosystem– for example, the abundance of dead trees as nest habitat, abundance of vegation on the ground after fire, hydrology and stream flow, and smoke dispersal. All of these models are tools to help land managers and the public make informed decisions.

Slide 70. You may live in an area where forest management practices affect you and your family's safety and property.

If you live in the mountains or have property there, you may have been threatened by fire, or you may be vulnerable to flooding after fire.

You may be concerned about the condition of our wildlands, parks, and wildernesses, wondering how to protect them for the future.

Mathematical models can help all of us be informed participants in managing our forests wisely.

Slide 71. I am grateful to the individuals and groups who provided data, advice, photos, and graphics to help me prepare tonight's presentation and especially Paula Fornwalt, who patiently shared here data, photos, and insights.

Thank you for your time and attention!