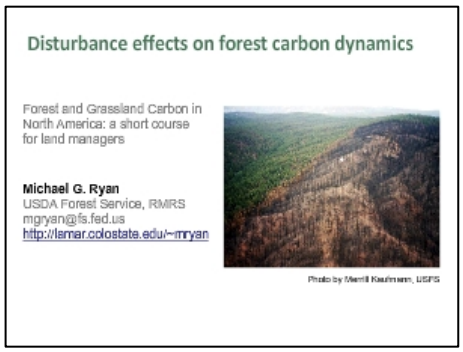
Disturbance Effects on Forest Carbon Dynamics

Mike Ryan*

Go to presentation

Slide 1. Disturbance Effects on Forest Carbon Dynamics

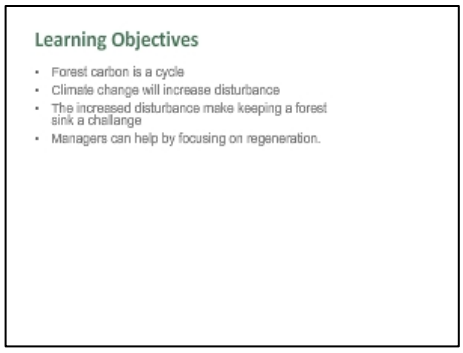


Hi, my name is Mike Ryan. I'm a Forest Service scientist from Ft. Collins, Colorado and I'm going to talk to you today about the effects of disturbance on forest carbon.

Slide 2. Science and Science Support

I'd like to acknowledge my collaborators and colleagues who help with the science behind what I'm going to tell you, and also my funding sources. Here's my learning objectives.

Slide 3. Learning Objectives



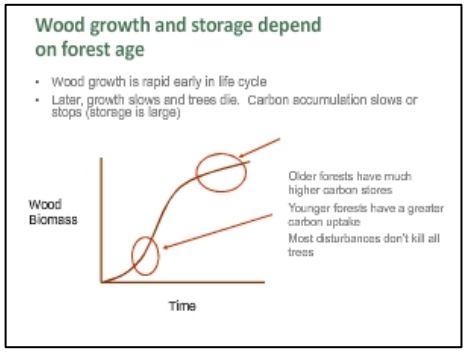
First of all, we're going to see that forest carbon is a cycle. Second, climate change is going to increase disturbance. This increased disturbance is going to make it a challenge to keep our forest carbon sink. And managers can help by focusing on regeneration.

** This document transcribes the presentation given by Dr. Ryan. The presentation is part of General Technical Report NRS-93, "Forest and grassland carbon in North America: A short course for land managers." The full report, comprised of 15 presentations, is in DVD format and can be obtained at http://nrs.fs.fed.us/pubs/order/40110. The presentations and related materials can also be accessed at http://www.fs.fed.us/ccrc/carboncourse/*

Slide 4. Forest Carbon has a Cycle

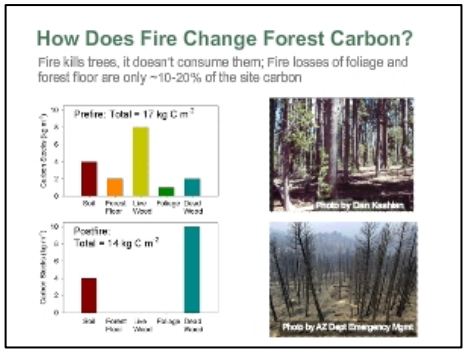
So the most important thing that I want you to take away in understanding about a forest carbon cycle is that it is a cycle. It's very different from taking a fossil fuel out of the ground. It goes into the air, it does some other things in the future, but we don't consider it as a cycle. It doesn't return to the ground on our time scales. But forests are different. They have this cycle. You go through a disturbance. You either lose some carbon right at the disturbance, like in a fire or afterwards as the trees that are killed in the disturbance decompose. Then you get regeneration, new trees start taking up carbon and balancing that out. And then after a long period of time you get another disturbance. So, over this cycle if you get regeneration, and if you have enough time to recover the carbon, you have a net carbon balance of zero. Okay? It's just the timing that's changed.

Slide 5. Wood Growth and Storage Depend on Forest Age



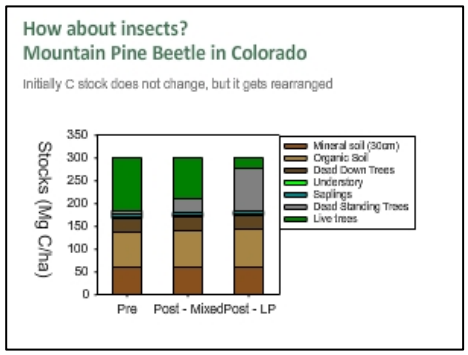
Let's take a look at the quickest or probably the most important component of this recovery and loss, and that is the growth of trees. Well, wood growth and storage are dependent upon forest age. Really young forests are accumulating carbon quickly, but they don't have much storage in them. Older forests have a lot of storage, but their accumulation rate is slow.

Slide 6. How Does Fire Change Forest Carbon?



So fires don't consume trees, or very much of them, but they do kill them, and that tends to rearrange the carbon that you have in the forest from living to dead pools. Basically, fire will remove the duff or the forest floor. It'll remove leaves and then maybe twigs, depending on how intense the fire is, but this carbon decomposes and is gradually lost as the trees fall down and decompose.

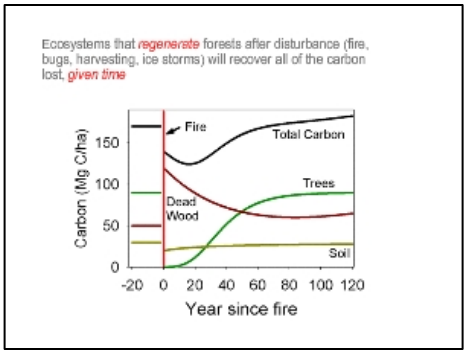
Slide 7. How About Insects?



Another disturbance that we're having a lot of in the West is mountain pine beetle, and initially they don't change the amount of carbon on the site at all, depending on the intensity, whether you've got a mixed stand or a pure lodgepole pine stand, and you can rearrange the carbon into more of the nonliving pools, which means the nonliving pools are eventually going to decompose.

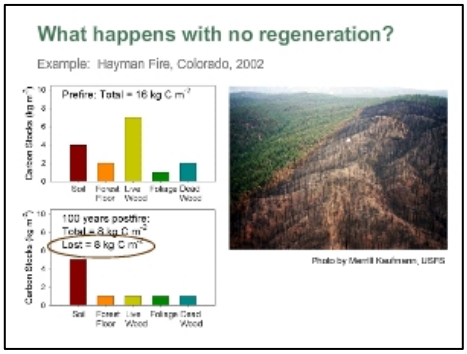
Slide 8. Regenerating Ecosystems and Carbon…

So there's a time element in this that's really important, and there's also a critical emphasis on regeneration that I'll show in the next slide. But if the ecosystems that the forest regenerate after a disturbance, and if you have enough time, you'll recover all the carbon that was lost in the disturbance. And those are two big important ifs from the standpoint of carbon recovery.



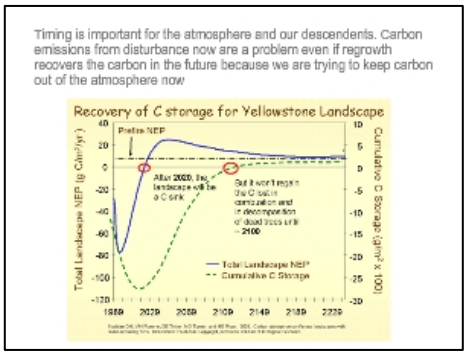
Slide 9. No Carbon Regeneration?

So what happens if you have no regeneration, like we have in ponderosa pine for 150,000-acre fire from the Hayman Fire in 2002 in Colorado? Giant chunks of the forest there are a long ways away from any seed source because of these large runs that occurred during a couple of days in the fire, and these things are going to be converted to meadows unless we intervene. Well, if you do the calculations, you're going to lose about half of the carbon in that forest ecosystem if you don't get regeneration.



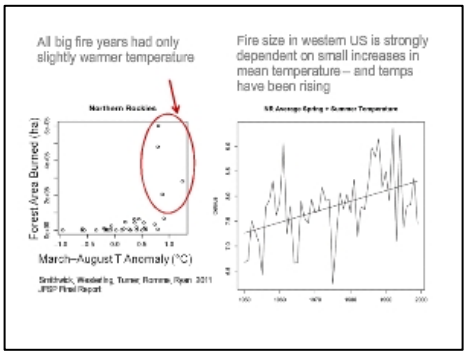
Slide 10. The Next 100 Years Are Important

So timing's also important. If your forest doesn't have enough time to regenerate before it gets another fire, then you're going to start lowering the amount of carbon. It's also important, timing is, for the atmosphere and for our descendants, because even though there is this cycle, we're trying to keep carbon out of the atmosphere right now, and the next 50 years are very critical. And so if we have lots of disturbance over the next 50 years, even if those ecosystems will eventually recover it, that's going to just create an additional challenge. Well, let's look at the future.



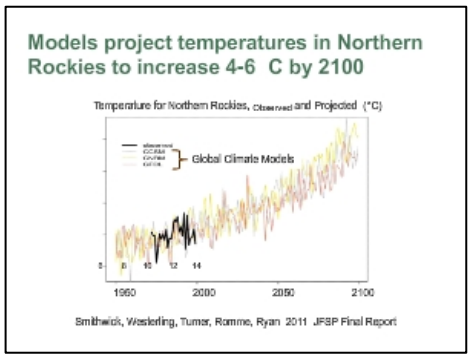
Slide 11. Big Fire Years

So, fire size in the U.S. is strongly dependent on small increases in mean temperature. So all the big fires years have had only slightly warmer temperatures, and temperatures have been increasing.



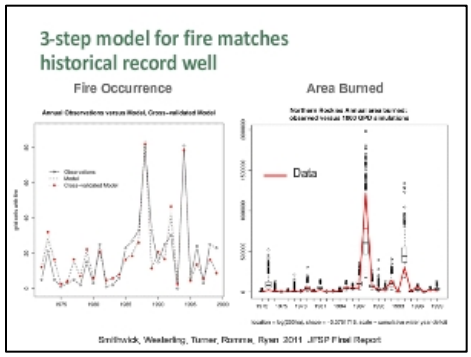
Slide 12. Temperature Projection in Northern Rockies

So global climate models predict that temperatures in the Northern Rockies are going to increase 4 to 6 degrees Celsius in the next 90 years. So how do we predict fire?



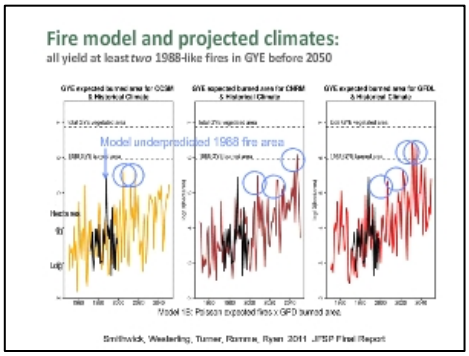
Slide 13. Three-step Model

Well, the first thing we do is try to relate it to climate, and it turns out it's a fairly complex process of taking climate and relating it to fire. If you're interested in more, there's a reference on the last slide with a link to our Joint Fire Science Report that tells you how we went through this, but basically you predict whether fire is going to be there and then how big it's going to be and relate those to certain climate factors. And the model does a good job of predicting the data that it was calibrated with.



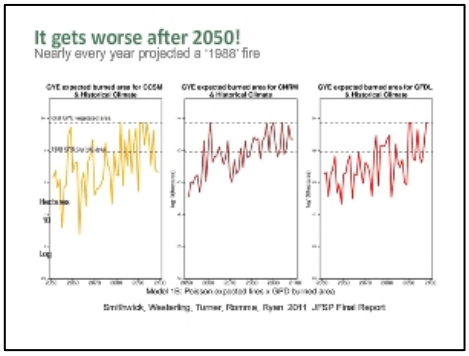
Slide 14. Fire Model and Projected Climates

So if you take that fire model and you link it with these climate model projections, you can say something about predicting fire in the future. And if you do that for all three of the models that we used, you find something that's very different. In the next 40 years, with really only about a predicted 2 degree Celsius increase in temperature, the system looks to be switching from something that used to have a fire return interval of 200 to 300 years, to something that's got much more frequent fire return interval.

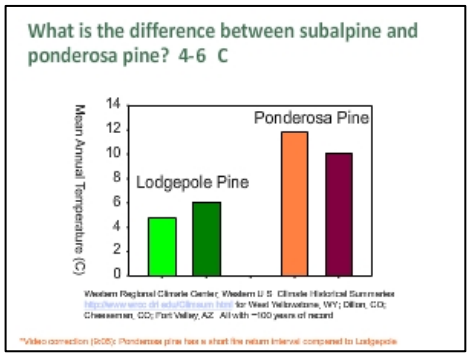


Slide 15. It Gets Worse After 2050!

If you go out to the end of the century, basically the model says that climate is no longer constrained on having stand replacing fires in this ecosystem. Fuels are going to be the constraint.



Slide 16. Subalpine vs. Ponderosa Pine

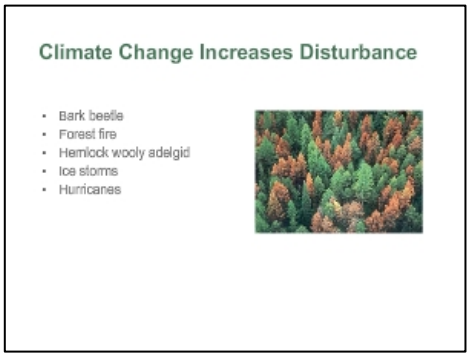


And so I really had a hard time when Tony Westerling was starting to work with this, you know, thinking that this was going to be this big of a change with this kind of projected temperatures. So one of the ways that I tried to think about my skepticism was, well, what is the difference between something that has a very long fire return interval like ponderosa pine and something that has a very short fire return interval like lodgepole pine? And it turns out if you look at the climate record, it's 4 to 6 degrees. So, basically we are going to change ecosystems in the Northern Rockies sometime, you know, between now and the next 90 years, maybe sooner than later.

Slide 17. Conclusion

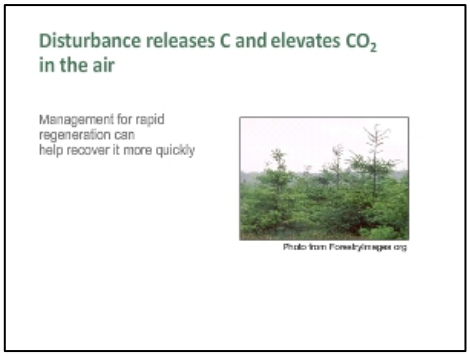
This ecosystem change is going to be accompanied, and probably promoted by fire, and we're going to lose a fair bit of carbon, and this carbon loss is going to make storing more carbon in forests even a bigger challenge.

Slide 18. Climate Change Increases Disturbance



Climate change increases with disturbance. If you look at the literature, you know, bark beetles, forest fire, woolly adelgid, ice storms, hurricanes, these are all going to be more common. These are all going to reset the forest and tend to put more carbon from the forest into the atmosphere.

Slide 19. Disturbance Releases C and Elevates CO^2

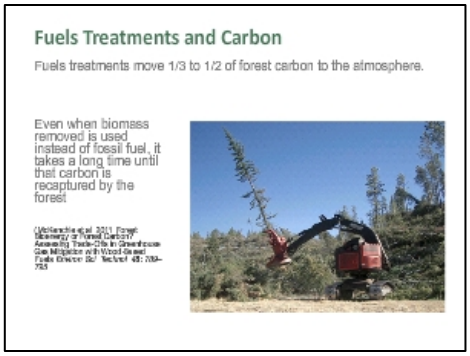


This disturbance releases carbon and this carbon from the forest is going to increase the CO_2 in the air. Management of forests can help. We can help by making sure that these lands stay in forest, that regeneration is rapid. From a carbon standpoint, the more quickly you get regeneration, the less carbon you're going to lose over this boom and bust cycle that forests go through.

Slide 20. Can we be Proactive?

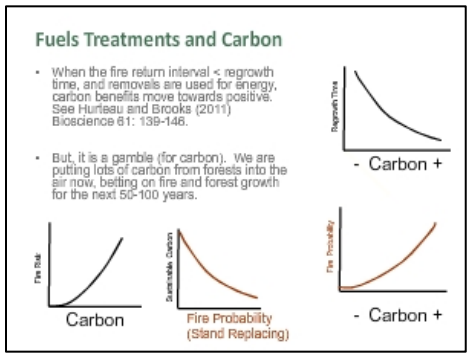
Can we be proactive? So here is an issue that the Forest Service has been dealing with a lot, well and private landowners, using fuels treatments, basically lowering the amount of carbon on the landscape to reduce the risk of fires. The basic idea works like this. If you have a less dense forest like the lower panel, if you get a fire through there you going to have a lower risk of tree mortality. You're going to lose fewer trees, on the average, than if you have a more dense forest, you're going to get a fire in there it's more likely to be a stand replacing crown fire that will kill all the trees. Okay, so that's the basics,

Slide 21. Fuels Treatments and Carbon



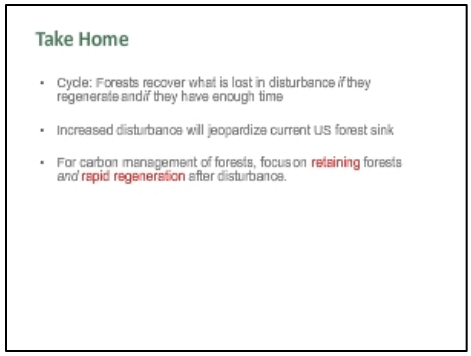
…but the other side of the equation, and this is from a carbon standpoint, only from a carbon standpoint, is that you have to remove a third to a half of the biomass to achieve this. So you have to take a lot of carbon out of the ecosystem to get a fuels benefit for fire. So even if you take this biomass and use it for biofuels, it takes an awful long time for that ecosystem to recover all that carbon that's immediately put in the air. So it's a long recovery time. So these are things that work against it being a carbon benefit.

Slide 22. Fuels Treatments and Carbon



So with the help of a couple of folks here at the conference, I thought about more what are sort of the tradeoffs and when would it be a carbon benefit and when would it be carbon negative, and here's just some relationships that I put together on here that showed that the more carbon you have the higher the fire risk. Maybe sustainable carbon is going to vary with how much fire you have or what the probability is of getting a stand-replacing fire. If you have a high probability of getting a stand-replacing fire, the amount of carbon that you can actually maintain on that forest is probably going to be low. The amount of time that it takes to recover the carbon that you removed in fuels treatment is going to have an impact on whether it has a carbon benefit or not. If you can regrow that carbon quickly, you'll be moving towards the positive end as opposed to it takes a long time to do it. And then finally you're going to move more towards a carbon benefit if the fire probability is high. So the way I like to think about it is that if the fire return interval for a stand-replacing fire gets to be lower, the amount of years gets to be lower, then the amount of years that it takes to grow the amount of carbon that you lose in a forest fire, then you're going to be more likely to have a carbon benefit, if you also use the thinnings for biofuels. But it is going to be a gamble. You know, we're putting lots of carbon in the atmosphere right now and betting that we'll have this fire return interval, and we know what the forest growth is for the next 50 to 100 years. So fuel treatments are a good thing, but from a carbon standpoint you've got to have certain conditions before you even start thinking that they have a positive carbon benefit.

Slide 23. Take Home



My take home message is that forests recover what is lost in disturbance if they regenerate and if they have enough time. Increased disturbance because we're starting to cut into the amount of time, we're not giving them enough time to recover, is going to jeopardize the current U.S. forest carbon sink. I think that the best thing that we can do for carbon management, just from the standpoint of carbon, is focus on retaining forests and rapidly regeneration getting regeneration after disturbance.

Slide 24. Carbon is Only One Ecosystem Service

And finally I want to make this point, make sure this point gets made in this talk, that carbon is only one ecosystem service of forests. Forests do a lot of other things, and if we were to focus even if something like fuels treatments came up to be carbon negative once we did all the science, that doesn't mean that we shouldn't do them because there's lots of other good reasons to do them. You can work through the logic on this for many other things, so just keep that in mind. Thank you very much.