Forest Structure and revegetation in the first seven years after the Warner Creek fire

A presentation by

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based on research coordinated by

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Important note:

This is the script for an oral presentation and is not intended for publication. These results have not yet been peer-reviewed and should be considered tentative until the authors have published the full methods and results of this project in a peer-reviewed paper. Please contact Martin Brown (martin@brownandbrown.tv) if you intend to reference or distribute this script.

Forest Structure and revegetation in the first seven years after the Warner Creek fire

speech	*slide*
The Warner Creek fire, which occurred near Oakridge in the Western Cascades, has become a little infamous -- the fire was reputedly started by arson (USDA Forest Service, 1993), and the fire area was also the site of a long protest. But the fire also presented some great opportunities for really basic research. At Warner there was the opportunity to directly observe the changes in forest conditions and revegetation in the years immediately following the fire. Though this sounds like something that should have already been done, it has not. The refereed scientific literature has very few direct observations of things like natural structural changes and natural regeneration after fire in the western Cascades. In our region factors like fire suppression and laws requiring replanting may have limited opportunities for research. So Warner provided an opportunity to observe a real range of postfire conditions in a relatively natural environment. This information might be a useful reference for people managing forests or trying to simulate historical forest processes. There are also few places where Warner results can provide a reality check to historical reconstructions and theories. E.g. the literature's picture of natural regeneration after fire in this area consists mostly of historical reconstructions, such as Franklin & Hemstrom 1981. Warner will show how at least one forest measures up to those concepts.	**The 1991 Warner Fire presented opportunities** ***Fame, Arson, Protest, & Research*** ***Direct observation of postfire revegetation and structural processes*** ***A place to observe the variety of postfire conditions*** ***A "reality check" on theories and historical reconstructions***
Today I'll summarize the results from one intensive set of observations at the Warner site. This field work was coordinated by Jane Kertis and Mark Huff of the Forest Service. My role in the project was mostly as data analyst. I was not in the field as much as them; they weren't at the computer as much as me. They also have not yet had time to review this particular presentation. So while we're all here today and we all answer questions, I'm solely responsible for the specific contents of this presentation. I'm going to discuss the following subjects: • Tree mortality during and after the fire • Coarse woody debris dynamics such as snag	**Contents of this Presentation** ***Results from research coordinated by Jane Kertis and Mark Huff*** ***Tree mortality during and after the fire*** ***Coarse woody debris dynamics such as snag breaking and falling*** ***And revegetation by herbs and shrubs and tree seedlings***

breaking and falling

- And revegetation by herbs and shrubs and tree seedlings
- All as observed in the seven years after the fire.

But first, you probably want to know some basics about the fire, site and methods. Here's a vista of the Warner area, including a burned ridge.

The fire burned October 1991, spanning about 3600 hectares.

The stands we studied were all mature forest before the fire, with dominant trees >50 years old. Many sites were older than that, with trees >100 or >200 years old.

The sites were in two generally recognized forest types, the silver-fir mountain hemlock zone at higher elevations, and the western hemlock-Douglas fir zone below.

The area includes various burn intensities and scattered "restoration" treatments that were applied to the ground immediately after the fire. The biggest treatment in terms of area was seeding with annual ryegrass (Lolium sp.) and barley (Hordeum sp.). That touched about a third of the fire area (1200 hectares). (USDA 1993)

So the place we are studying is not exactly "virgin" forest. It has been touched in various ways by humanity. However, given current day realities, Warner may be as "natural" and "realistic" a study area as we're going to get.

The Warner Fire and our study area

Burned October 1991, 3600 hectares.

Mostly forest. Everything we studied was mature forest.

Two forest types: ABAM/TSME and TSHE/PSME

Landscape shows various burn intensities and scattered "restoration" treatments.

As "natural" and "realistic" as we're going to get?

We set up 13 plots in the silver fir zone, and 11 in the western hemlock zone.

These plots were not a random sample of the landscape. Rather, we intentionally tried to place plots in stands with widely varying fire intensities.

This means that these results can't be summed up to

Plots/sampling

13 plots in silver fir, 11 in western hemlock

not a random sample; results show range of forest conditions

describe the entire Warner landscape. However, they should provide a pretty good picture of the RANGE of postfire conditions in burned stands.

We visited these plots twice.

First in summer 1992, 1 year after the fire. During this visit a key assumption was that we could distinguish the prefire condition of trees and snags.

Next in summer 1997-8, 6-7 years after the fire. This time a key assumption was that we could refind every tree or snag we evaluated before.

visited plots twice

Here are some live trees and some dead trees in various states -- standing, falling, etc. Let's see how they relate.

Here is the graph of live tree density in each plot in the silver fir zone. Note that tree density is on the Y axis, years after the fire is on the X axis. Each jagged line is one study plot. So obviously, a large proportion of trees died in the fire.

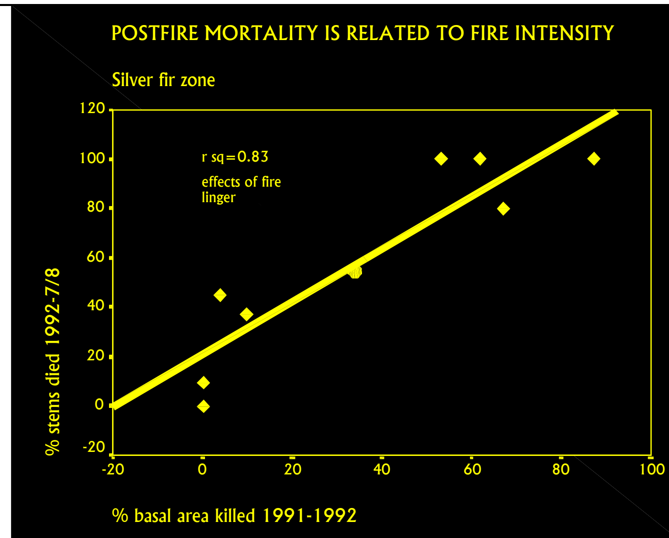
Not all trees died equally, though. Small trees in terms of dbh or height were more likely to die. Silver fir was more likely to die. Douglas-fir was more likely to survive.

Now here's the really interesting thing. There is death not just in the fire -- that's how we defined various fire intensities -- but also afterwards. Note how these plot lines continue to go down. On average 30-60% of trees surviving at 1 year after the fire were dead by 6-7 years after the fire. That postfire mortality is very rapid for silver fir and mountain hemlock.

Moreover, that postfire mortality is related to fire intensity. This graph shows that the more intense the fire was originally, as seen on the X axis, the greater the post-fire mortality, on the Y axis.

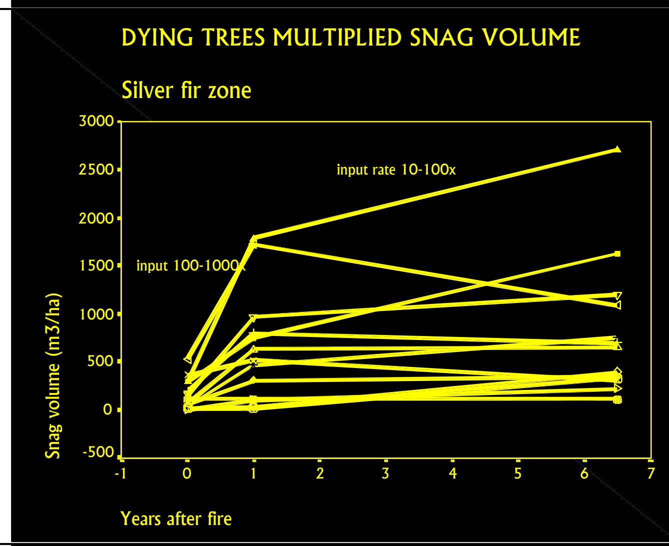
So the effects of the fire are lingering. Trees which are alive 1 year after the fire could easily be on their way to dying. Some authors say trees can be weakened by fire (e.g. Gray and Franklin 1997.)

This also means that if you measure fire intensity based on tree mortality, like a lot of people do, you've got to pick a certain point in time to make that measurement.



Now this next graph shows that these dying trees don't go away. Here on the x axis is years after the fire, and on the Y, snag volume. Each plot is one jagged line. So you see here the fire immediately doubles, triples, quadruples the volume of snags.

In that year, the rate of input to the CWD pool is 100-1000x the rate expected for an unburned steady-state forest (Harmon et al 1986). Even afterwards, in the next 5 or 6 years, the rate of input is still 5 or 10 or even 100 times that steady-state rate.



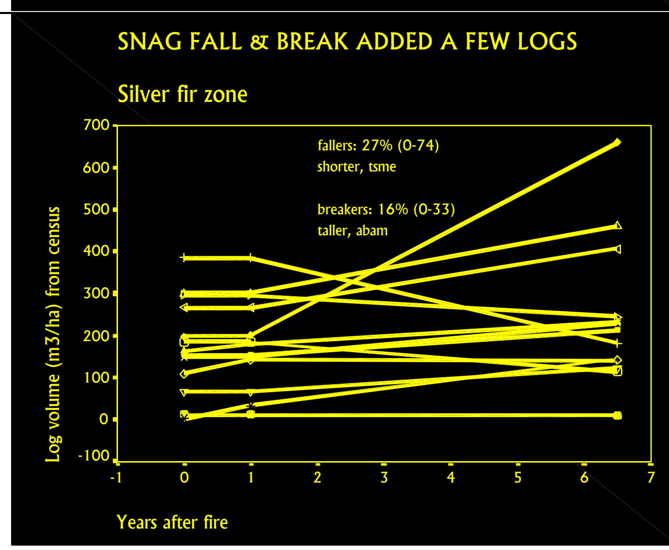
Coarse woody debris in the form of logs didn't quite show the same dramatic increase as snags. Here's the same kind of graph, but now for log volume.

By seven years after the fire, log volume has gone up maybe by a third or a half in each plot.

We assume these logs came from breaking and falling snags we observed. In some places, a lot of snags fell -- between 0 and 74% of the snags per plot here in the silver fir zone, with a mean of 27% per plot. Rates in the western hemlock zone weren't that high.

Snags that fell tended to be shorter, small diameter snags. Snag fall rates weren't very different than models (Mellen & Ager 1998) would expect for unburned Douglas-fir and western hemlock forest, but rates were very high for mountain hemlock and silver fir.

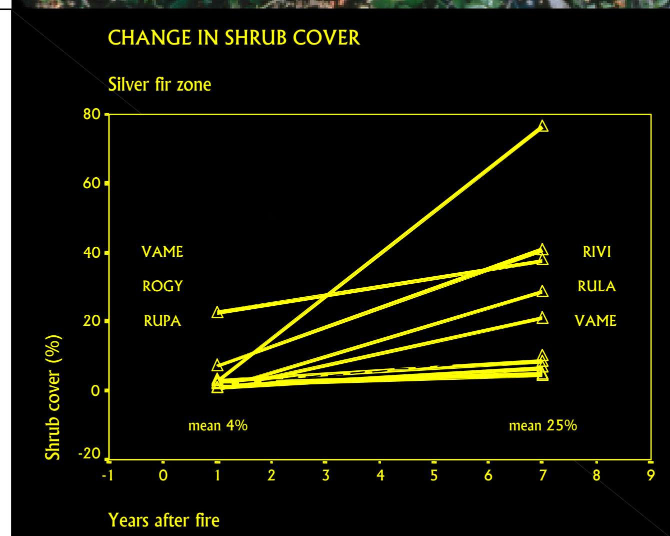
Similarly, a mean of 16% of snags per plot broke into



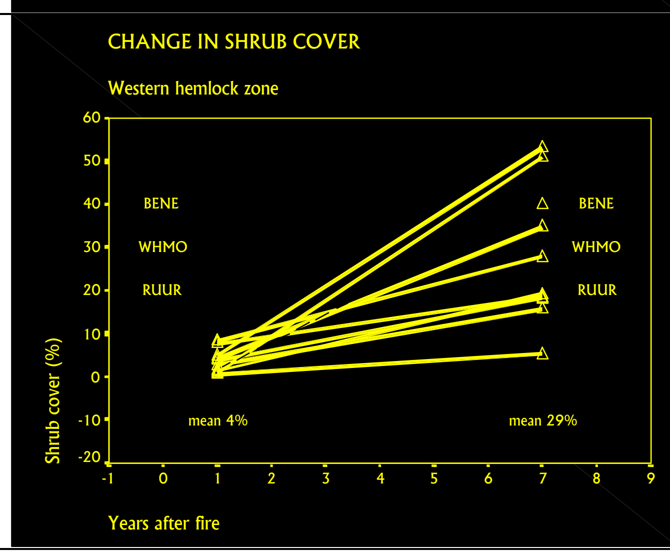
two parts, a snag and a log. Snags that broke tended to be taller snags. As far as I can tell, the snag break rates for Douglas-fir and western hemlock are similar to published values (Mellen & Ager 1998), but for silver fir they are very high.

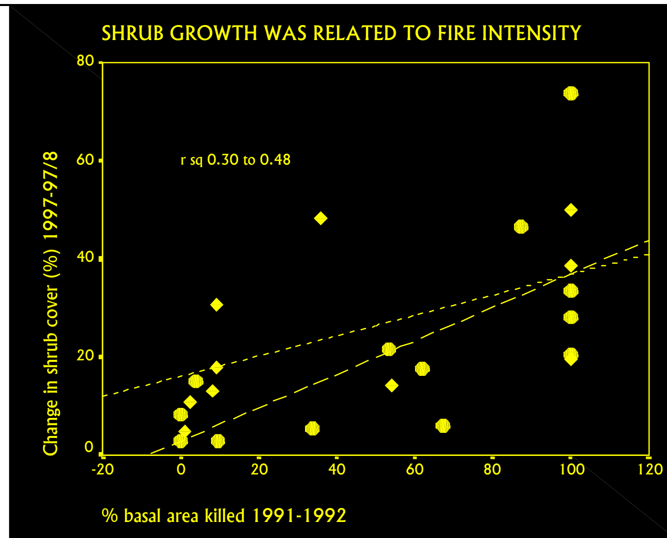
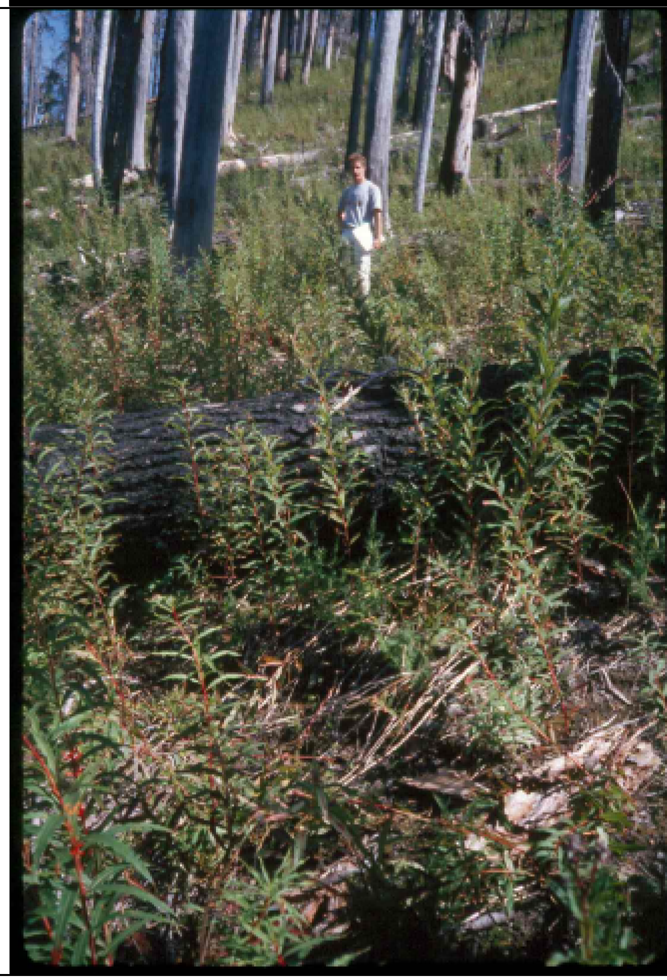
While all that stuff was falling down, shrubs were also growing up.

This graph shows the abundance of shrubs in the silver fir zone. Here on the Y axis there's shrub abundance, and on the X axis years after the fire. Right after the fire shrub cover was low, a mean cover of 4%, with the most frequently encountered species huckleberry, rose, and blackberry. By seven years after the mean was a lot bigger, 25%, and some plots had has much as 75% shrub cover, and Ribes had become one of the most frequently encountered species.

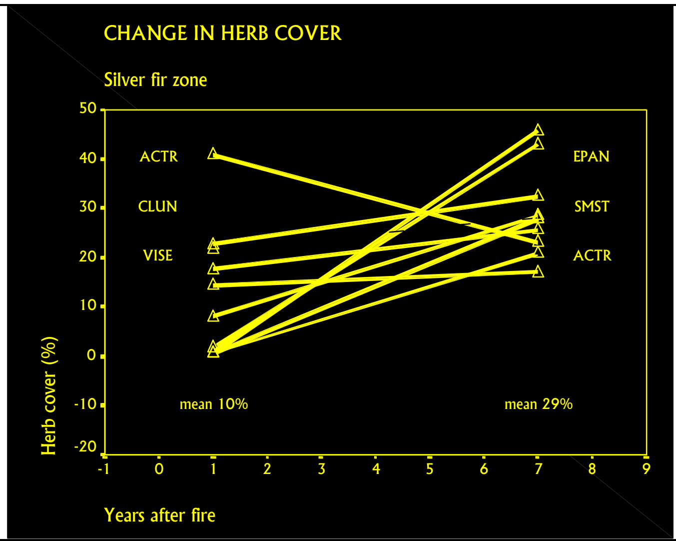


Results for the western hemlock zone are very similar, though the species are different.

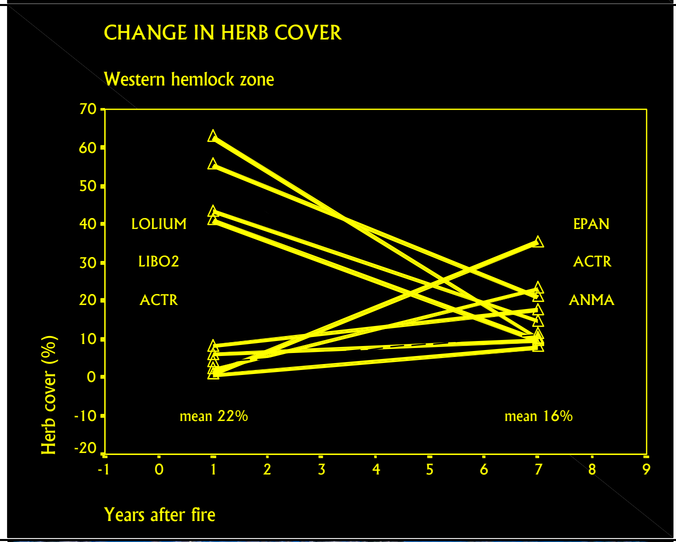


In both zones, the growth in those shrubs was related to fire intensity, with the biggest growth to the biggest covers, shown on the Y axis, occurring in the stands with the highest fire intensities, shown on the X axis. It's not an incredibly exact relationship but it is significant.	
Herb cover was a little more complicated.	

Seeing this kind of graph again, with years after fire on the X axis and herb cover on the Y axis. Plots in the silver fir zone some relatively high covers one year after the fire. But they didn't show as dramatic an increase as shrubs by 7 years after.



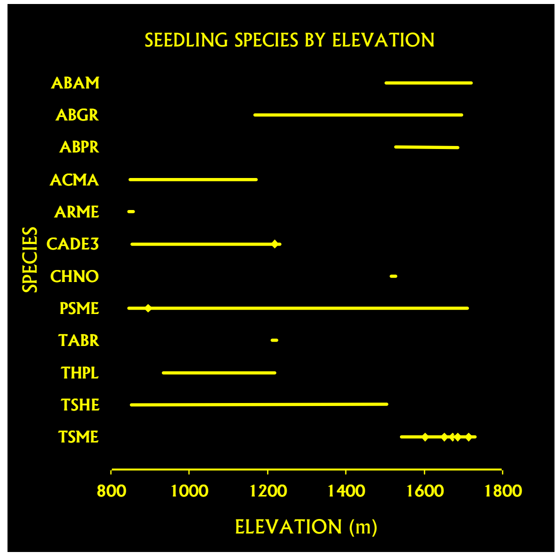
Here in the western hemlock zone, something totally different went on. Some of the covers 1 year after the fire were very high, because an annual Lolium had been seeded as part of fire "restoration" efforts. By seven years after the fire, this Lolium was almost entirely gone, and fireweed was the most common species.



While those herbs and shrubs were growing, new tree seedlings were also growing.

We found nearly all the major species, pretty much where you'd expect them.

This graph shows the range of elevation where we found seedlings of each species. Here are the species and here are the elevations. Silver fir (labeled ABAM) and mountain hemlock (labeled TSME) were found above 1500 m. Meanwhile, western hemlock (labeled TSHE) and bigleaf maple (labeled ACMA) were found only below that. Note the Douglas-fir (PSME) is everywhere.



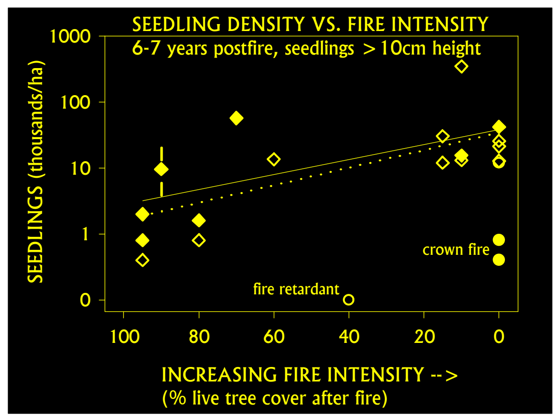
This graph shows the densities of seedlings that we found, on the Y axis, and compares it, on the X axis, to fire intensity.

The first thing you notice is that these numbers are fairly high. Very often, plots showed seedling densities of 5-50 thousand per hectare. Ten thousand is the equivalent of one seedling in every square meter of the stand.

The seedling density is related to fire intensity. Generally, places with higher fire intensities have higher numbers of seedlings. These regression lines may not look very steep on the graph, but remember, this is a log scale.

The only major exceptions to this relationship are these unusual sites with low numbers of seedlings and odd histories. One of them got bombed with fire retardant and has practically zero when everything else has at least a few. The others had very intense crown fires and may have burned up the closest source of seed.

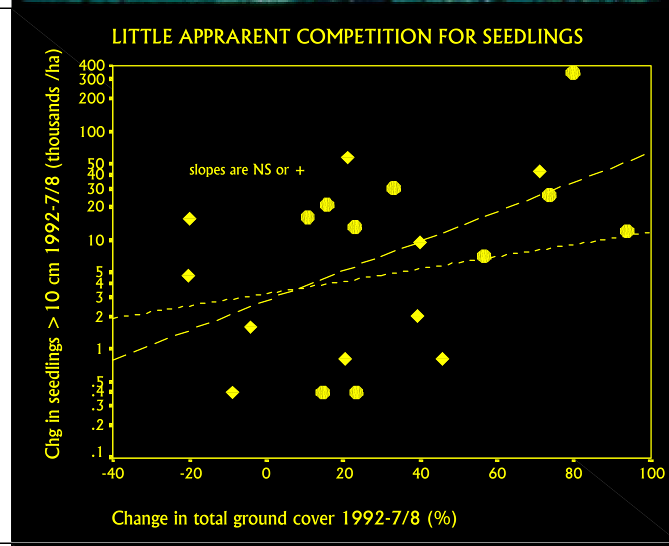
Effects of fire intensity on regeneration have been noticed in other ecosystems (Little et al 1994, Schimmel & Granstrom 1996), but this is the first time I've heard of it for the Cascades.



In this slide you see several kinds of regeneration simultaneously. We were curious if the herbs and shrubs that were growing up might have been discouraging the establishment or growth of seedlings, so we made another graph.

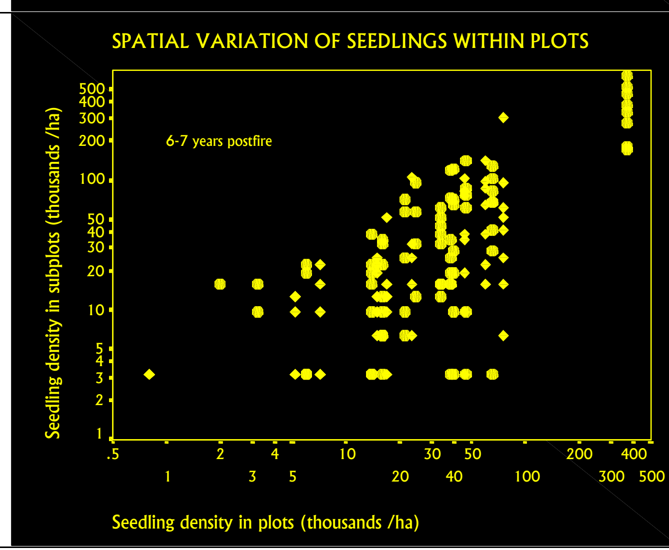
This graph compares change in seedling count between 1 and 7 years after the fire, seen here on the y axis, with change in ground cover over the same period. If direct competition was going on, we would expect to see an inverse relationship here.

Instead, that relationship is nonsignificant or positive, where the sites that increased the most in ground cover also increased the most in seedling density. That implies that there may be simply better and worse sites for new plant growth, and both herbs and shrubs or seedlings benefit or suffer more or less the same. In any case, we're not seeing any strong repression of seedlings in the data we've got.



We studied seedlings in some detail. Instead of just measuring cover, we set up eight small seedling subplots in each plot, so we could count the actual seedling densities and get some idea of spatial variation.

This graph compares the total seedling density in the whole plot (on the X axis) to the seedling density in the individual subplots (on the Y axis). What you see is that seedling density can vary a lot within a plot. You might have a general density of 50 thousand per hectare, but locally those numbers could be anywhere from 0 to 300 per hectare. These seedlings are numerous, but not laid out in a grid!



It's possible to take these seedling observations in subplots and use them to make a fast and loose calculation of how long it will take the stands we studied to return to a consistent forest cover.

I defined consistent forest cover as having every subplot

Projecting "restocking" times for well-burnt plots

A fast and loose calculation of time to

in a plot occupied by at least one seedling of 10cm or more. Then I used my seat of the pants calculation to predict how long it would take for each stand to reach that point.

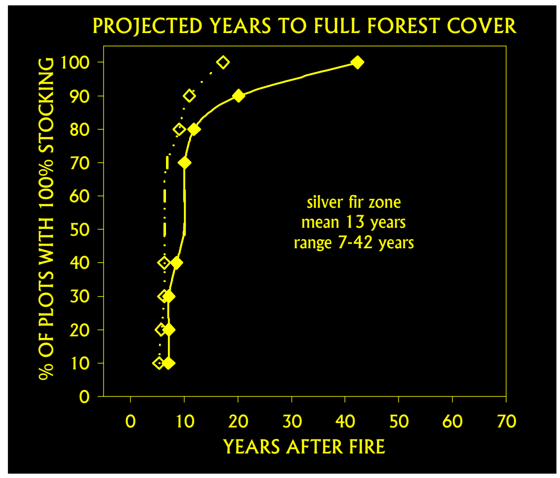
I only did this projection for stands that had lost at least two-thirds of their trees by 1997/8. The remaining stands seemed to have a fairly substantial forest cover remaining.

consistent forest cover

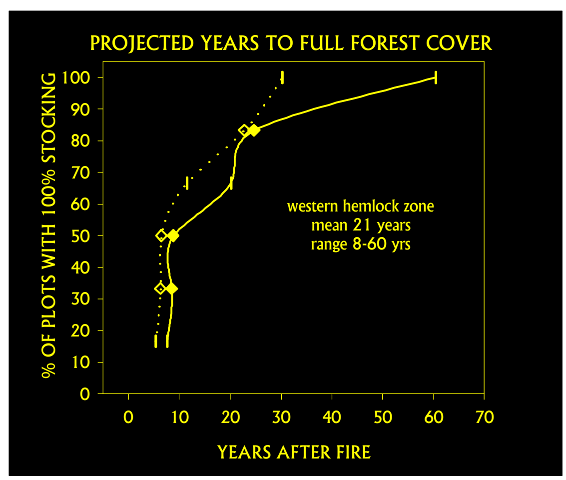
"Consistent forest cover" = 1+ seedlings in each subplot

Data limited to stands that lost two-thirds or more of trees

Here's what the results of that number crunching look like for the silver fir zone. The x axis has years after the fire, and the Y axis has the projected percent of stands that are fully stocked. Looking at the solid line, you see that most of the stands "restock" pretty quickly -- the mean is 13 years. However, a portion, maybe a fifth, take a lot longer, up to 42 years.



In the western hemlock zone, the time can get a little longer. The projected mean time is 21 years, and the range is 8-60 years.



These projected times match pretty well with the historical reconstructions I've seen (see nearly all the reference list). Most of those papers project times of 3, 5, even 10 decades before complete forest re-establishment of Douglas-fir. A few reconstructions have shown a mix of quick and long re-establishments.

Discussion of projected restocking times

Range of times matches well with reconstructions

Those slowly restocking stands imply that historically, there could be stage of forest succession, decades-long, that was characterized by a lack of complete tree cover. I wonder, was there a unique ecological value to that stage that we want to replicate today? I don't know the answer, I'm just throwing that out there.	***Slowly restocking stands imply a stage of forest succession without total tree cover*** ***Was there a unique ecological value to that stage we want to replicate today?***
In conclusion, at Warner, we observed a lot of important ecological activity: trees dying and turning into snags, snags falling and breaking into logs, shrubs and seedlings coming back in force. These processes occurred on every plot, but varied much in speed or magnitude. That variability is related to the original fire intensity, with faster or bigger changes often associated with higher intensity fire. That variability in speed of postfire processes will probably lead to considerable spatial variability in the future Warner landscape. If the goal of our management activities is to imitate natural or historical processes, Warner provides a useful example of how variable the effects of a single event can be.	**Conclusions** ***At Warner, we observed a lot of simultaneous ecological activity*** ***These processes occurred on every plot, but varied much in speed or magnitude*** ***That variability is often connected to fire intensity/ will lead to spatial variability*** ***If the goal of our management activities is to imitate natural or historical processes, Warner provides a useful example of how variable the effects of a single event can be.***
Thank you. Contact me at martin@brownandbrown.tv	**Thank you.** ***Contact me at martin@brownandbrown.tv***

References

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Gray, AN & Franklin, JF. 1997. Effects of multiple fires on the structure of southwestern Washington forests. Northwest Science 71:174-185. [reconstruction of forest history showing mostly quick but occasionally long (34 years) period of seedling establishment]

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Schimmel, J., and A. Granstrom. 1996. Fire severity and vegetation response in the Swedish boreal forest. Ecology 77:1436-1450. [field experiment showed best regeneration at moderate fire intensities]

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