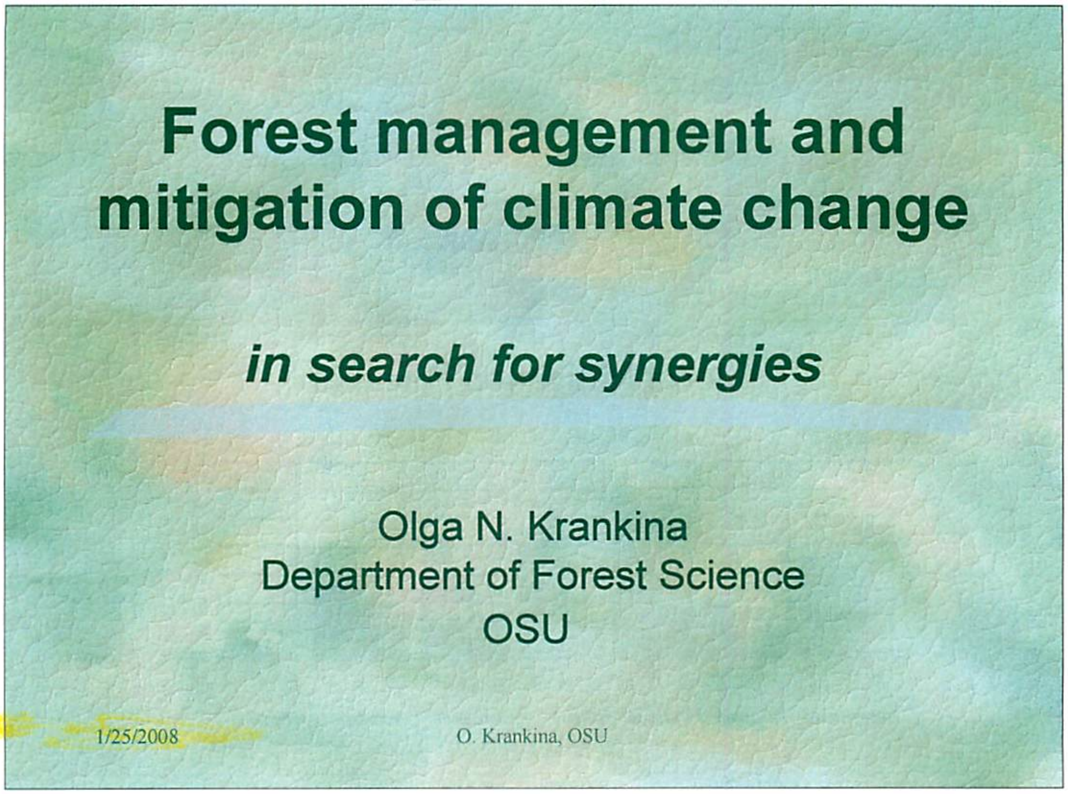
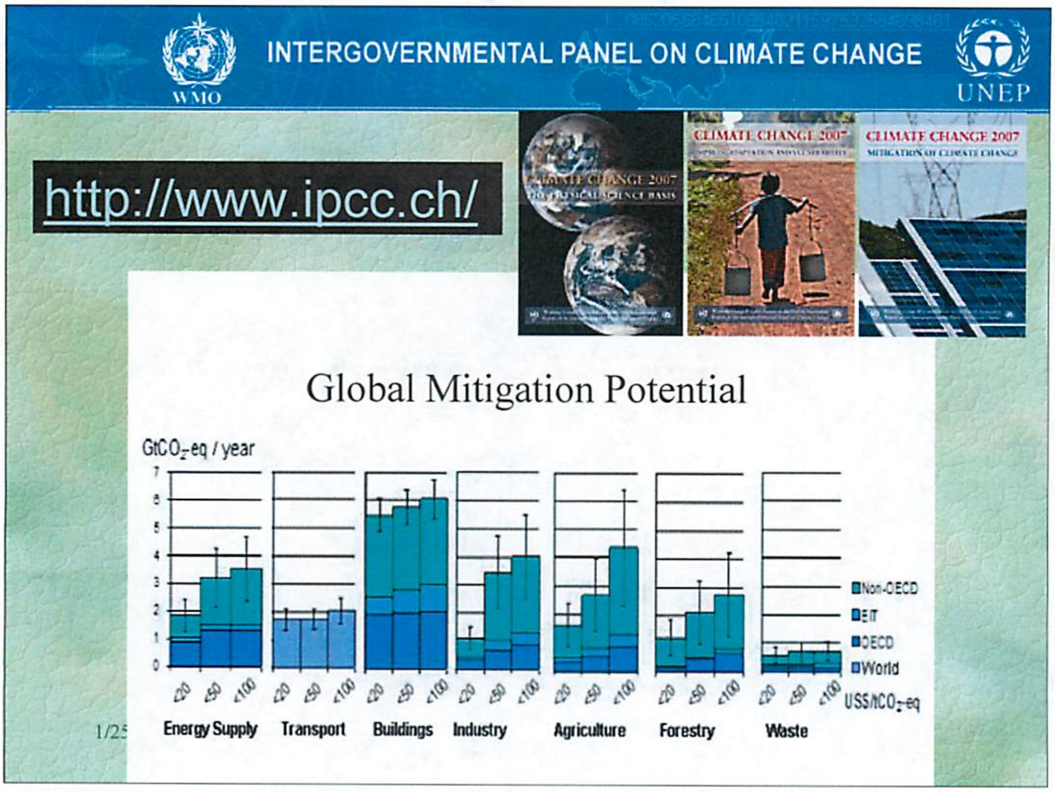
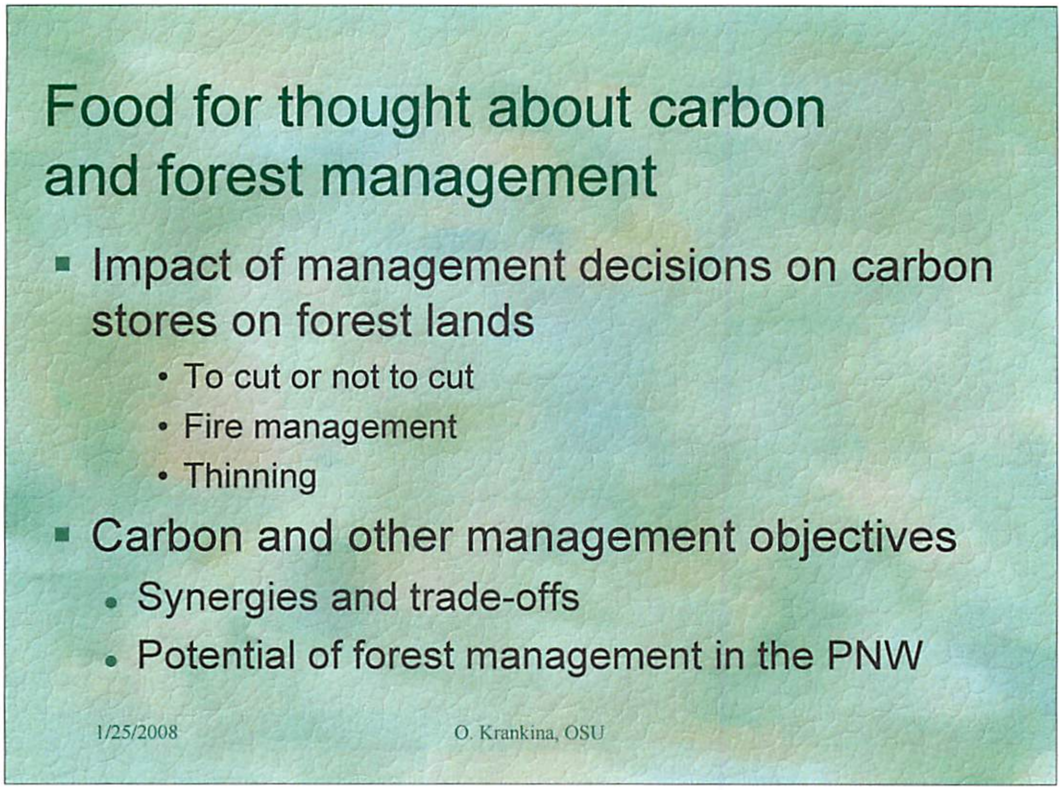


Mark – explained the problem, and I wish I could just lay out all the solutions for you here. Unfortunately, I cannot do that and I do not think anybody can. But it is not all gloom and doom. If you remember the wedges diagram – it clearly shows that it is possible with present-day technologies to avoid the doubling of CO2 concentrations in the atmosphere. The important point is that we cannot afford to pick and choose, we really need action on all fronts, including energy conservation, alternative enery sources, improved efficiency of industrial energy use and transportation, and YES changes in forest management which is the subject of my talk.



A comprehensive literature review on climate change, its impact and mitigation options can be found in the assessment reports of the IPCC. The latest IPCC report was released last year and shortly thereafter came an announcement that IPCC and al gore received the Nobel Peace Price. I am among 2000+ scientists who contributed to IPCC reports and I will be using in my talk some materials the latest two reports. For example this chart (from 2007) report shows that the forest sector can play a substantial role globally on par with other sectors. So why does not mass media talk about climate change mitigation using forest management measures? Why is FM essentially absent from all the recent policy initiatives? I believe the positions of both forest industry and environmental community contributed to this unfortunate outcome, but I am not representing any interest group here and in my talk I will rely on one important principle that guides the IPCC work - that is to deliver policy-relevant information without making policy prescriptions. In other words, I am not here to tell you guys what to do about climate change, rather my objective is to provide some

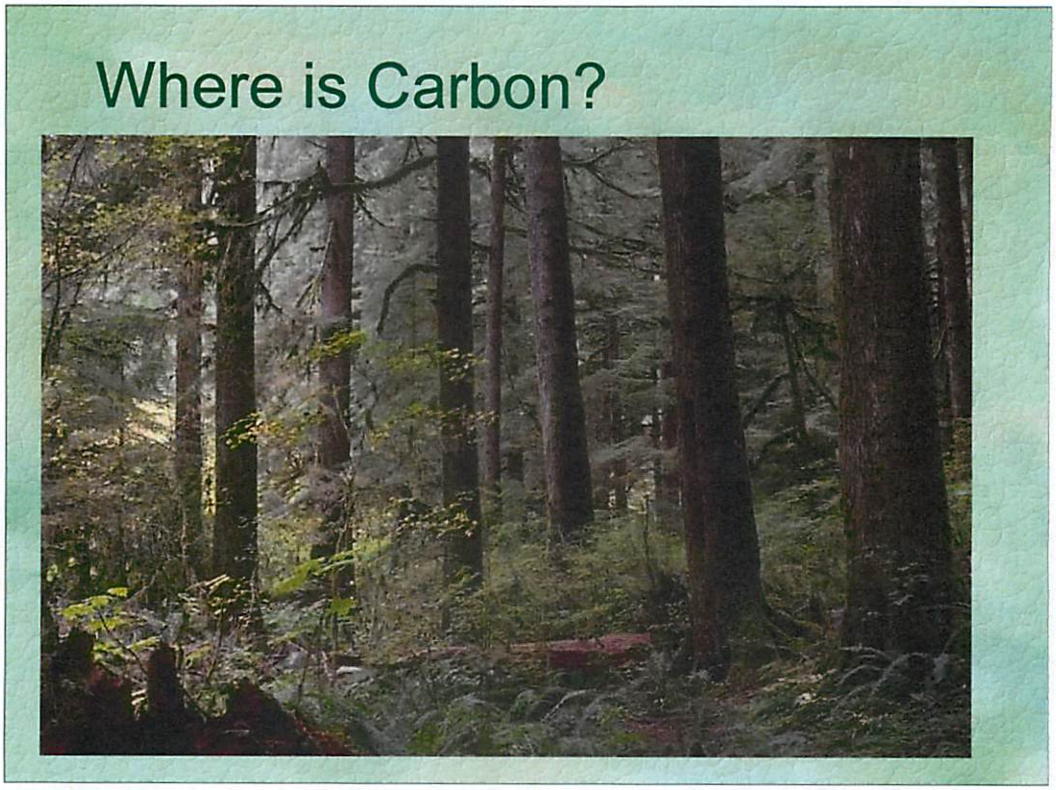


provide with some food for thought about C as a new and distinct dimension in forest management. We will go over the impact of management decisions on C stores on forest lands focusing of three often discussed issues:

To cut or not to cut at the time when stand approaches economic maturity; what is the effect of changing fire regime and the expanding forest thinning that is proposed as measure to prevent major fires. Is young fast-growing forest our target if we manage for carbon storage? Is thinning going to increase C stores on forest lands? How much increase in C stores on forest land can be expected from prevention of stand-replacing fires and replacing them with frequent light burns? – I will try to answer those questions and I think some answers may surprise you. I do not plan to show any new or groundbreaking forest science here, my goal is pretty much the opposite –to demonstrate how common sense and some basic forests ecosystem knowledge and can be used to evaluate forest management practices in terms of C storage.

We will look at what makes forests in the PNW unique in this context

Synergies seem easy to recognize but there are also conflicts and the need for tradeoffs and those can be difficult to accept. Finally, I would like to discuss the potential and limitations of forest management in the PNW as a tool for mitigating climate change. And time permitting share my views on



Where is C?:

Trees: what makes trees different from other plants – hold on to the C (forest versus field of corn). 50% of tree biomass is C;

Trees are the most prominent and the most visible component but truth be told they only account for about half, where is the other half? Soil, dead plant material.

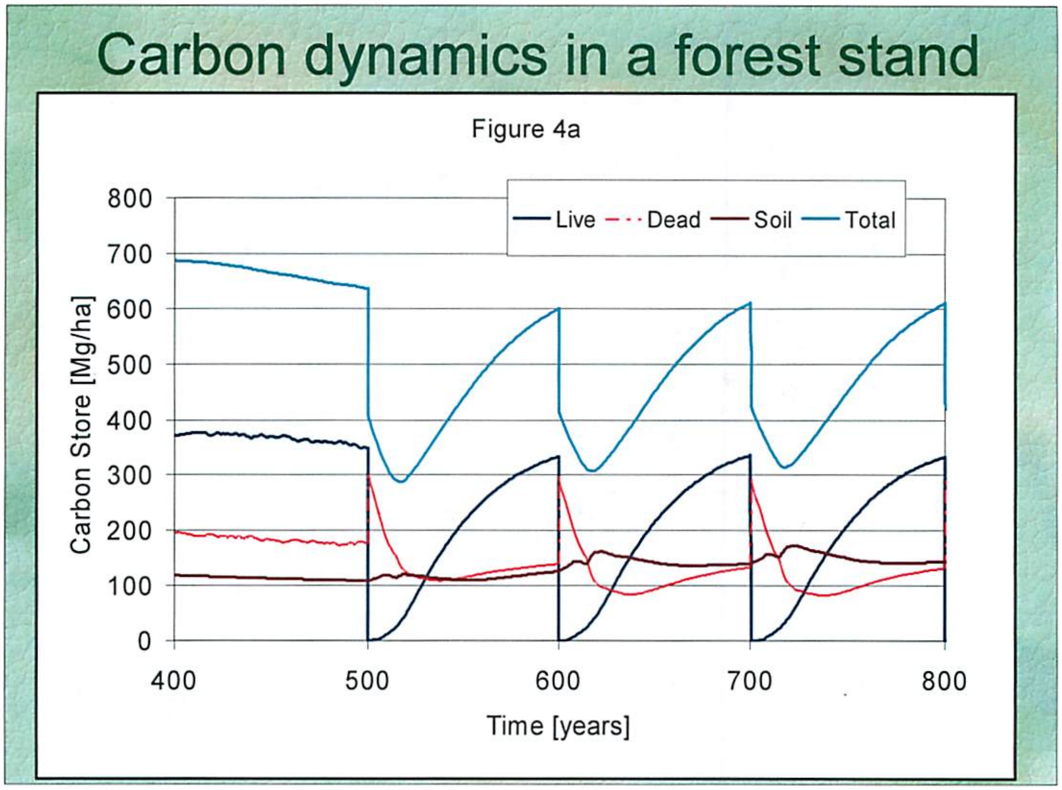
C in all these components has been removed from the atmosphere and these are the components we need to track if we are to understand the C balance of a forest ecosystem.

at some point and the more C is stored on land the better for reducing C concentration in the atmosphere.

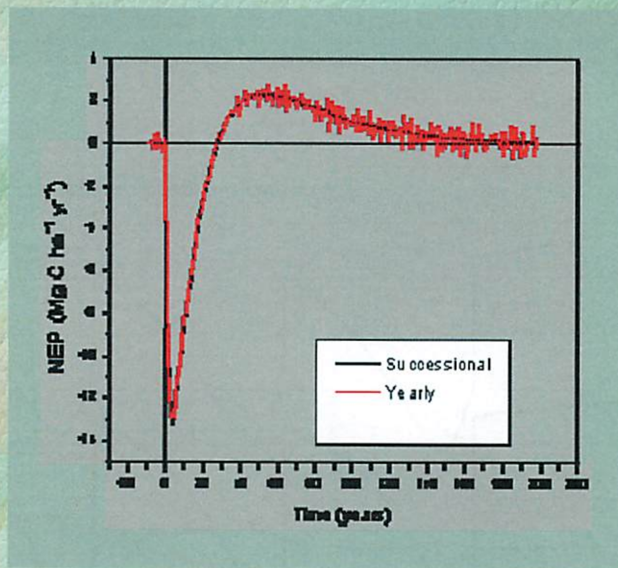
50% rule:

50% of C in forest is in trees (up to!!)

To the extent that you know stand dynamics and the effect of management on those dynamics you can actually figure out the rest of my talk yourselves – but if you like some help in getting you started on that path – please do keep listening.



Change in live forest biomass following timber harvest – probably looks familiar: it drops to 0 once the trees are cut, them followed the good old s-curve, the cycle repeats itself. Other major ecosystem component however do not change in sync with tree biomass or timber volume for that matter. Dead biomass is receives a big influx of material following harvest, and this is not just needles, tops and branches – a large porting of it is stumps and roots. All this material decomposes and loses C gradually over many years and decades; the dead pools declines for a while then increases again as dead material inputs from the new stand exceed losses from decomposition. Soil C pool changes over time as well but those changes are relatively minor at the time scale decades. The total C pool in a forest changes similar to live biomass but there are some notable distinctions: live biomass is about one-half of the total C store; the other half is NOT in sync. Because of that total C stores decline for 10-2o years following disturbance and this means that the forest is a source of C even as new generation of trees actively accumulates C. The divergent dynamics of live biomass and dead organic material is key to understanding distinction between optimal management for timber production and the optimal management for C stores on forest land.



StandCarb Model output, M. Harmon (adapted from Cohen et al. 1996)

1/25/2008 O. Krankina, OSU

This is another representation of the pattern of carbon loss and accumulation following disturbance indicating forest transition from near-equilibrium with respect to C to very active source of C to the atmosphere then to C sink. The transition from source to sink can takes many years even with prompt regeneration and I know people often have hard time with this idea .

I hope this visual aid will help:

The role of disturbance

- Transfer of material from live to dead carbon pools and out of the forest
- Transition of forest stand from sink to source; then back to sink as new stand develops
  - an individual stand the impact depends on the selected time frame.
- Average carbon stores are constant over a landscape where a selected management option is repeated indefinitely

1/25/2008 O. Krankina, OSU

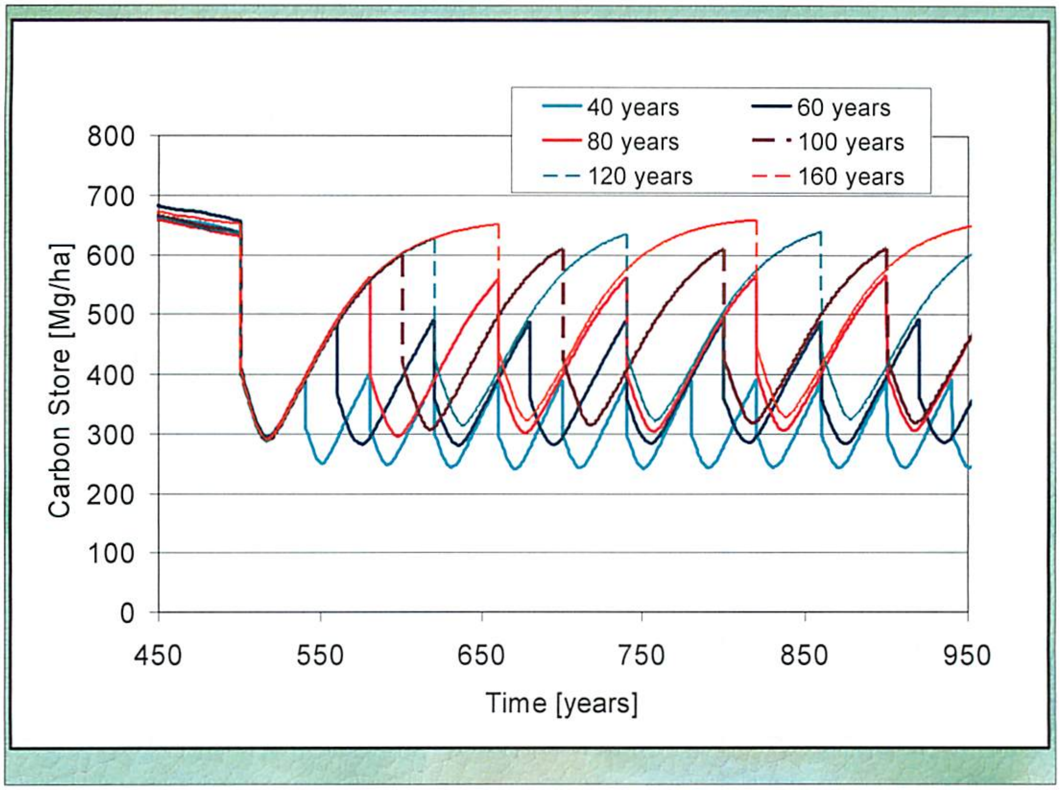
Forest disturbance is a major impact on C stores

Transfers,

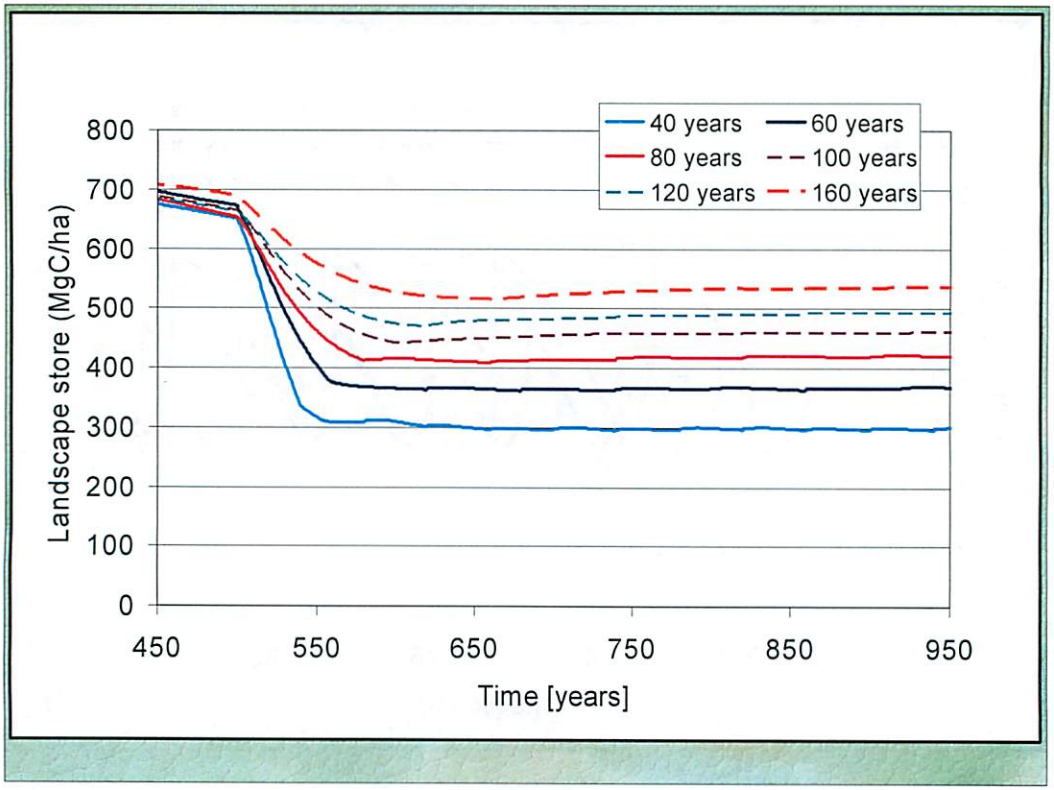
Causes transition

A significant confusion in literature about the impact of forest management practices on carbon stores is related to the fact that for an individual stand the impact depends on the selected time frame. At the level of an individual stand in a given year or decade it is actually impossible to evaluate the impact of FM. If a stand

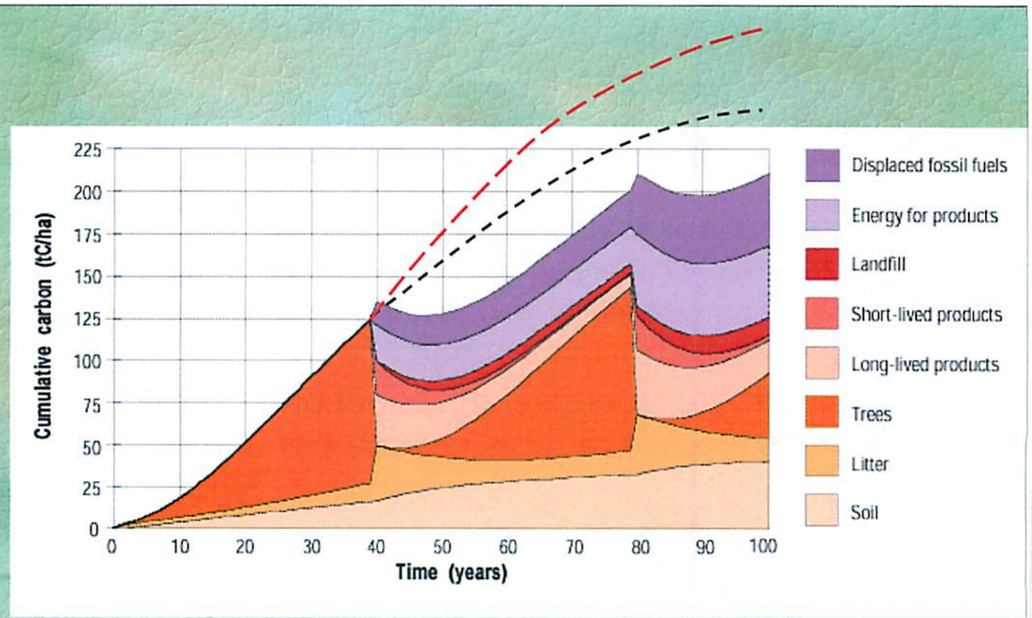
At a landscape-scale analysis can be more meaningful because we can compare the averages of carbon stores over a landscape where a selected management option is repeated indefinitely and those are constant as long as the regime is maintained. This idea tends to be a bit of a mental hurdle, let me try to explain



40 year rotation – this and the earlier graph show output of STANDCARN model developed by Mark Harmon. We can increase the interval beween harvests and get a different pattern of peaks and valleys but still the long-term average is constant and the difference between different rotations is in the average level of C stored on land- the longer the rotation the higher is the average store of C.



We can get a clearer picture if we run the model for a large population of stands within a landscape. Clearly rotation length makes an important difference. One can gain a 50% increase in C stores by extending rotation from 40 to 100 years. And it makes sense – keeping trees growing and accumulating C should lead to more C in live biomass and in other forest C pools as well. But what about forest products? Their output and C store will decline, right? And will lose the benefit of substituting wood for energy intensive products on top of that? Well, let us actually compare gains and losses.



Cumulative carbon changes for a scenario involving afforestation and harvest (adapted from Marland and Schlamadinger, 1999)

1/25/2008 O. Krankina, OSU

this graph comes from a paper that did a very detailed and thorough analysis of the benefits associated with harvested wood. The authors are not from this region but as a gift to us they actually use the douglas-fir growth curve. The graph shows the growth of a forest stand for 40 years followed by harvest and distribution of harvested material is tracked – some of it goes into slash that is added to litter pool, some becomes long-lived and short lived FP – the short-lived products transition into landfills and decompose, some of the long-lived products are still around at the time of next harvest. Then there are 2 pools shown in purple that representing prevented emissions – one represents fossil fuels displaced by the use of wood waste for energy production, the other one shows the effect of using wood in place of alternative energy intensive materials (metals and cement). Over time benefits of rotation forestry accumulate nicely and these are the sort of graphs forest industry advocates will use to show how they contribute to solving the problem of climate change. One comparison that the authors did not make is with letting trees grow beyond 40 years. Here is my rough reconstruction of the growth curve and it looks like it will take much longer than the time interval on this graph for the C storage associated with forest products to catch up with C storage in a forest stand where tree that are allowed to grow. Exactly how much longer is an interesting question and the answer depends on the growth curve used. The red one reflects growth as measured on ecological plots, the black is what you will get if you use forest inventory statistics.

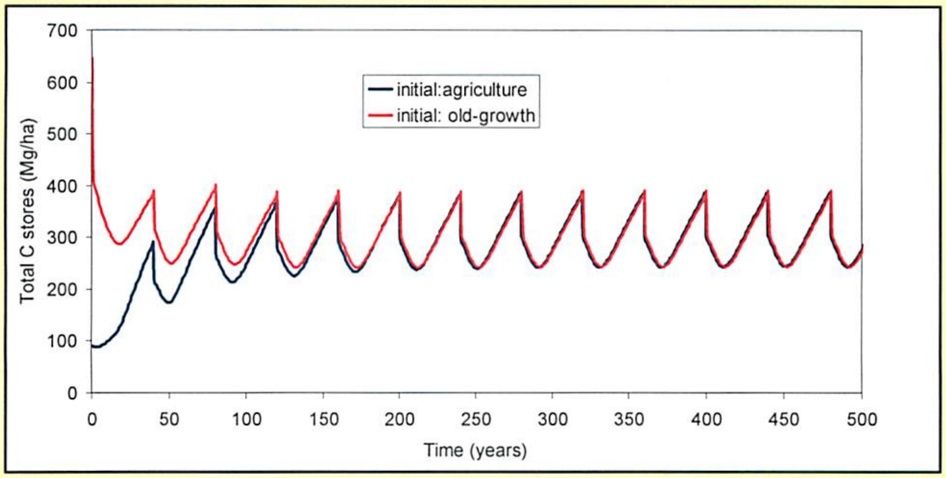
Forest products sector

- Retains carbon in products
  - Rates of carbon loss through decomposition and combustion are similar to decomposition rates of coarse woody debris on the forest floor
- Can contribute to emission reduction in other sectors IF forest products reduce the use of fossil fuels
  - Gains are cumulative
- Net carbon gains (compared to no-harvest option) take many decades (or centuries) to begin

1/25/2008 O. Krankina, OSU

Trees are just so incredibly effective in capturing and storing carbon that it is hard for our technology to compete. Because of that most measures reducing timber harvest tend to create some increase in C stores on land.

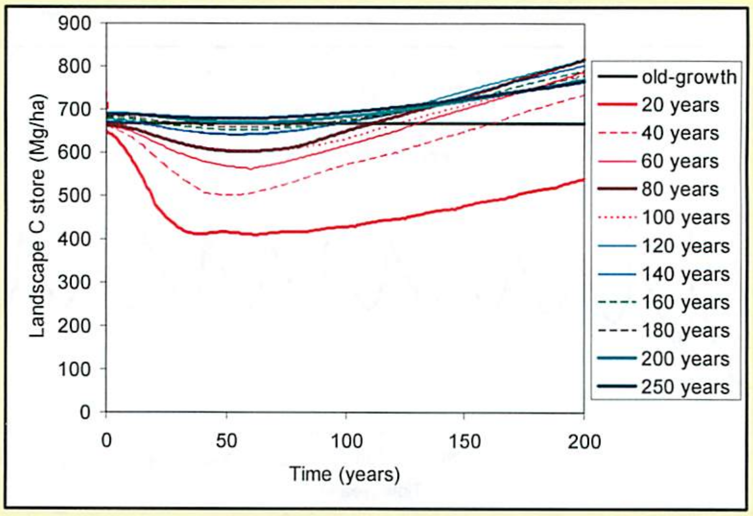
Is intensive forest management always a bad idea? NO!



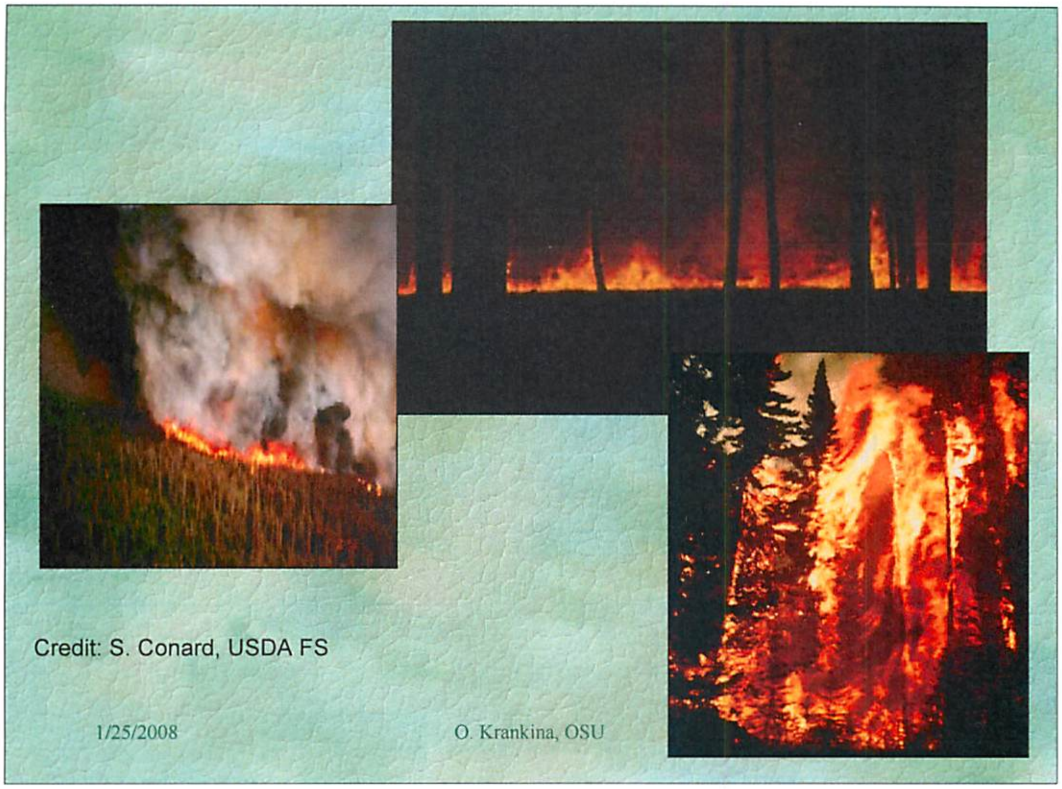
40 year harvest interval

1/25/2008 O. Krankina, OSU

Total Carbon Balance-totals

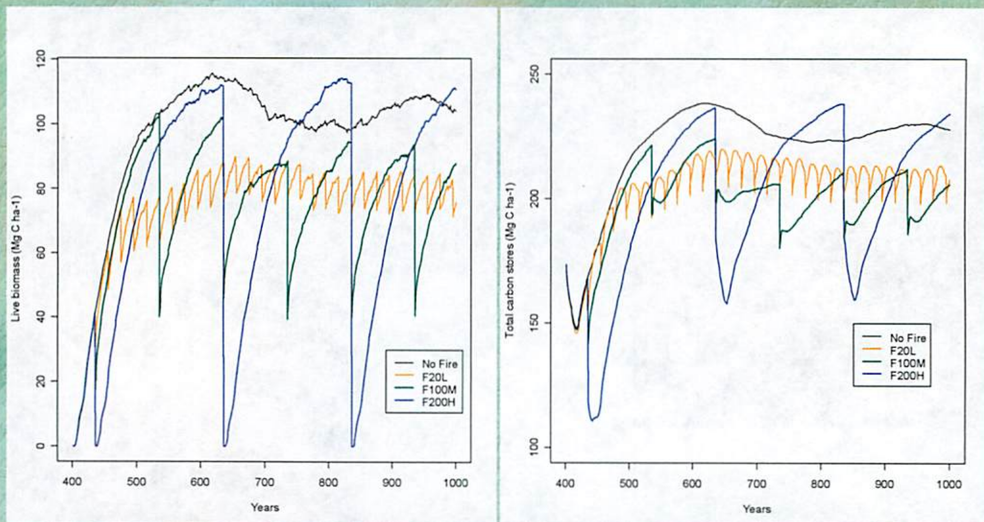


Forest products= 75% Biofuels=12% Substitution 75% of harvest

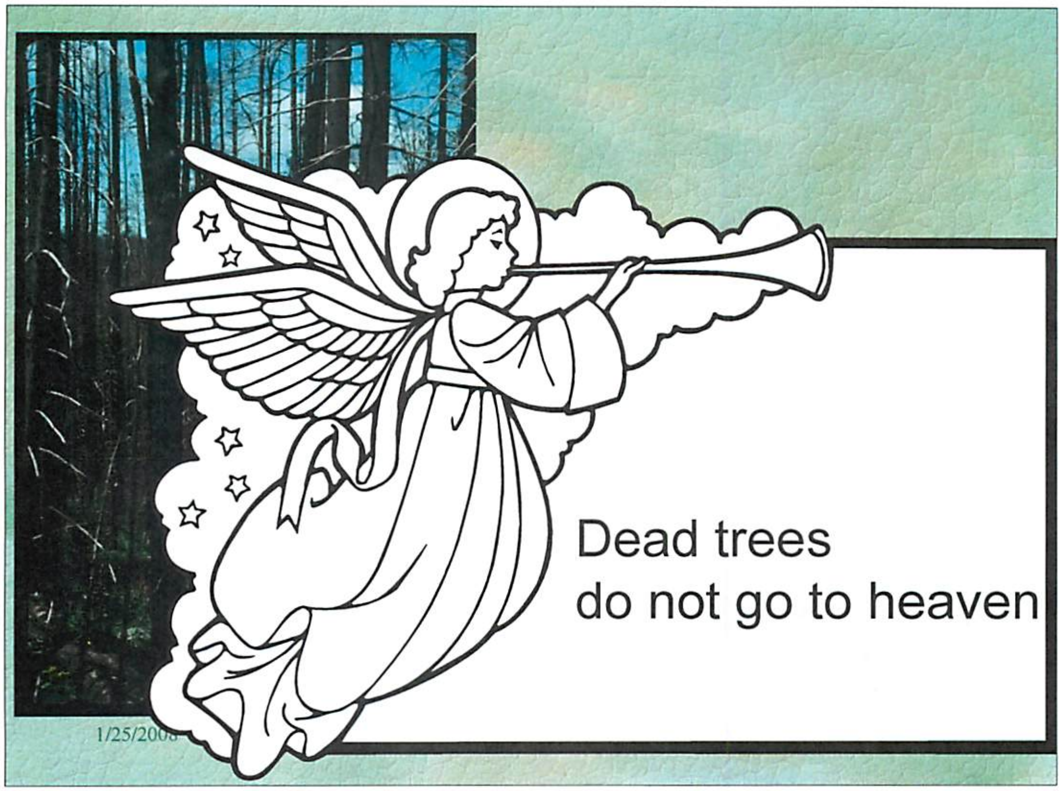


Fire is on everybody's mind. The search is on for ways to prevent severe stand replacing fires by reducing fuel lods, thinning, and generally returning forests to that ideal light frequent burning that was around in good old days. There many good reason fire=proof the forests and help prevent severe forest fires. But now that the smoke has blown off let us try to understand what this means in tems of C.

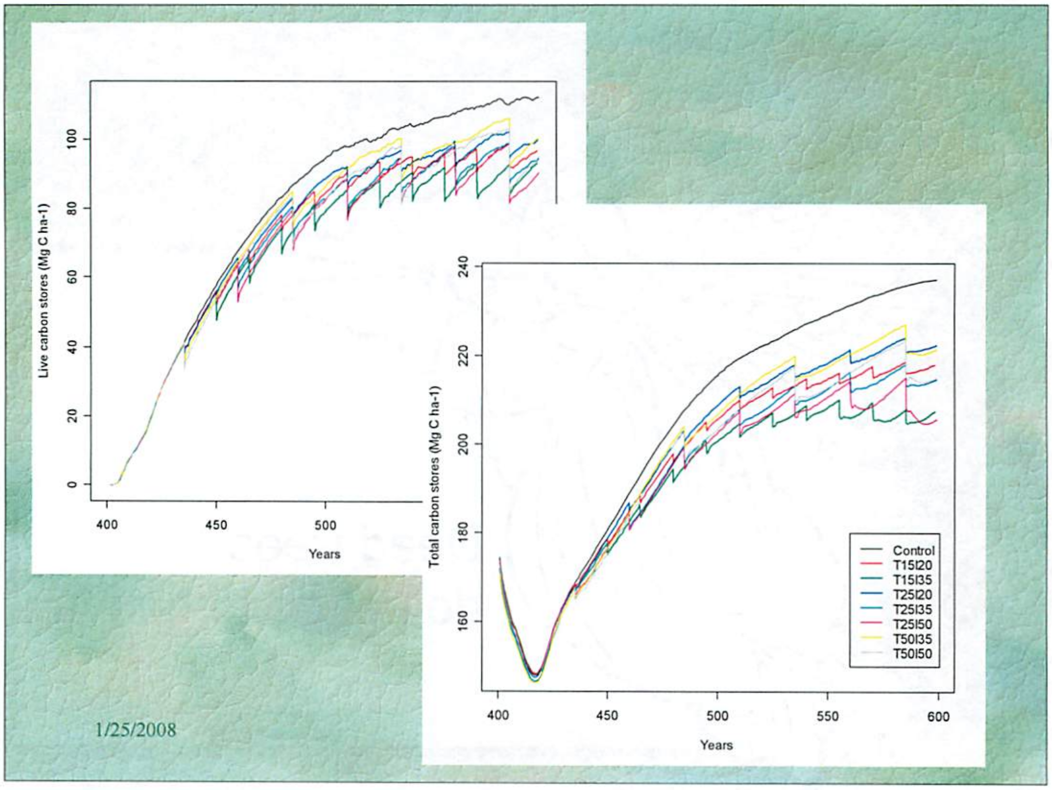
Fire frequency and severity (Ponderosa Pine forest type)



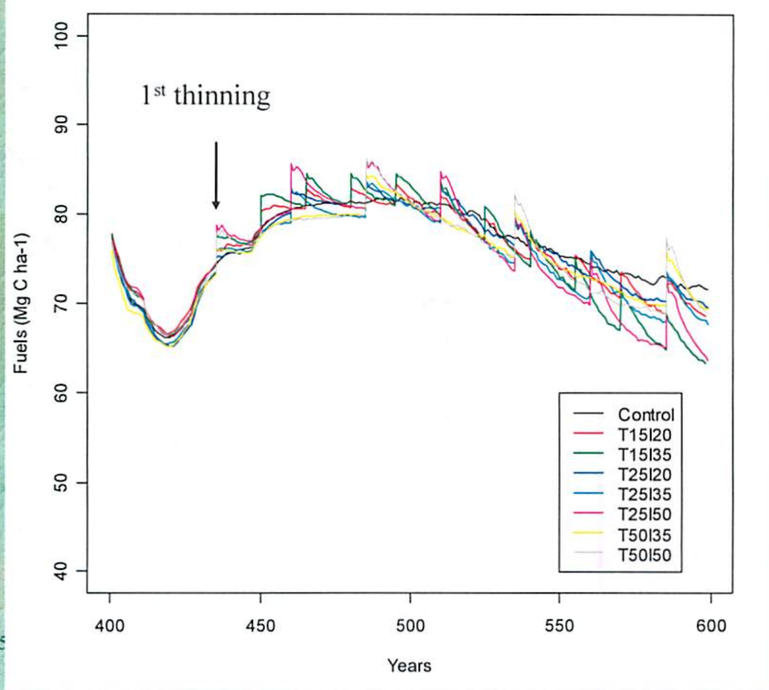
1/25/2008 O. Krankina, OSU



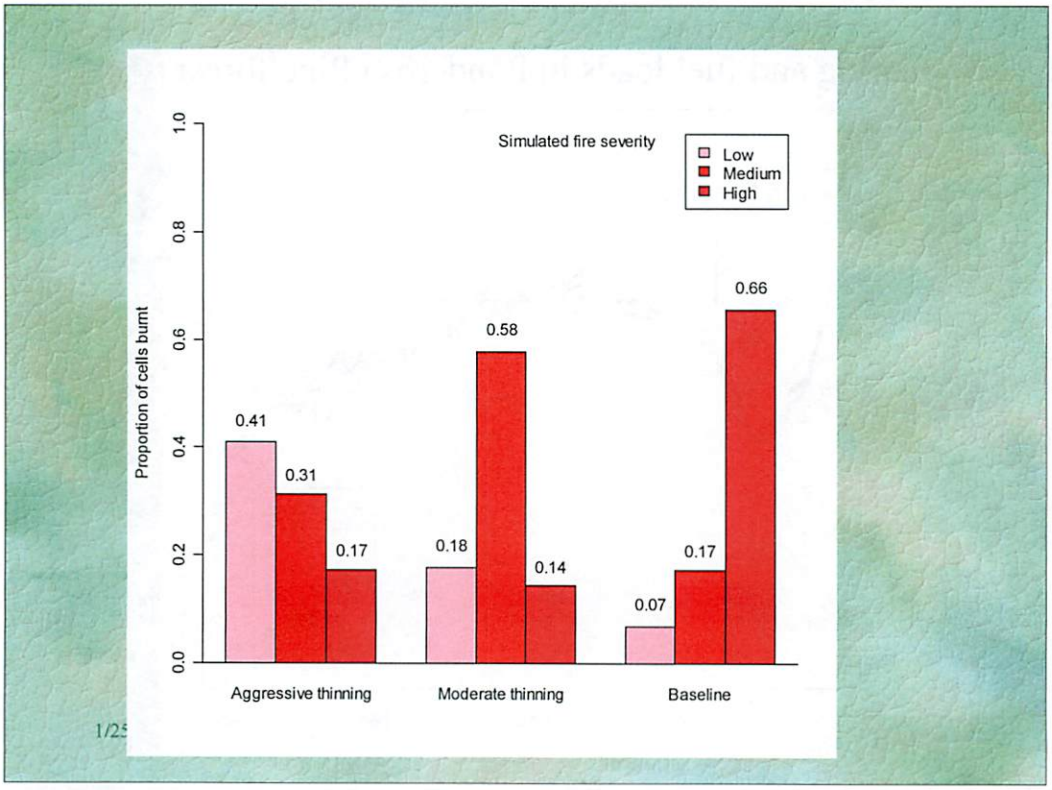
Are those pesky dead trees. After a severe burn 90% of biomass stays, and decomposes surely but very slowly. And maintains high stores of C in the process. In other words – the one simple idea to keep in mind when thinking through C dynamics. This is a general rule for all forests but its impact on C stores is especially important in our region because


Live carbon stores (Mg C ha-1)
0
20
40
60
80
100
400
450
500
Years
Total carbon stores (Mg C ha-1)
160
180
200
220
240
400
450
500
550
600
Years
Control
T15I20
T15I35
T25I20
T25I35
T25I50
T50I35
T50I50
1/25/2008

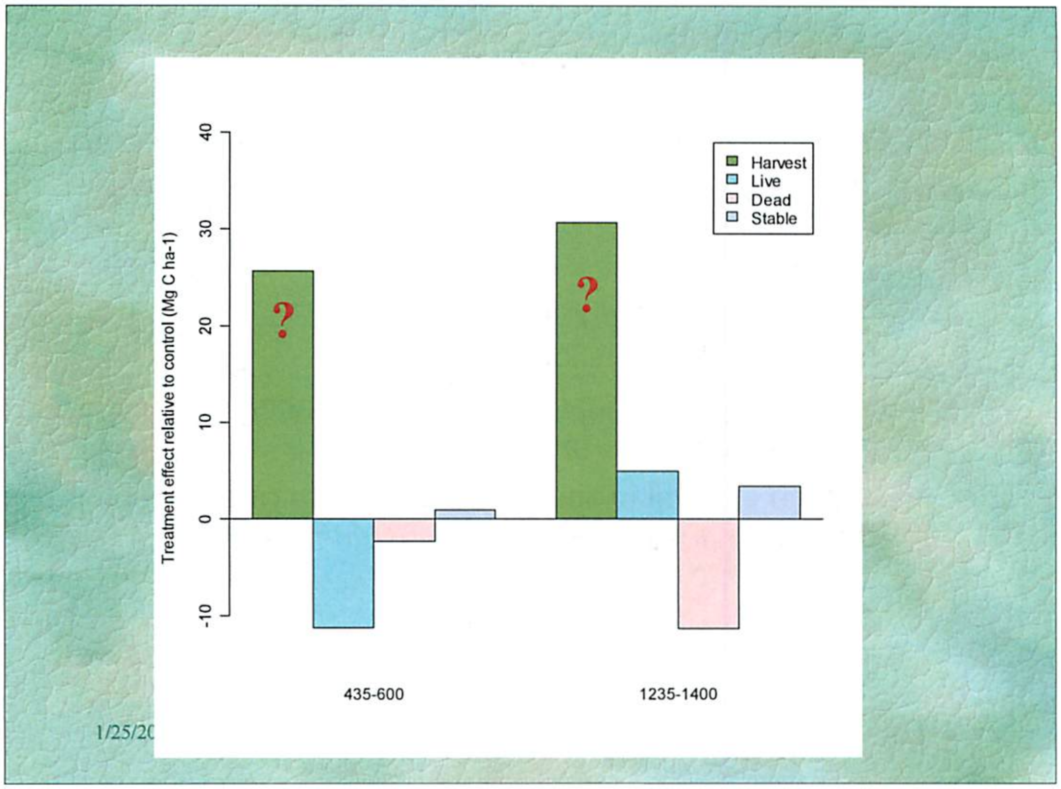
Thinning and fuel loads in Ponderosa Pine forest type

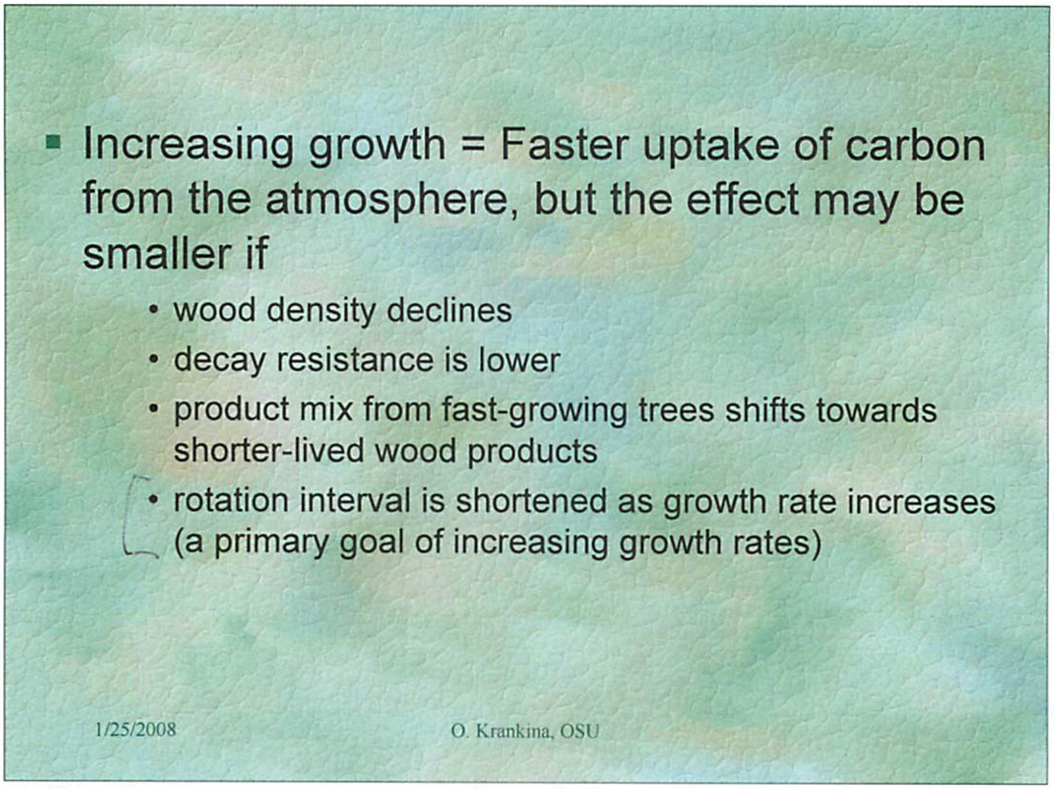


1/25



Simulated fire severity
Low
Medium
High
Proportion of cells burnt
0.0
0.2
0.4
0.6
0.8
1.0
0.41
0.31
0.17
0.18
0.58
0.14
0.07
0.17
0.66
Aggressive thinning
Moderate thinning
Baseline
1/2


Treatment effect relative to control (Mg C ha-1)
40
30
20
10
0
-10
Harvest
Live
Dead
Stable
?
?
435-600
1235-1400
1/25/20



Measures to accelerate the growth of trees may provide for faster uptake of carbon from the atmosphere. However, the effect on carbon storage may be smaller than the increase in growing stock volume if the wood density declines, or if the decay resistance of a faster-growing tree is lower, or if the product mix from fast-growing trees shifts towards shorter-lived wood products. Moreover, if the rotation interval is shortened as growth rate increases (a primary goal of increasing growth rates), then there will be little net carbon gain on-site. Some of the new genetic engineering research aims to increase decay-resistance of fast-growing poplars by increasing the proportion of lignin in wood (Rosenberg et al. 1998); this may enhance carbon storage in decomposing woody material on site as well as in wood products.

Higher carbon stores on land might mean the risk of higher future carbon emissions with more forest disturbance resulting from climate change, for example, lack of drought resistance or invasion of new pests. Several measures can reduce the risk of economic losses and losses of carbon, e.g., selection of species for potential growth and resilience in a warmer climate. Stand and landscape architecture can be designed to increase resistance and resilience. Plans for coping with large-scale disturbance events can ensure optimal results.

Protecting Carbon Gains against the Impacts of Future Climate Change

- ***Choice of species***
- ***Stand and landscape architecture***
- ***Plans for coping with large-scale disturbance events***

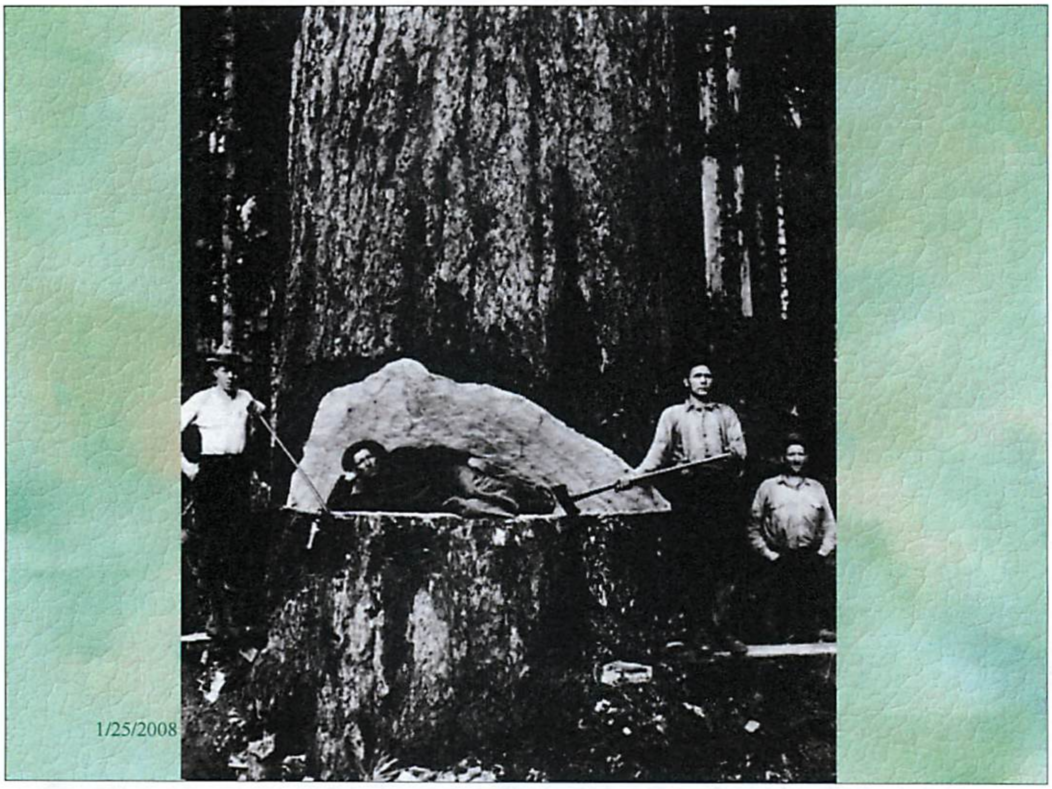
1/25/2008 O. Krankina, OSU

Higher carbon stores on land might mean the risk of higher future carbon emissions. Depending on the rate and magnitude of change, the new climatic condition may exceed the ability of certain tree species to adapt and lead to large-scale dieback of the most vulnerable ones. Invasion of new pests and pathogens is an additional risk factor which might be exacerbated in an altered climate. While it is difficult to anticipate the specifics of future impacts, several general measures can increase the stability of forests in changing environment and reduce the risks of economic losses as well as losses of carbon.

Choice of species. In selecting species for planting at a given site it is important to consider their potential growth and resilience in a warmer climate, with possibly more frequent droughts and weather extremes. Drought resistance is probably the most important trait, as few trees die of excess temperature alone. Long-term resistance to fire, pests, and pathogens is also important as all may become more active. In addition to local pest and pathogen species, those likely to migrate from the south need to be considered as well.

Stand and landscape architecture can be designed to increase resistance and resilience of forests. For example, avoiding extensive coverage by a single species and maintaining mixed species within stands and landscapes or creating fire breaks with reduced fuel loads tend to increase the stability of forests. Thinning treatments can improve stand stability as well.

Plans for coping with large-scale disturbance events are needed to ensure optimal timing for salvage, regeneration, and other important decisions with long-lasting consequences



Here trees grow big and decompose slowly and we are in one of in the very few places in the world where those massive and slow-decomposing trees are still around; well some of them at least.

PNW Forests

- Potential to store additional carbon is among the greatest in the world
  - High productivity
  - Douglas-fir is long-lived and maintains high growth rates
  - History of forest management
    - reduced C stores between 1953 and 1993 by 24% on private industrial lands and by 7% on federal lands (Melson 2004)
    - extensive past harvest created a large cohort of young forest stands that are on track to absorb and store large quantities of carbon
- Potential to prevent C emissions is among the greatest in the world
  - Some old-growth still remains
  - Public support for forest conservation

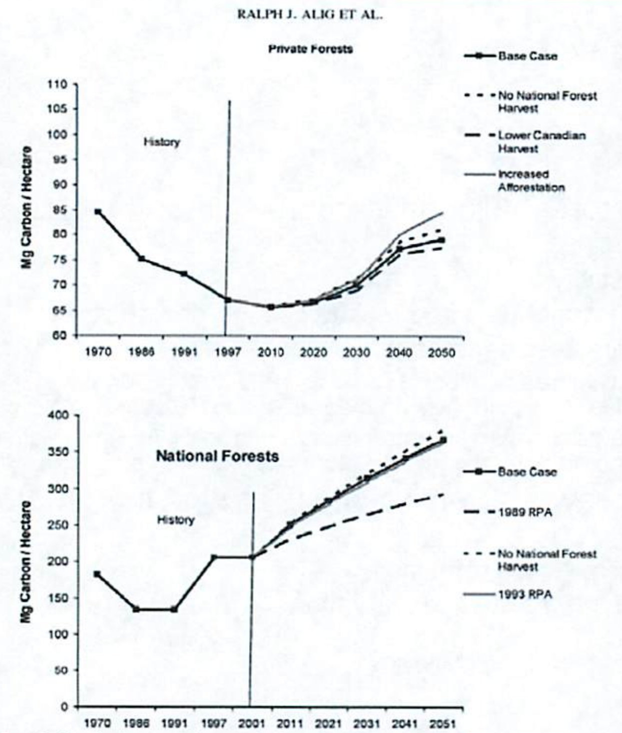
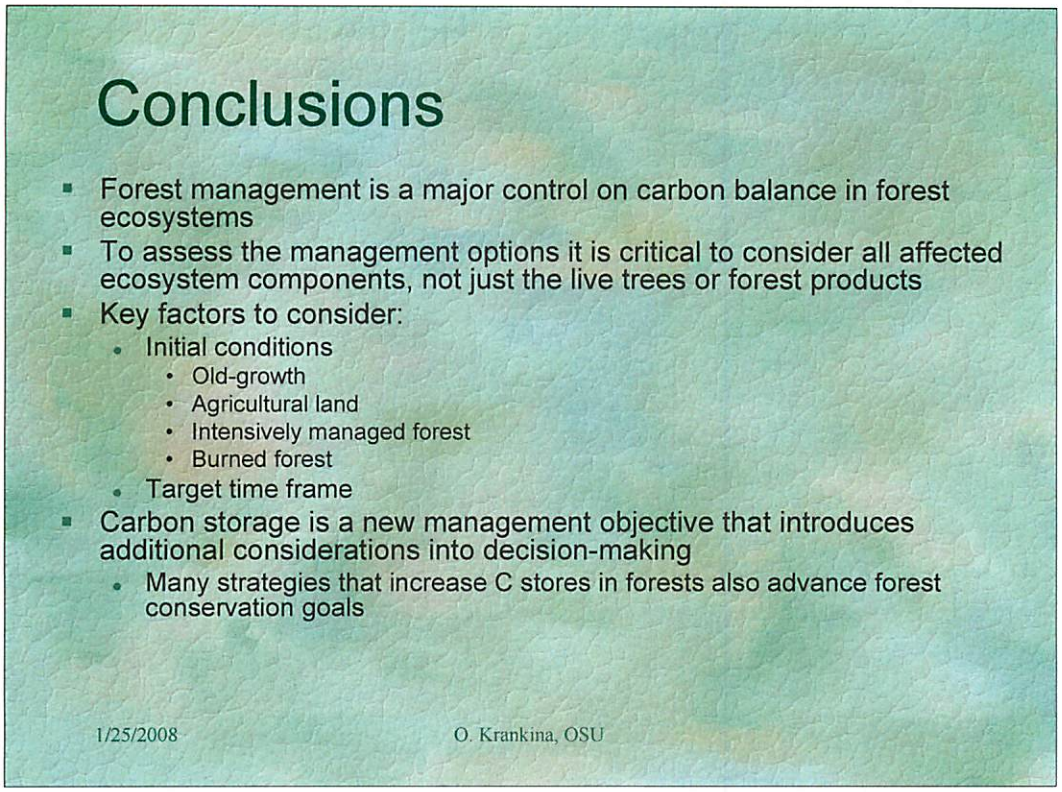
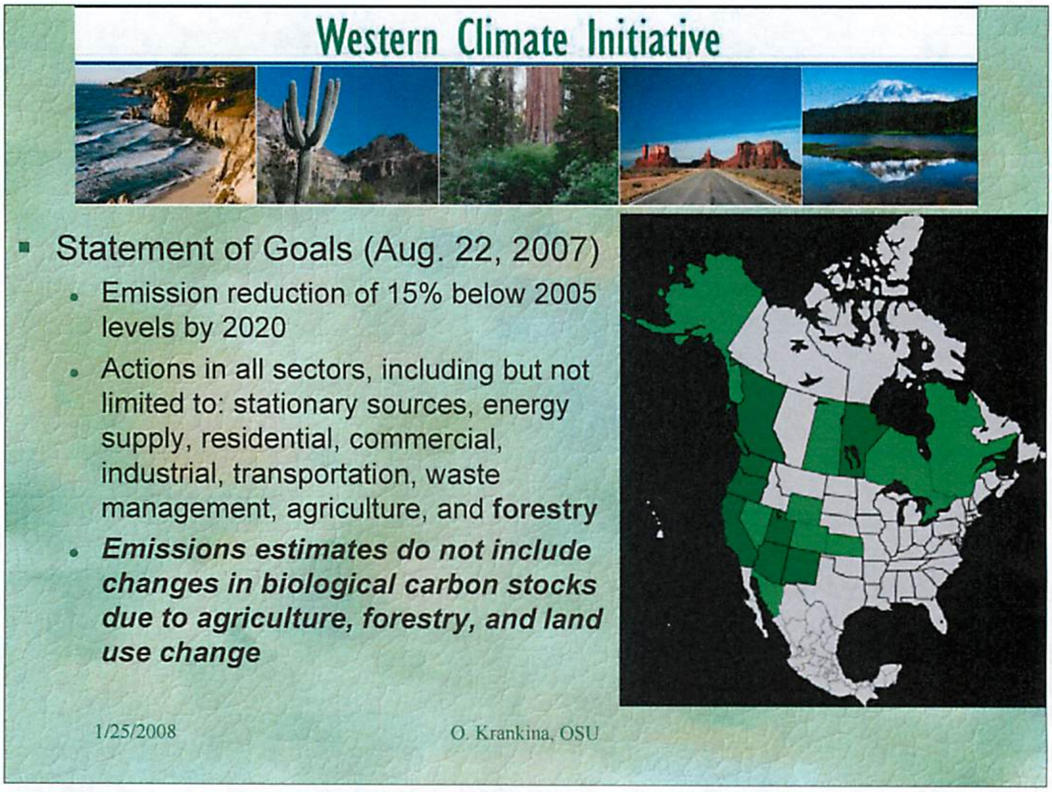


Figure 5. Historic change and future projections of carbon stores in live forest biomass for private ownerships and National Forests in the PNWW region. Units are in megagrams of carbon per hectare.

Analysis limited to live biomass show interesting differences between private lands and national forests. While all scenarios in both ownerships project increase in C stores the absolute values are vastly different: in NF the current level is over 200 TC/ha and pushes above 300 50 years into the future, on provate lands the pattern is similar but the C store values are 3 times lower – this is the scope of long term impact of forest management on C stores.

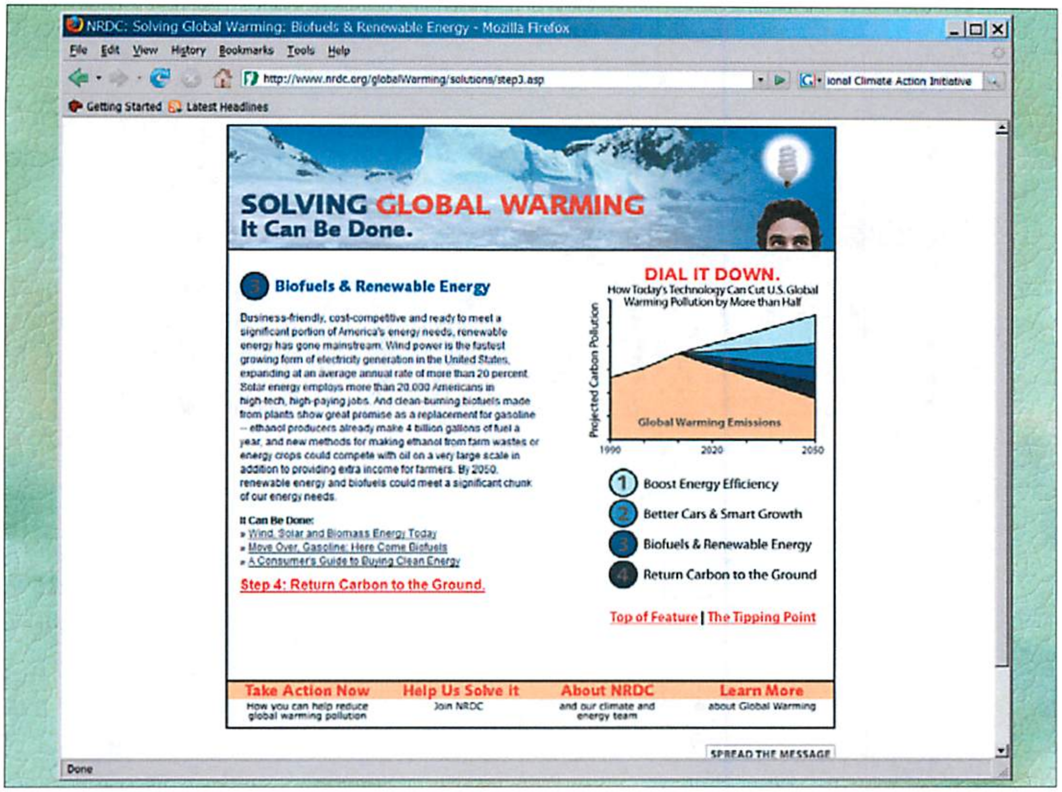


While large-scale assessments and future projections of the role of forests in carbon exchange with the atmosphere are contradictory and uncertain, there is a solid basic understanding of how this role can be modified by forest management. This understanding is supported by the body of knowledge of the effects of management practices on forest ecosystems, including the patterns of forest harvest, regeneration, and growth. These processes are among the principal driving forces controlling the carbon balance on forest lands and causing predictable changes over time in response to management practices and natural disturbance events



Oregon is part of this intiative and all kinds of incentives are being designed to support emission reduction goals but the way these goals are formulated it does not appear possible to make sensible changes in forest management or also advance forest conservation goals. If I read between the lines correctly – taking action in forestry without accounting for changes in C stocks means in plain English incentives for forest products sector. Because defensible and transparent accounting for C benefits in forest products does not seem possible chances are those incentives will never materialize. And for reasons I do not fully understand environmental community does not promote any incentives to increase C stocks on land even though it can serve both forest conservation and mitigation of climate change. Carbon credits for additional C stores on land seems like a great opportunity to support conservation goals. I am not a policy analyst so I do not follow these developments very closely. I keep hoping that this

Unfortunately neither forest industry



But when I checked the NRDC web site yesterday I found 4 measures offered to solve global warming and forest conservation was not one of them. Returning C to the ground sounded promising but it actually deals with using coal more effectively

I hope this conference will advance the idea of synergies between forest conservation and climate change and I thank you inviting me