LTEP Biscuit Fire study

Funded by the Joint Fire Science Program
and the USDA Forest Service,
PNW Research Station, LTEP program

Participants

Disclaimer

Because this long-term ecosystem productivity (LTEP) research is being funded by public agencies, we provide initial results in the spirit of open discovery and rapid disclosure. Findings reported here should be considered interim, pending further analysis and peer review. Please do not cite.

Last updated September 15, 2005

Initial Findings

1. Simplistic rules sometimes belie inherent ecosystem complexity.
2. Unburned controls change how fire effects are interpreted.
3. Past management changed how the Biscuit Fire burned.
4. Tree mortality and fire temperatures are significantly related.
5. Past management changed how fire affected species composition.
6. Added woody debris did not significantly affect fire temperature.
7. The fire effects on some soils were extreme.
8. Rain-driven erosion was large but locally constrained.
9. Wind-driven erosion was large?

Introduction and Background

Study Objectives

Methods

Hypothesis tests

Initial Results

This web page can be navigated by following initial findings backward (left links), or by exploring the sequence leading to the initial results and findings (right links)

Simplistic rules sometimes belie inherent ecosystem complexity.

The Biscuit Fire has important lessons for us, about the effects of wildfire on forest ecosystems. Our study—above all else—demonstrates that interactions of wildfire with ecosystem processes and conditions can create very complex patterns of response. Complex responses from previous fires likely created much of the high small-scale spatial variability described for these sites (Homann et al. 2001). We also have documented important temporal complexities. For example, many legacies from the last fire, about 110 years ago, persisted until fire returned. Legacies include hardwood mid-canopy trees (tanoak, madrone, and others), over-mature knobcone pines (with serotinous cones), and apparent seed banks in the soil. We expect that Biscuit legacies, by extrapolation, will likely last to the next fire. Spatial and temporal complexities are extended by other uncertainties and surprises about ecosystem processes (such as possible plume-driven soil loss and a damping effect on fire by mid-canopy hardwoods, discussed later).

The general conclusions are supported by results from our study. We found that the degree that ecosystems were affected by the fire was determined in part by pre-fire management, and that these various outcomes hold different consequences for future ecosystem development, including future fire risks. Some widely held views on the magnitudes and even directions of management effects were not well supported. The most extreme effects of fire on soils that we observed at stand scales should be long-lasting, suggesting that special interest should be paid to pioneering plants that can help rebuild nutrient pools. Soil development itself was substantially affected in many places. New insights into soils, forest productivity, and diversity in forests with frequent fire-return intervals are likely with continued investigation.

Background (related to this finding) | Objectives (related to this finding) | Methods (related to this finding) | Initial results (related to this finding) | HOME

Having unburned controls changes interpretations.

Unburned control stand (left)

Burned control stand (below)

Trends before and after fire in vegetation, woody debris, tree mortality, and even soils can be easily misinterpreted without understanding background changes in unburned stands. In some cases what appears to be distinct fire effects turn out to be lacking or overshadowed by background changes already underway.

Background related to this finding | Methods related to this finding

Objectives related to this finding | Initial results related to this finding

Initial Findings

Past management changed how the fire burned.

Background related to this finding

Objectives related to this finding

Methods related to this finding

Initial results related to this finding

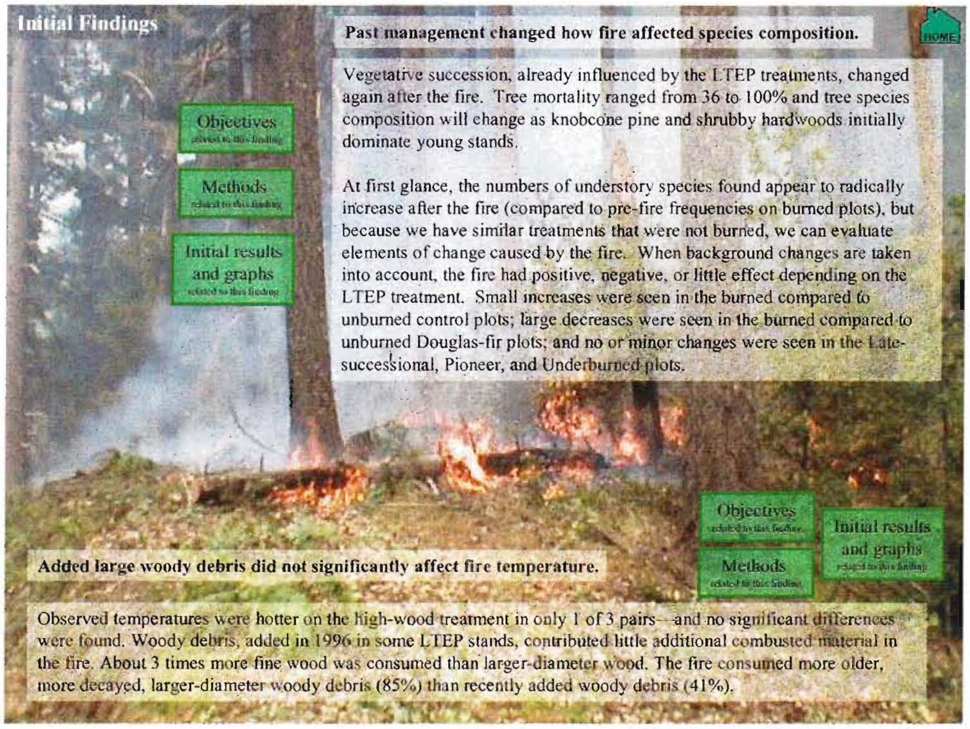
Past management, created as experimental manipulations in the LTEP study—of 110-yr-old, fire-origin, Douglas-fir-dominated stands—changed how the fire burned. The thinned and underburned stand had the least mortality (36%); the two control stands had intermediate mortality (63 and 77%); thinned, low woody debris stands had moderately high mortality(91 and 94%); while thinned high woody debris and 6-yr-old pioneer and Douglas-fir stands had 100% mortality. The relatively low mortality in the controls was most unexpected, and not predicted by the fire models (Raymond 2004, Raymond and Peterson 2005). The relative similarity among pairs in replicated treatments (controls and thinned low woody debris) gives us limited confidence in these conclusions. We must also consider, however, that fire behavior is influenced by more than fuels. Even though most stands burned on the same day, how they started, what was adjacent to them, and other factors may have come into play. Potential explanations for observed patterns of mortality—including a possible role for mid-story hardwoods removed in the thinning of these stands—deserve future attention.

Tree mortality and fire temperatures are significantly related.

Although not surprising, tree mortality averaged across individual treatments explains about 50% of the variation in average temperature as measured by the degree that aluminum tags melted along our grid system. Future work will examine relationships between caloric consumption, temperature, fuel distribution, hardwood distributions, slope, woody debris, and other variables.

Methods related to this finding

Objectives related to this finding | Initial results related to this finding



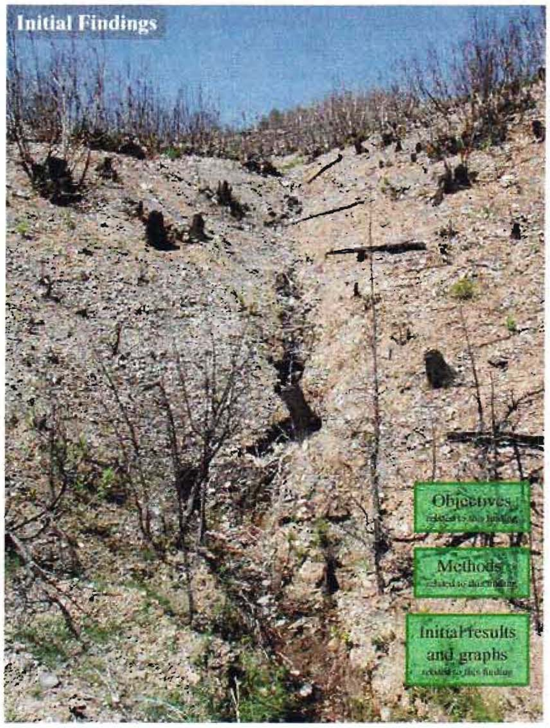
Our quantitative-pit soil sampling across 2-ha grids, before and after the fire allows us to determine fire effects quantitatively at the stand scale. Some soils were greatly affected by the fire, and soil effects appear related to stand conditions before the fire, as well as temperatures during the fire. Stands with less mortality appear to have less soil effects (for example, the amount of surface rock is positively related to average tree mortality in stands).

The most affected soil appears to have lost its entire organic horizon, all of the top mineral horizon (A), as well as over 10% of the upper B horizon. More than 5 kg/m^2 of soil (organic and fine-mineral components) are now missing, with associated changes in particle-size distribution (for example, many rocks at the surface), bulk density, charcoal content, and many other factors.

Nitrogen associated with these losses and changes in remaining soil add up to about 400 kg/ha. Combined with vegetative losses (not yet quantified) we expect that up to 18 years of typical N uptake in vegetation was lost. Losses of other elements know to volatilize at lower temperature (S, P, K) have yet to be quantified.

Taken together, changes in soil organic matter, bulk density, particle size, and nutrient content are likely to impact forest productivity for some time to come. Tracking new growth against that observed before the fire, and that in unburned treatments will reveal direct measures of wildfire on productivity. Of particular interest will be to follow the nitrogen-fixing plants that may or may not come to dominate burned stands. The LTEP program is considering growth plots of uniform seedlings to evaluate fires of different intensities. Unlike background changes in vegetation, soils appear relatively unchanged in unburned stands. Thus, observed changes are easily attributable to the Biscuit Fire.

HOME

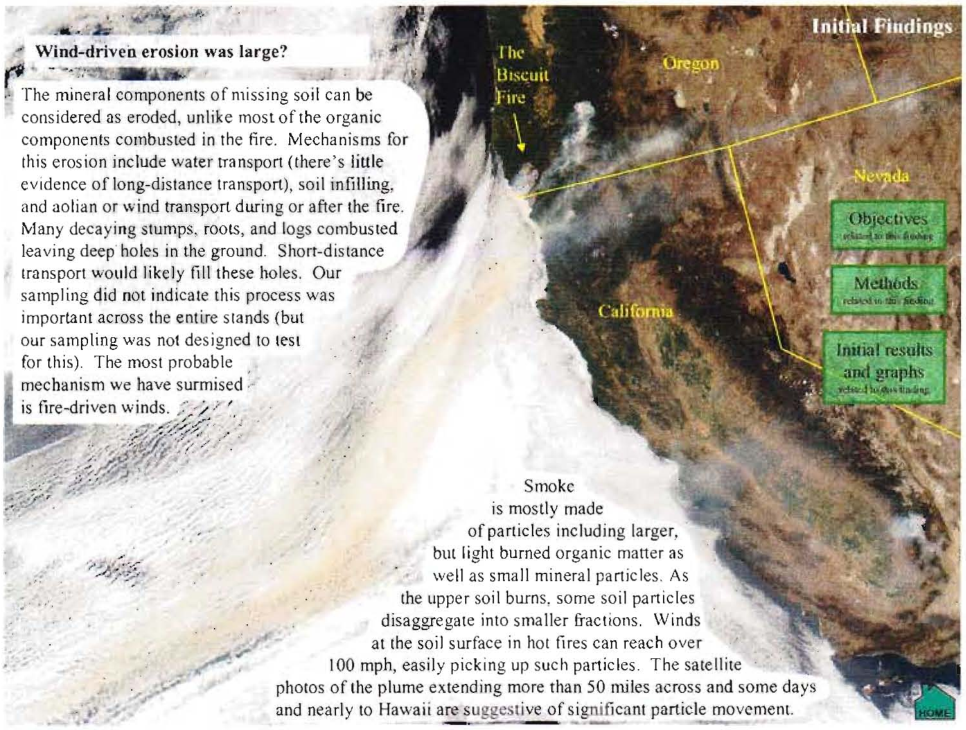


Rain-driven erosion was large but local.

Erosion was large on burned soil relative to unburned soil, at least at small scales. Evidence indicating large short-distance transport included controlled erosion boxes and pins. Boxes showed a relation for burned soil between slope and transport, as expected. Pins demonstrated fluctuating soil-surface heights (relative to the top of rebar grid-point posts). We failed to see, however, significant movement at the base of hotly burned units. Little soil accumulated in ditches above the road. Microtopography from old windthrow mounds, stumps, and decaying logs appeared to sharply limit long-distance transport. Needles that fell from heat-killed conifers formed numerous needle dams in the first and second year after the fire, trapping large amounts of ash. Needles appeared to decompose by the 3rd year and ash may be moving again, so any nutrient or soil trapping effects may not differ from initially treeless areas over time.

The photo on the left is the intermittent stream at the base of the 30-acre hotly burned LTEP pioneer treatments. Little soil accumulated in the ditch along the road where this photo was taken.

HOME



Wind-driven erosion was large?

The mineral components of missing soil can be considered as eroded, unlike most of the organic components combusted in the fire. Mechanisms for this erosion include water transport (there's little evidence of long-distance transport), soil infilling, and aolian or wind transport during or after the fire. Many decaying stumps, roots, and logs combusted leaving deep holes in the ground. Short-distance transport would likely fill these holes. Our sampling did not indicate this process was important across the entire stands (but our sampling was not designed to test for this). The most probable mechanism we have surmised is fire-driven winds.

Smoke is mostly made of particles including larger, but light burned organic matter as well as small mineral particles. As the upper soil burns, some soil particles disaggregate into smaller fractions. Winds at the soil surface in hot fires can reach over 100 mph, easily picking up such particles. The satellite photos of the plume extending more than 50 miles across and some days and nearly to Hawaii are suggestive of significant particle movement.

Background Links

On August 16, 2002 the Biscuit Fire burned nearly 500,000 acres in southeast Oregon.

Biscuit info | The Wilderness Society | Siskiyou Project

Long-Term Ecosystem Productivity

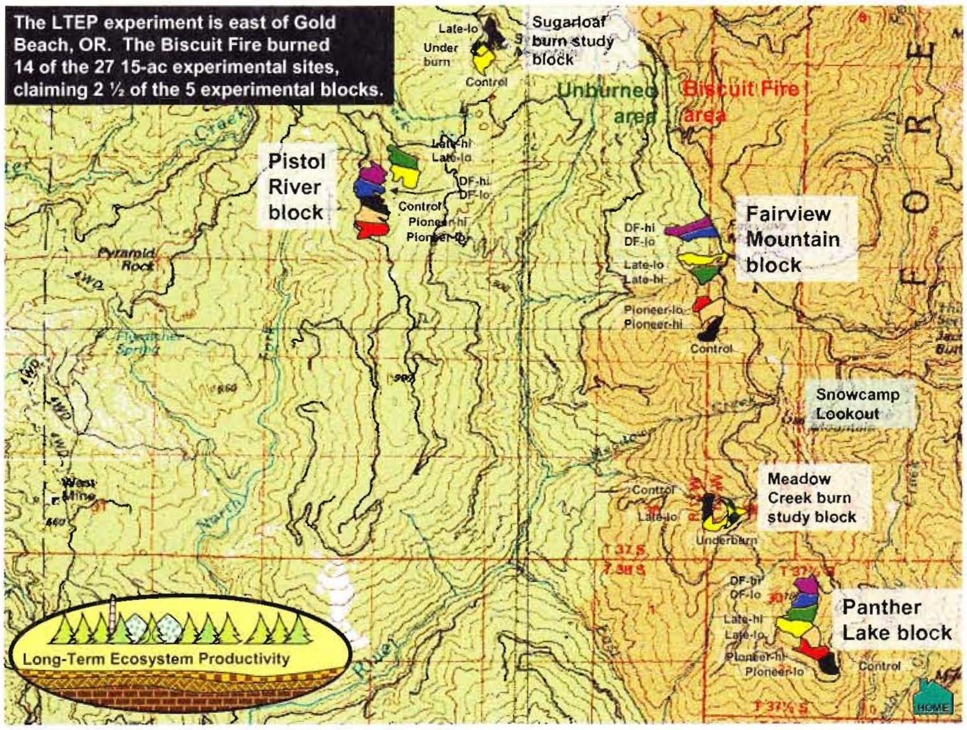
Among the burned acres were parts of the large-scale LTEP experiment established by the USDA Forest Service, Pacific Northwest Research Station and the Siskiyou National Forest in 1992. This experiment is part of a series of experiments around the Pacific Northwest .

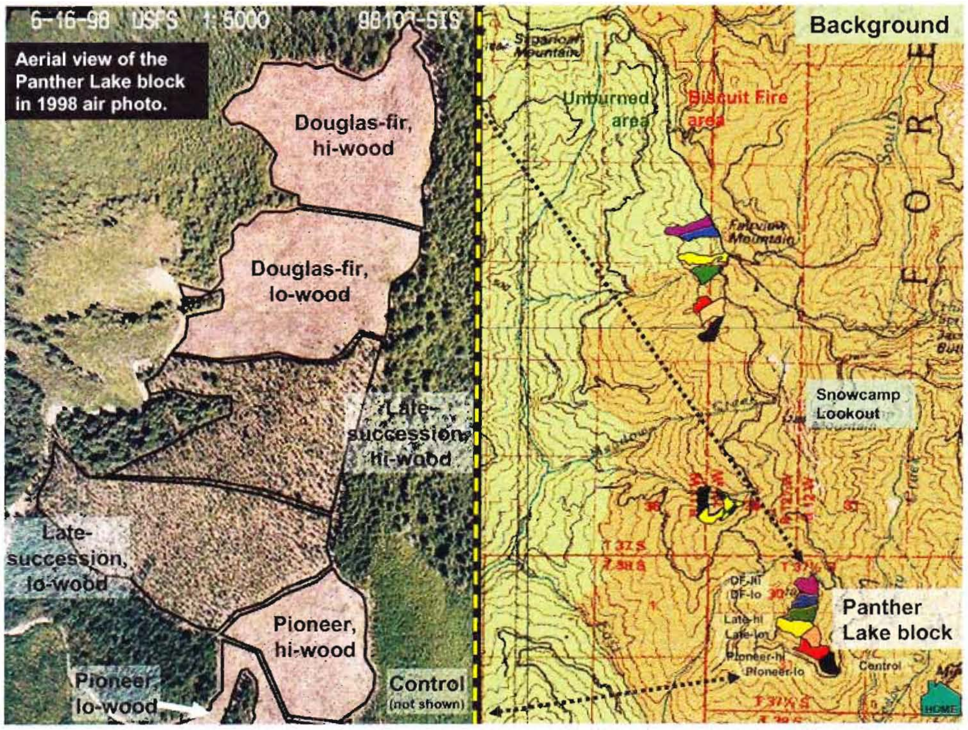
Pacific Northwest Research Station | Siskiyou-Rouge River National Forest

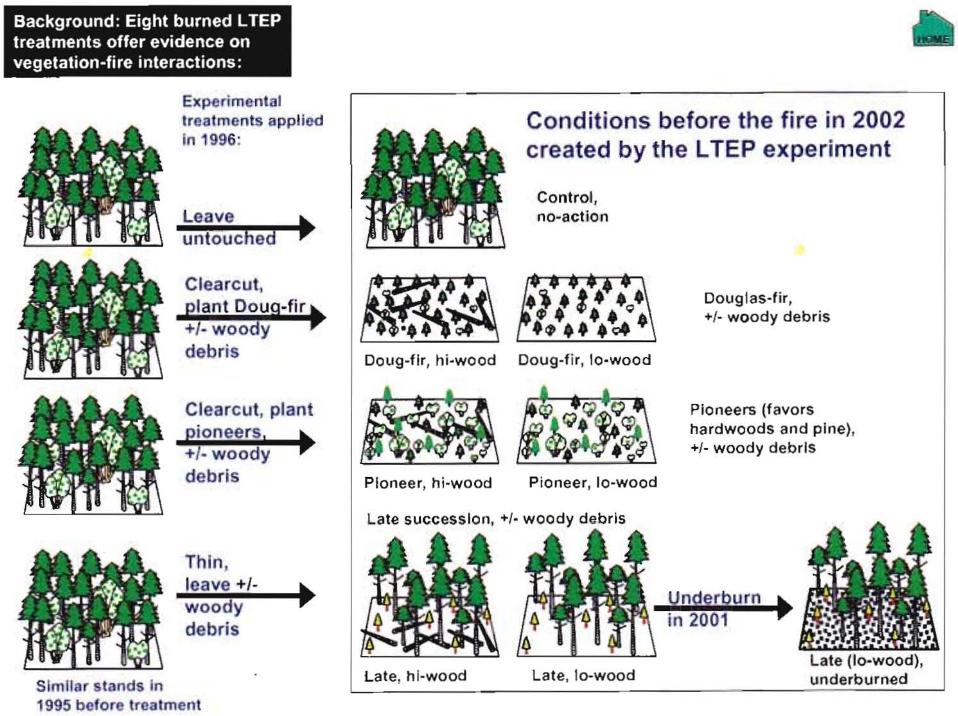
Largely because of the nearly unparalleled soil and vegetation data on pre-fire conditions, the Joint Fire Science Program funded a study in 2004 to examine ecosystem effects of the fire.

Joint Fire Science Program

Research Supporting Sound Decisions



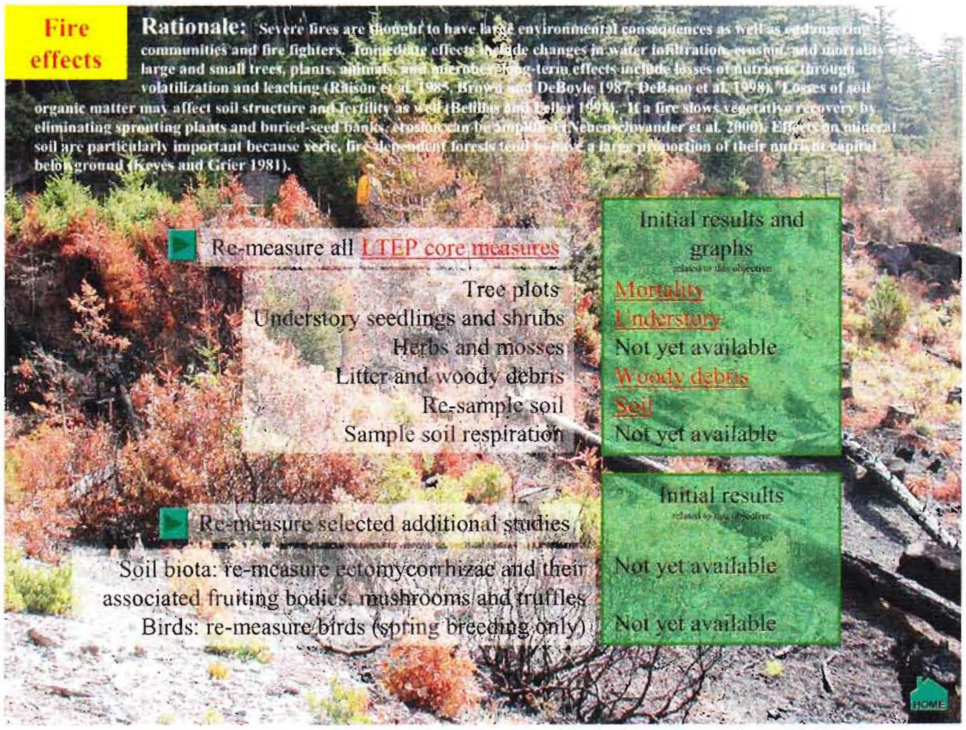

6-16-98 USFS 1:5000 98107-SIS
Aerial view of the Panther Lake block in 1998 air photo.
Douglas-fir, hi-wood
Douglas-fir, lo-wood
Late-succession, hi-wood
Late-succession, lo-wood
Pioneer, hi-wood
Pioneer, lo-wood
Control (not shown)
Background
Unburned area
Biscuit Fire area
Snowcamp Lookout
Panther Lake block

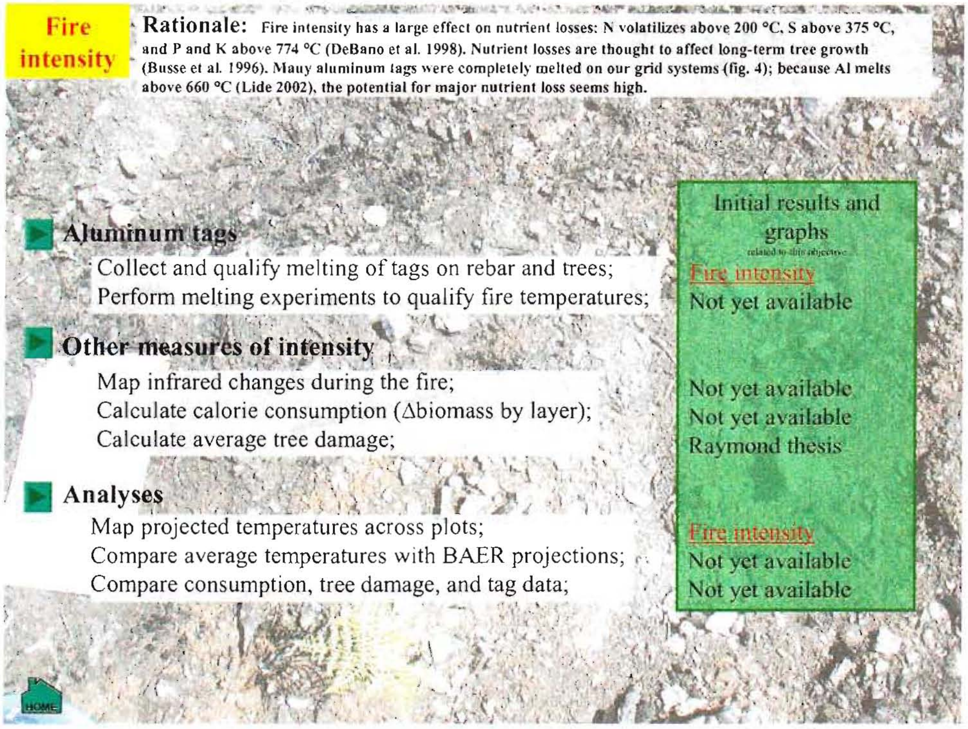

Background: Eight burned LTEP treatments offer evidence on vegetation-fire interactions:
Experimental treatments applied in 1996:
Leave untouched
Clearcut, plant Doug-fir +/- woody debris
Clearcut, plant pioneers, +/- woody debris
Thin, leave +/- woody debris
Similar stands in 1995 before treatment
Conditions before the fire in 2002 created by the LTEP experiment
Control, no-action
Douglas-fir, +/- woody debris
Doug-fir, hi-wood
Doug-fir, lo-wood
Pioneers (favors hardwoods and pine), +/- woody debris
Pioneer, hi-wood
Pioneer, lo-wood
Late succession, +/- woody debris
Underburn in 2001
Late, hi-wood
Late, lo-wood
Late (lo-wood), underburned

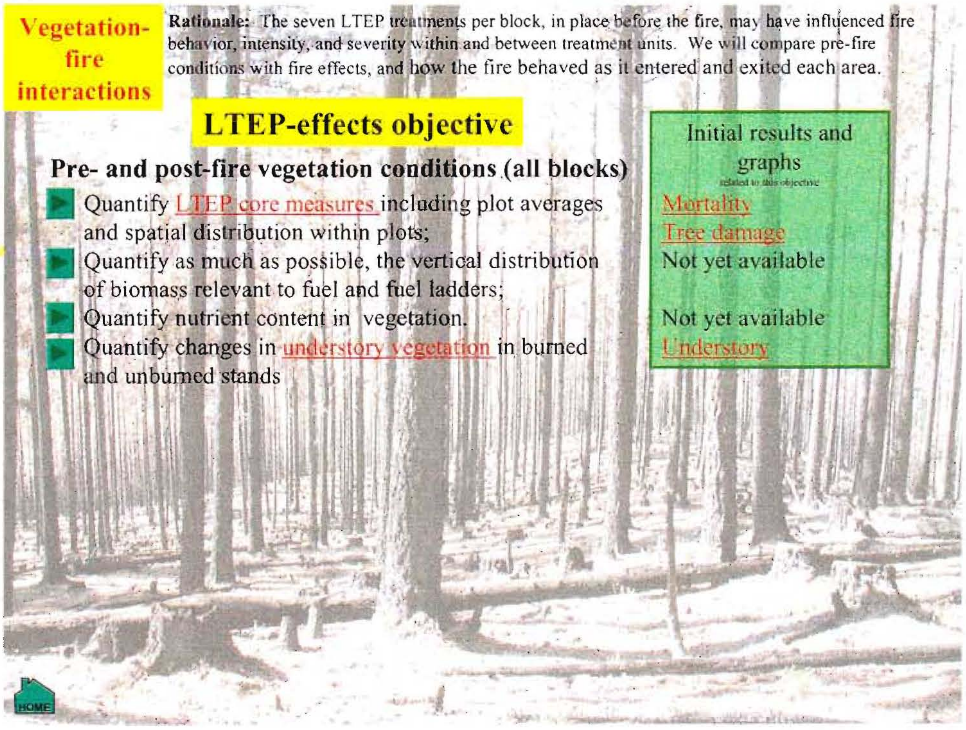
Project Objectives

- **Quantify first-year ecosystem effects** over a spatially distributed range of fire intensity and severity, of the Biscuit wildfire and backburn. Primary effects will focus on georeferenced ecosystem parameters measured intensively before the fire that relate to biodiversity and long-term productivity (tables 3 and 4, including changes in fuels; woody debris; soil organic detritus; biomass; total N, S, P, K, Ca, and Mg in vegetation and organic- and mineral-soil layers; and also fungi, birds, small mammals, and herpetofauna).
- **Quantify the apparent intensity of the fire** at 25-m grid points where aluminum tags, on steel posts, were variously affected by the fire (grids in burned areas cover more than 100 acres). Estimate severity, as total calories expended, from losses of organic matter and extent that crowns were damaged. Reconstruct movement of the fire through the plots with sequential infra-red images from the National Interagency Fire Center and create a fire history layer on a experiment-scale GIS system.
- **Quantify erosion in the first year after the fire** by measuring changes in position of washers (placed before significant rains in October 2002) relative to the top of the steel posts. Erosion associated with the underburning study (burned in 2001) appears significant in places. We can also follow soil accumulation behind charred wood and pedestal erosion under burned wood and perched logs. Slope and other factors can be accounted for by entering all grid points into the GIS.
- **Evaluate the effects of experimentally added woody debris** on fire intensity and severity, fire propagation to adjacent areas, and subsequent 1-yr effects on soils, vegetation, and other ecosystem attributes. We hypothesize that fires burned the upper crowns and soil hotter where logs were present. Woody debris is added to enhance long-term productivity and biodiversity under the Northwest Plan, but fire interactions are not well known.
- **Evaluate the effects of experimentally manipulated overstory and understory plants** on fire intensity and severity, fire propagation to adjacent areas, and subsequent 1-yr effects on soils, plant and animal succession (especially resprouting, serotinous knobcone pine, invasive species, and birds), and other ecosystem attributes.

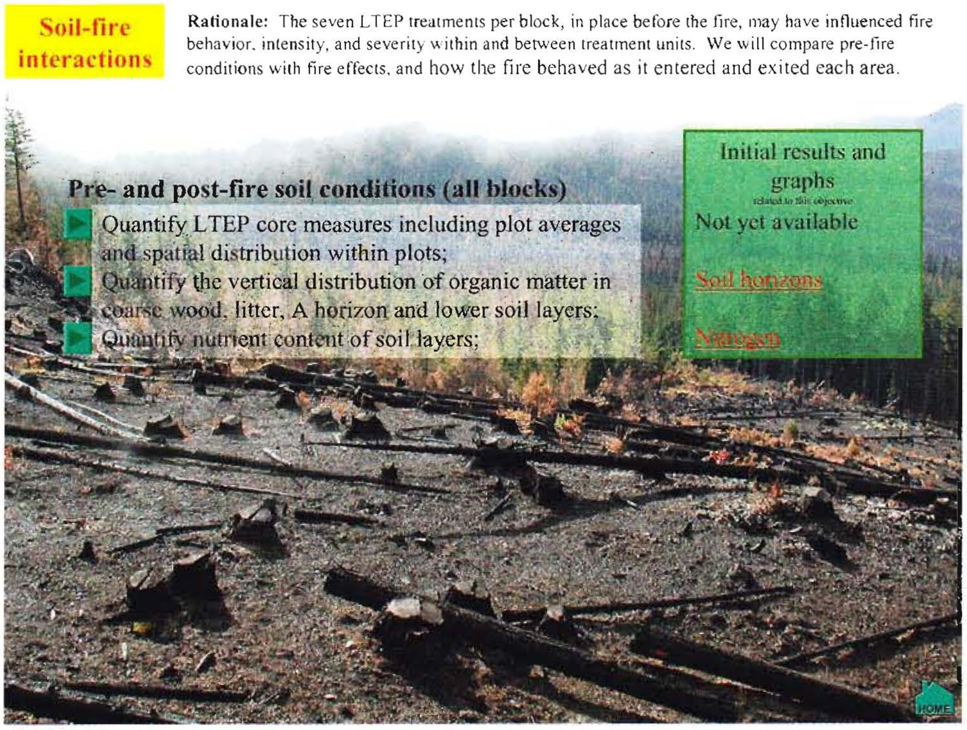
HOME

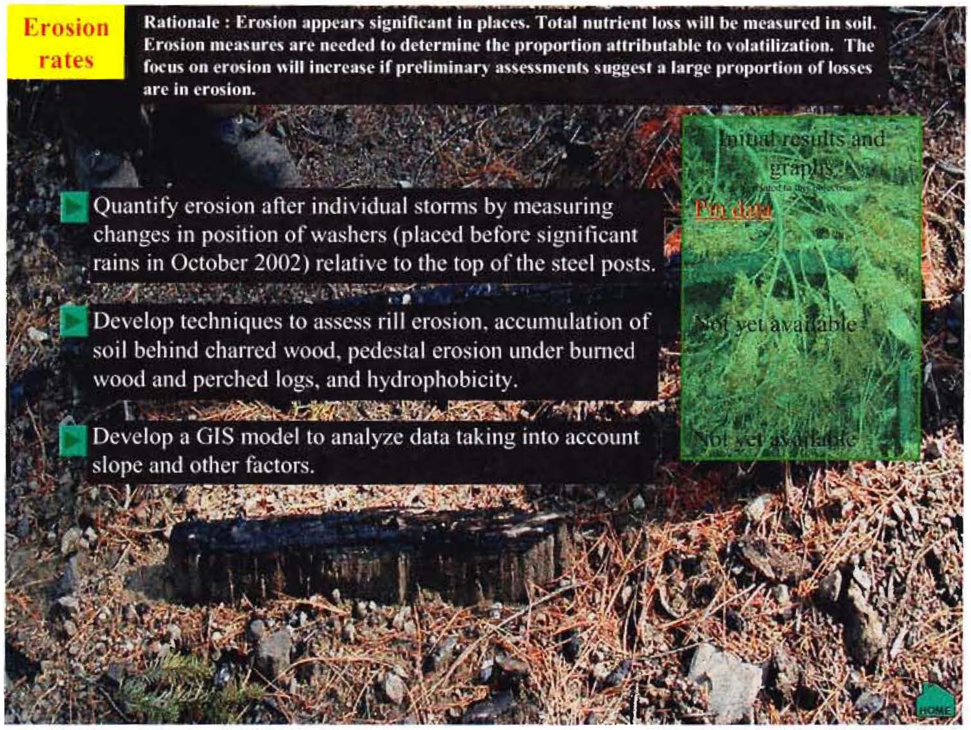


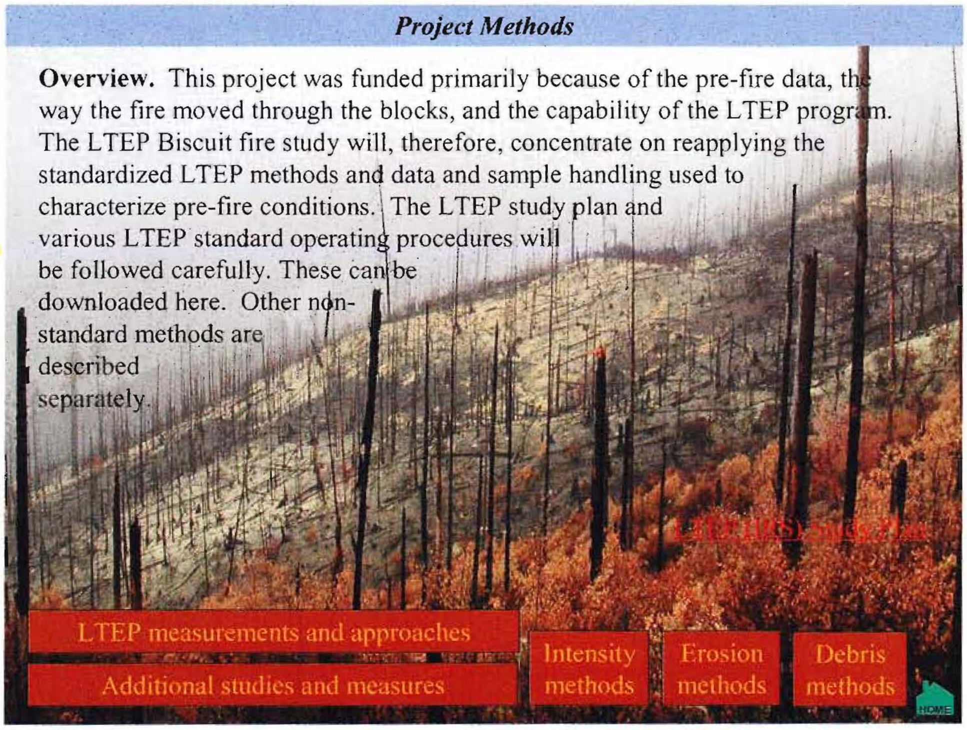

Fire intensity
Rationale: Fire intensity has a large effect on nutrient losses: N volatilizes above 200 °C, S above 375 °C, and P and K above 774 °C (DeBano et al. 1998). Nutrient losses are thought to affect long-term tree growth (Busse et al. 1996). Many aluminum tags were completely melted on our grid systems (fig. 4); because Al melts above 660 °C (Lide 2002), the potential for major nutrient loss seems high.
Aluminum tags
Collect and qualify melting of tags on rebar and trees;
Perform melting experiments to qualify fire temperatures;
Other measures of intensity
Map infrared changes during the fire;
Calculate calorie consumption (Δbiomass by layer);
Calculate average tree damage;
Analyses
Map projected temperatures across plots;
Compare average temperatures with BAER projections;
Compare consumption, tree damage, and tag data;
Initial results and graphs
related to this objective
Fire intensity
Not yet available
Not yet available
Not yet available
Raymond thesis
Fire intensity
Not yet available
Not yet available
HOME


Vegetation-fire interactions
Rationale: The seven LTEP treatments per block, in place before the fire, may have influenced fire behavior, intensity, and severity within and between treatment units. We will compare pre-fire conditions with fire effects, and how the fire behaved as it entered and exited each area.
LTEP-effects objective
Pre- and post-fire vegetation conditions (all blocks)
Quantify LTEP core measures including plot averages and spatial distribution within plots;
Quantify as much as possible, the vertical distribution of biomass relevant to fuel and fuel ladders;
Quantify nutrient content in vegetation.
Quantify changes in understory vegetation in burned and unburned stands
Initial results and graphs
related to this objective
Mortality
Tree damage
Not yet available
Not yet available
Understory
HOME


Woody debris
Rationale: Woody debris may have influenced fire behavior, intensity, and severity within and between treatment units. We will compare pre-fire debris with how the fire behaved as it entered and exited units with and without added woody debris.
Calculate plot-average pre-fire debris loads (burned plots only);
Map debris-load distribution within burned plots;
Initial results and graphs
Woody debris
Not yet available
HOME


Soil-fire interactions
Rationale: The seven LTEP treatments per block, in place before the fire, may have influenced fire behavior, intensity, and severity within and between treatment units. We will compare pre-fire conditions with fire effects, and how the fire behaved as it entered and exited each area.
Pre- and post-fire soil conditions (all blocks)
Quantify LTEP core measures including plot averages and spatial distribution within plots;
Quantify the vertical distribution of organic matter in coarse wood, litter, A horizon and lower soil layers;
Quantify nutrient content of soil layers;
Initial results and graphs
Not yet available
Soil horizons
Nitrogen
HOME

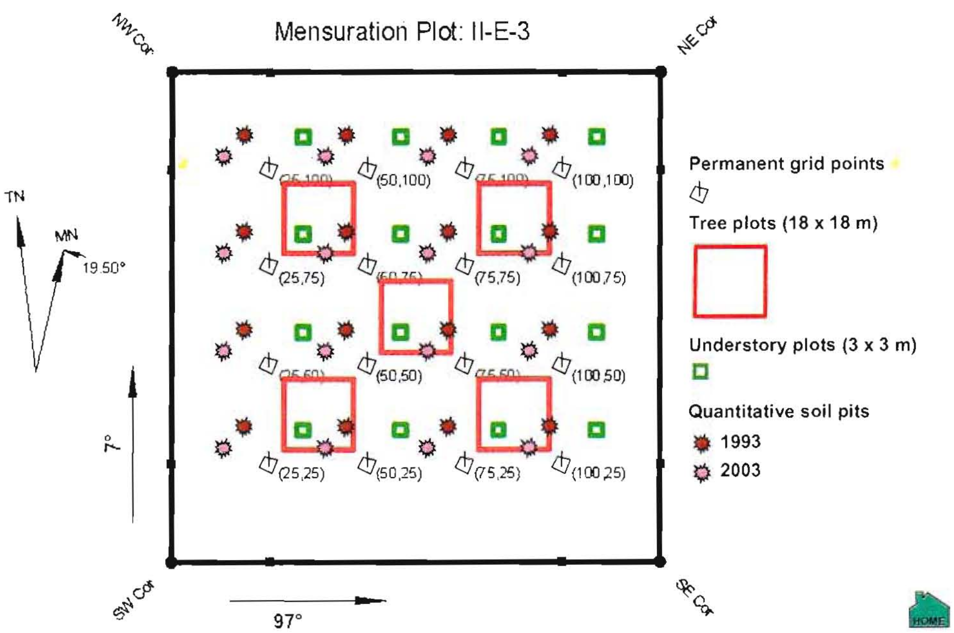

Erosion rates
Rationale : Erosion appears significant in places. Total nutrient loss will be measured in soil. Erosion measures are needed to determine the proportion attributable to volatilization. The focus on erosion will increase if preliminary assessments suggest a large proportion of losses are in erosion.
Quantify erosion after individual storms by measuring changes in position of washers (placed before significant rains in October 2002) relative to the top of the steel posts.
Develop techniques to assess rill erosion, accumulation of soil behind charred wood, pedestal erosion under burned wood and perched logs, and hydrophobicity.
Develop a GIS model to analyze data taking into account slope and other factors.
Initial results and graphs:
Not yet available
HOME

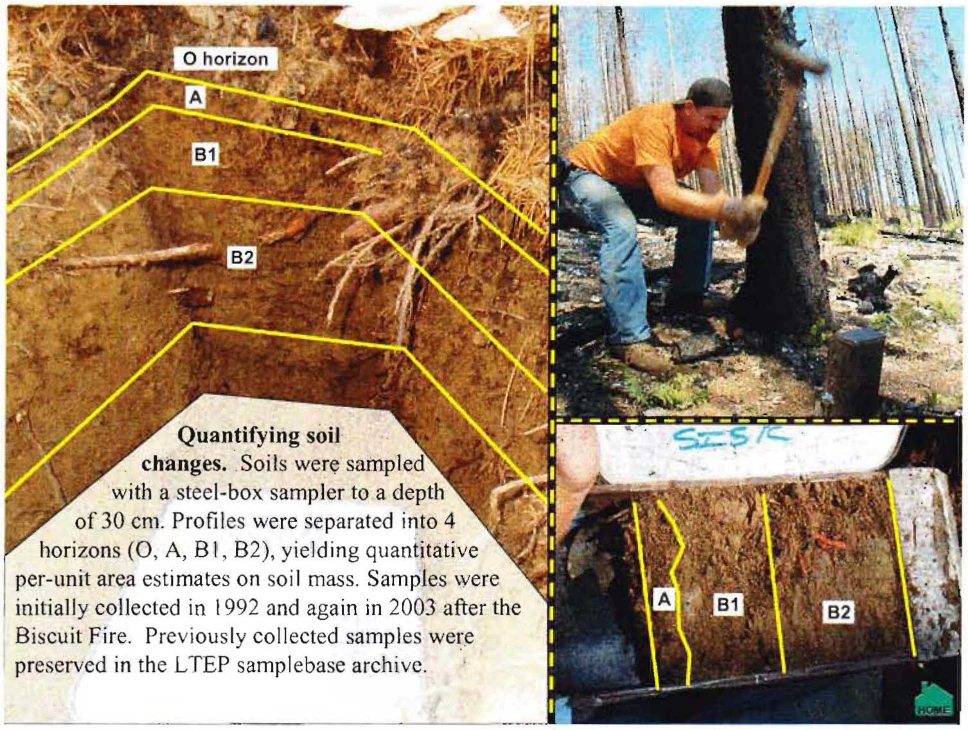

Project Methods
Overview. This project was funded primarily because of the pre-fire data, the way the fire moved through the blocks, and the capability of the LTEP program. The LTEP Biscuit fire study will, therefore, concentrate on reapplying the standardized LTEP methods and data and sample handling used to characterize pre-fire conditions. The LTEP study plan and various LTEP standard operating procedures will be followed carefully. These can be downloaded here. Other non-standard methods are described separately.
LTEP measurements and approaches
Additional studies and measures
Intensity methods
Erosion methods
Debris methods
HOME

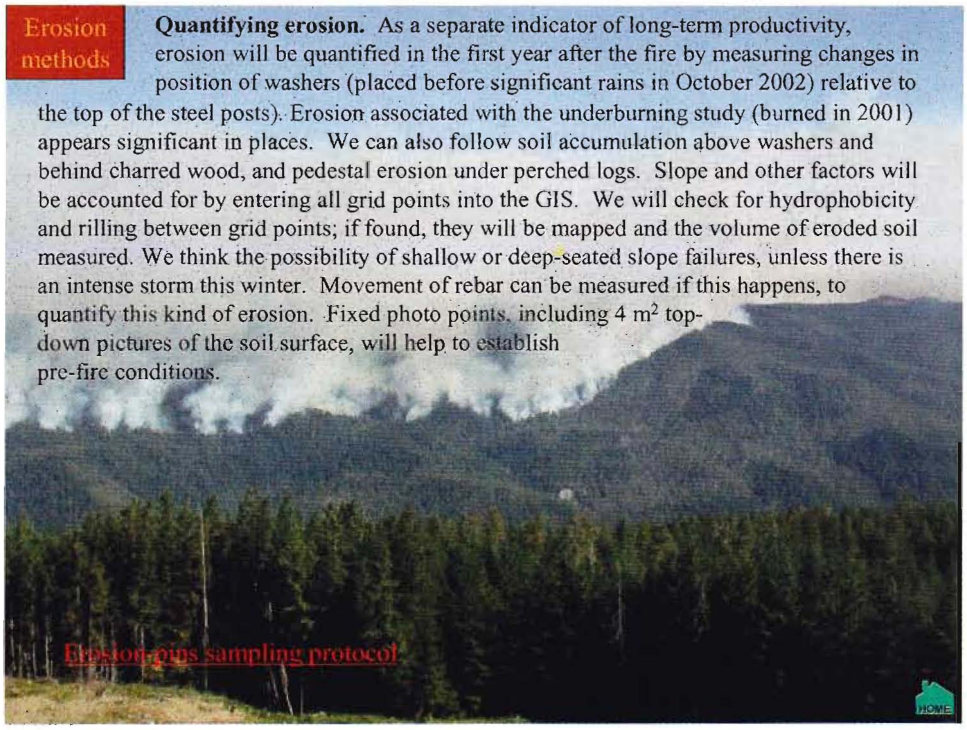
LTEP measurements and approaches

Subject	Core measures	Approach	Where and when
Trees (>2 m in height)	Species Location Diameter (dbh) Height Live crown, Crown class Live or dead Cores (pretreatment)	Census and sample five 18- by 18-m tree plots Produce entire-plot stem maps after LTEP treatments put in	LTEP and burn study, before and after treatment
Canopy	Maps of structure	Interpret low-elevation photos and video (Gray 1998)	LTEP only, pretreatment only
Seedlings and shrubs	Species Height Cover Live-crown Diameter at base	Census on 16 3- by 3-m shrub plots	LTEP and burn study, before and after treatment
Understory herbs, mosses	Species, Height, Cover	Census on 16 3- by 3-m shrub plots	LTEP and burn study, before and after reatment
Fine and coarse woody debris, including stumps	Species End diameter, Length in plot Decay class, Burn class	Census 15 50-m transects in each treatment unit with species, length, decay class, and shape (see also fungal measures)	LTEP and burn study, before and after treatment
Soil	Soil map Depth of horizons Particle-size distribution Bulk density Soil chemistry Soil biota Seed bank	Sample 16 15- by 10-cm quantitative pits by horizon: A, to 15 cm, and 15 to 30 cm; place data in long-term archives; Variability analysis by Homann et al. (2001)	LTEP and burn study, pretreatment only
Insects	Presence or absence	Standard FS survey by Catherine Parks	LTEP only, pretreatment only
Diseases	Presence or absence	Standard FS survey by Don Goheen	LTEP only, pretreatment only
Weather	Daily weather records	One weather station	Ongoing
Long-term productivity	Ecosystem C change Net primary productivity Soil structure and nutrients	Calculated from vegetation and soil data, with measures of soil respiration	Not yet evaluated
Biodiversity	Simpson's diversity index	Based on Lande (1996)	Not yet evaluated

The 1.5-ha mensuration plots centered in each of the 27, 15-acre treatment areas




O horizon
A
B1
B2
Quantifying soil changes. Soils were sampled with a steel-box sampler to a depth of 30 cm. Profiles were separated into 4 horizons (O, A, B1, B2), yielding quantitative per-unit area estimates on soil mass. Samples were initially collected in 1992 and again in 2003 after the Biscuit Fire. Previously collected samples were preserved in the LTEP samplebase archive.
A
B1
B2
HOME


Erosion methods
Quantifying erosion. As a separate indicator of long-term productivity, erosion will be quantified in the first year after the fire by measuring changes in position of washers (placed before significant rains in October 2002) relative to the top of the steel posts). Erosion associated with the underburning study (burned in 2001) appears significant in places. We can also follow soil accumulation above washers and behind charred wood, and pedestal erosion under perched logs. Slope and other factors will be accounted for by entering all grid points into the GIS. We will check for hydrophobicity and rilling between grid points; if found, they will be mapped and the volume of eroded soil measured. We think the possibility of shallow or deep-seated slope failures, unless there is an intense storm this winter. Movement of rebar can be measured if this happens, to quantify this kind of erosion. Fixed photo points, including 4 m² top-down pictures of the soil surface, will help to establish pre-fire conditions.
Erosion pins sampling protocol
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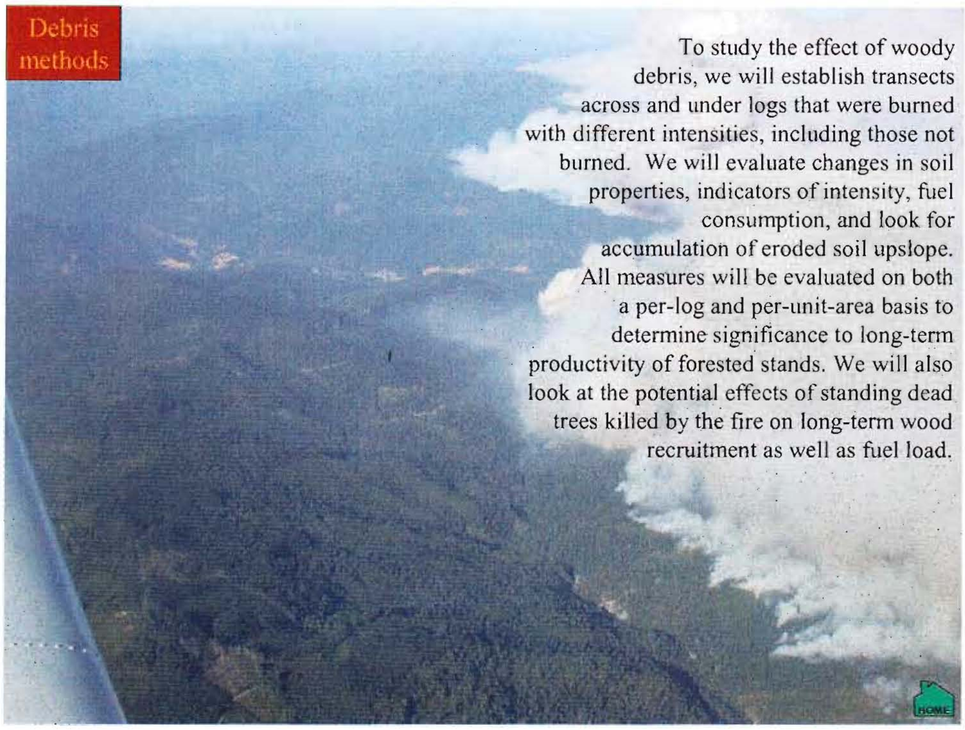
Debris methods
To study the effect of woody debris, we will establish transects across and under logs that were burned with different intensities, including those not burned. We will evaluate changes in soil properties, indicators of intensity, fuel consumption, and look for accumulation of eroded soil upslope. All measures will be evaluated on both a per-log and per-unit-area basis to determine significance to long-term productivity of forested stands. We will also look at the potential effects of standing dead trees killed by the fire on long-term wood recruitment as well as fuel load.
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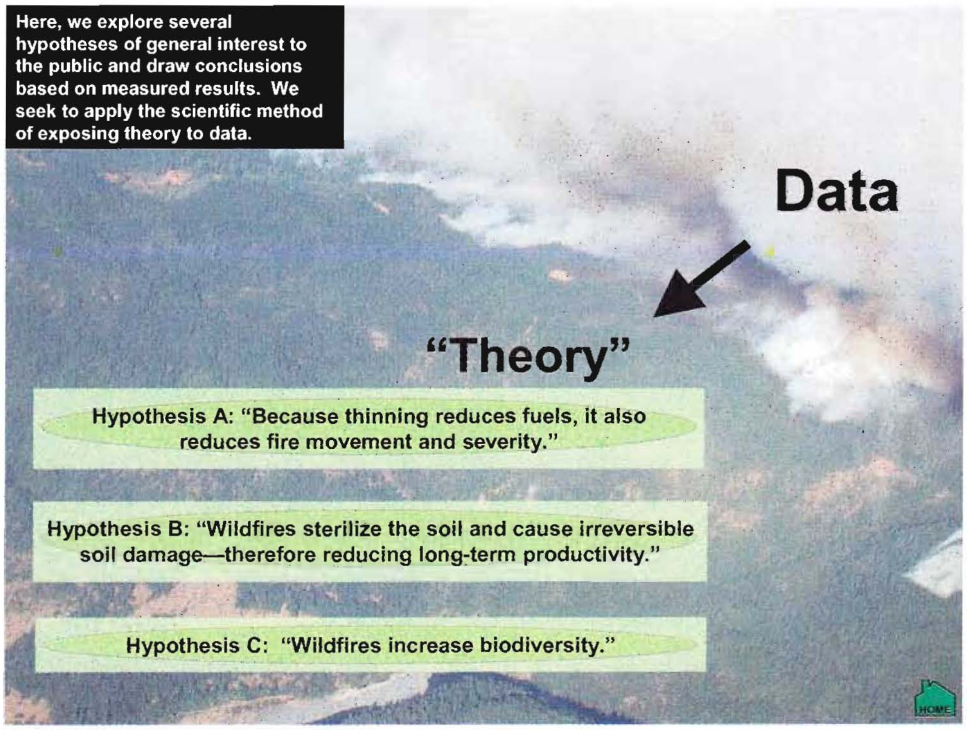
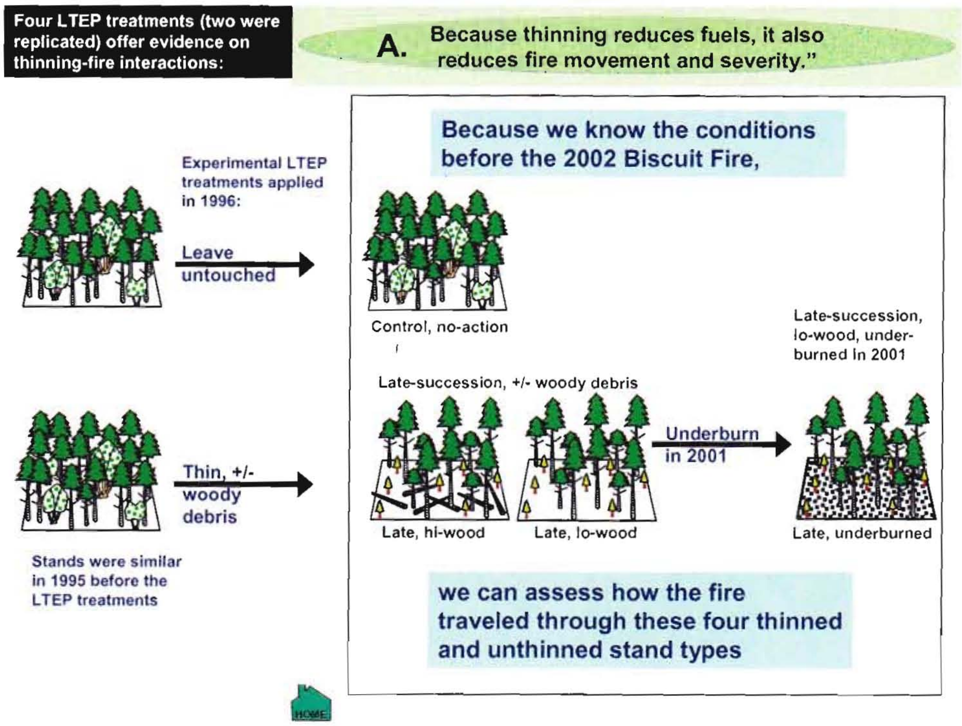
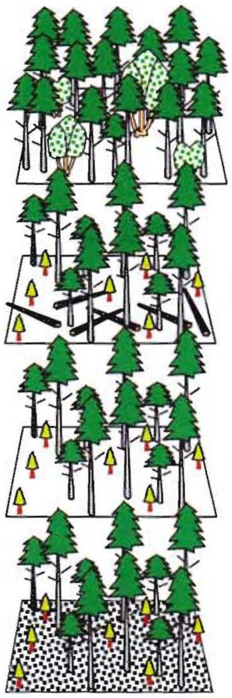

Here, we explore several hypotheses of general interest to the public and draw conclusions based on measured results. We seek to apply the scientific method of exposing theory to data.
Data
"Theory"
Hypothesis A: "Because thinning reduces fuels, it also reduces fire movement and severity."
Hypothesis B: "Wildfires sterilize the soil and cause irreversible soil damage—therefore reducing long-term productivity."
Hypothesis C: "Wildfires increase biodiversity."
HOME





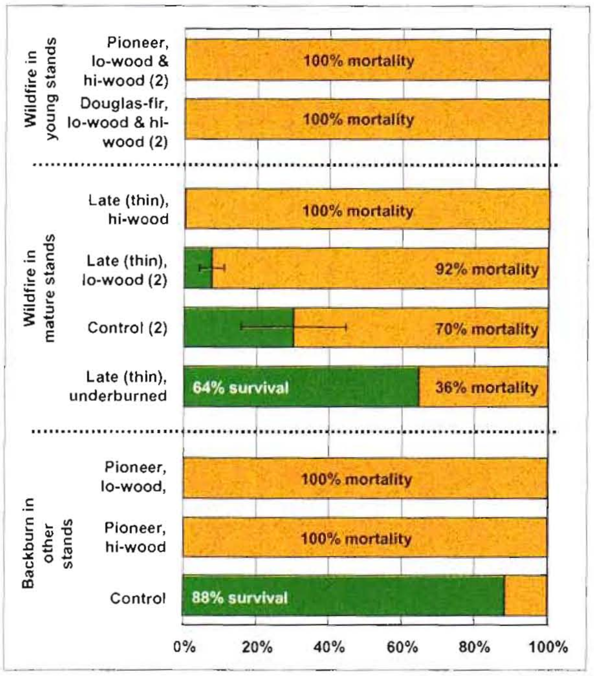
LTEP treatment	Expected (theory)	Actual (data)	
Control, no-action (photo)	Highest mortality	63% 77%	Theory fails
Late-succession, hi-wood (photo)	Medium mortality	100%	Theory fails
Late-succession, lo-wood debris (photo)	Low mortality	91% 94%	Theory fails
Late-succession, underburned (photo)	Lowest mortality	36%	Theory works

Fire-induced tree mortality across LTEP stands

Douglas-fir mortality (orange) and survival (green) percentages for 13 stands, corrected for ongoing background mortality (self thinning) as observed in unburned stands. Error bars are 95% confidence intervals for duplicate Control and Late, lo-wood stands.

Initial results:

- Douglas-fir saplings in young 5-yr-old stands (both Pioneer and Douglas-fir treatments) were all killed either by the wildfire or the backburn set to fight the fire.
- The Late-succession, thinned and underburned stand had the lowest Douglas-fir mortality (36%) of all the wildfire-burned stands.
- The two Control stands had significantly lower mortality (70%) than the two thinned, Late-succession, lo-wood stands (92%); and lower than the one thinned, Late-succession, hi-wood stand (100%).

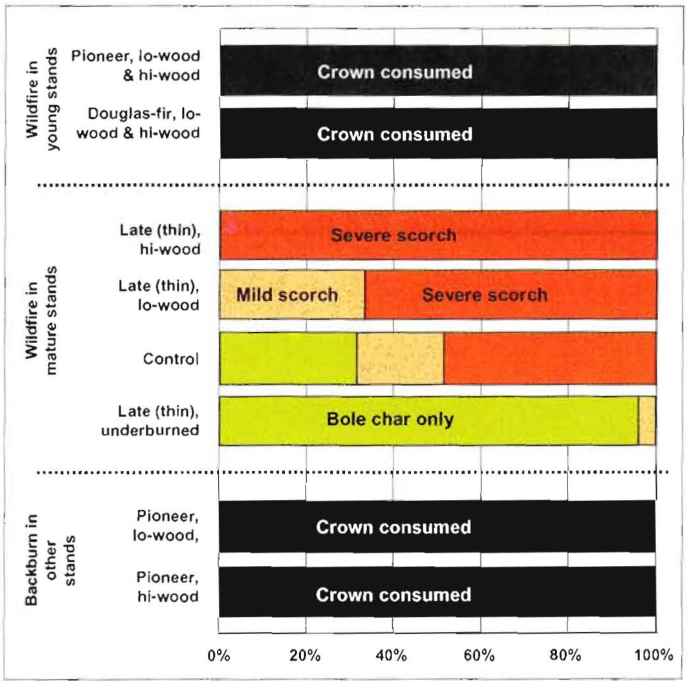


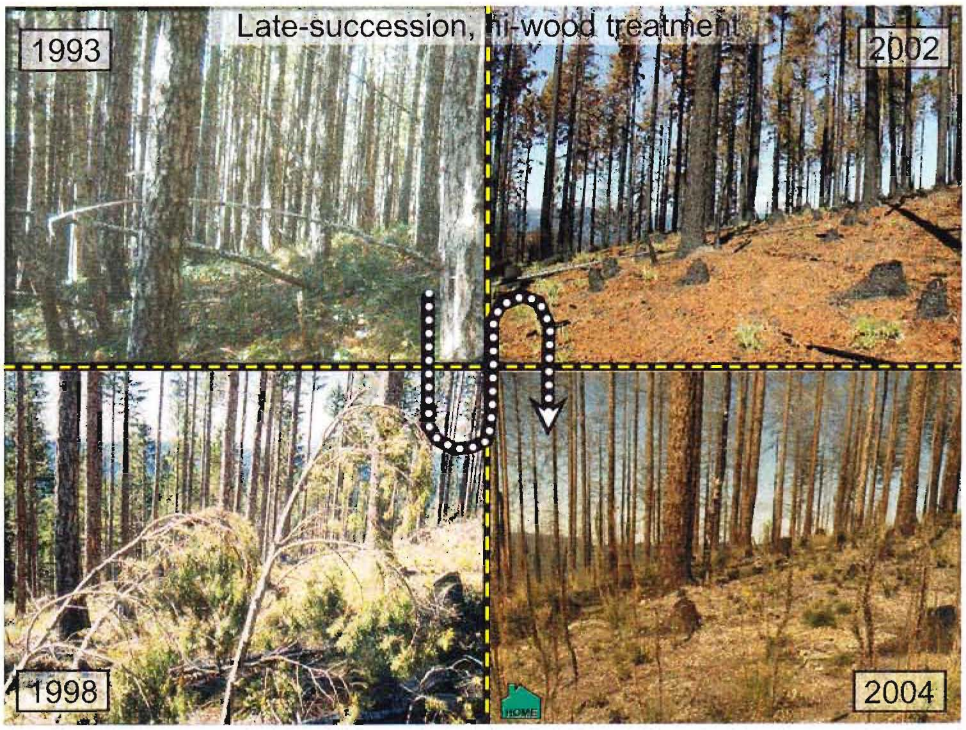
Fire-induced tree mortality across LTEP stands

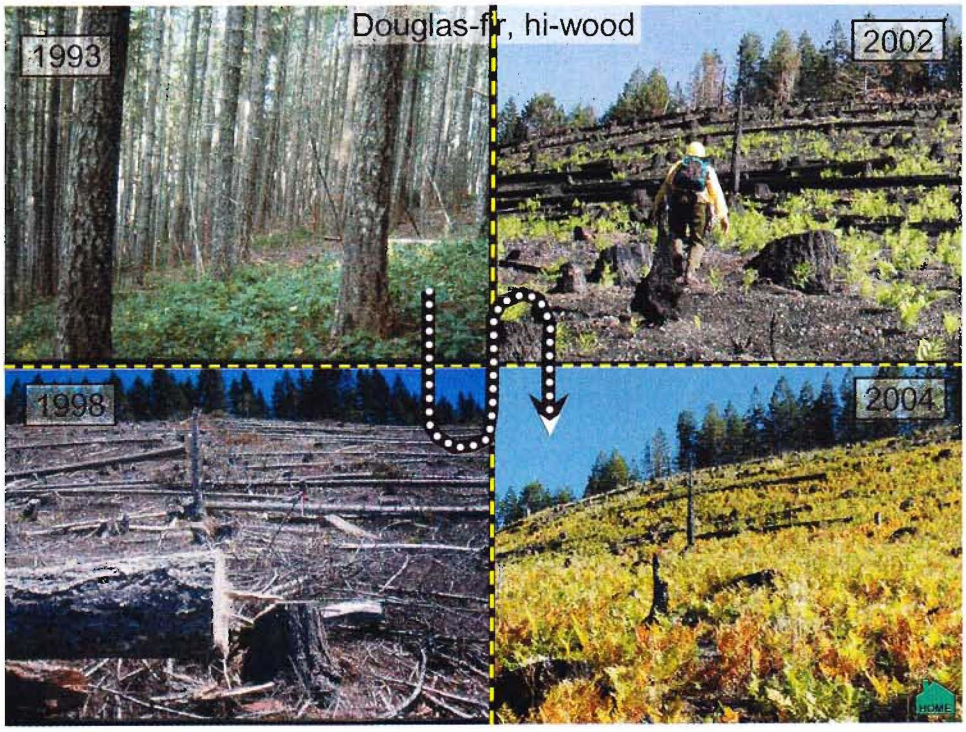
Fire damage to Douglas-fir trees as measured by bole char, scorch, and canopy loss (data courtesy of Crystal Raymond).

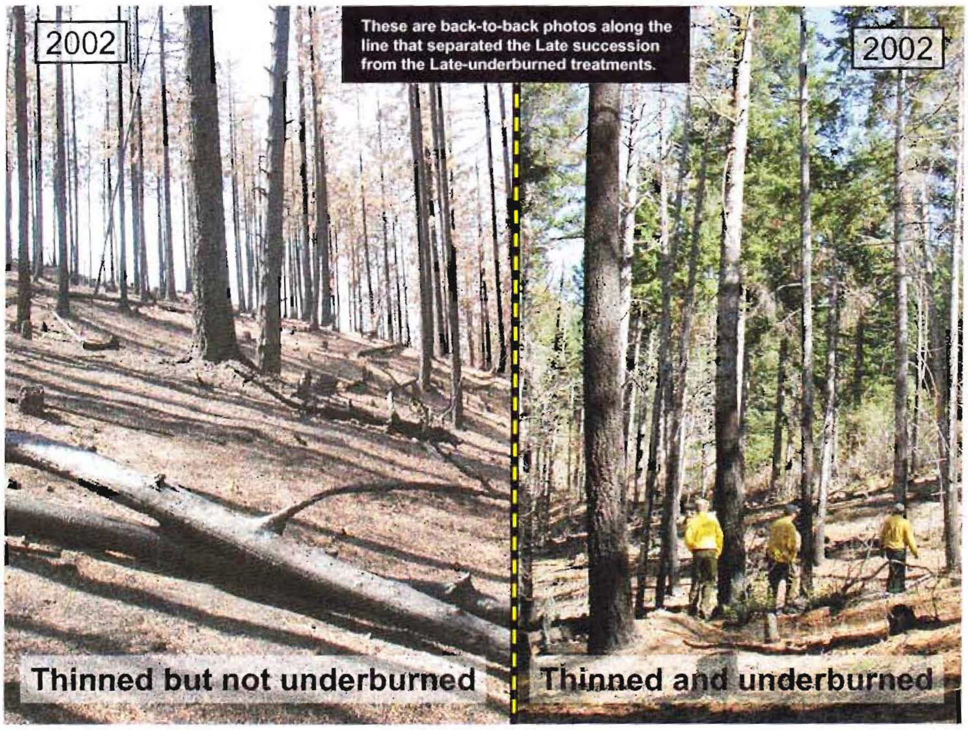
Initial results:

- Crowns of Douglas-fir saplings in young 5-yr-old stands (both Pioneer and Douglas-fir treatments) were all consumed.
- The thinned Late-succession, under-burned stand had the lowest scorch of the wildfire-burned stands.
- The Control stands had intermediate char and scorch.

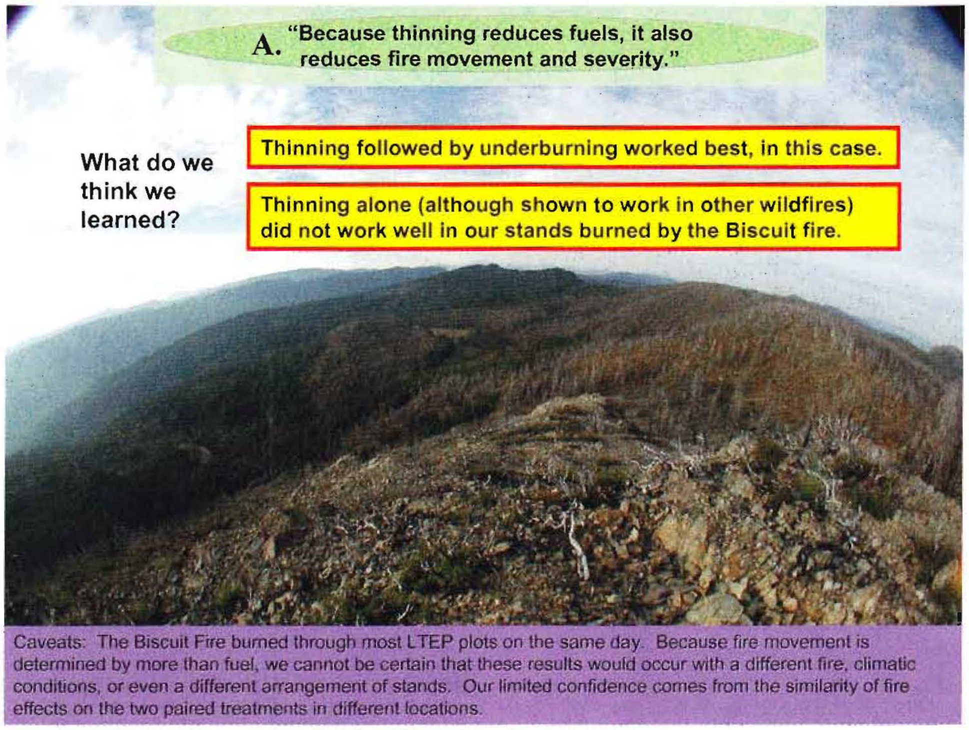



Late-succession, hi-wood treatment
1993
2002
1998
2004

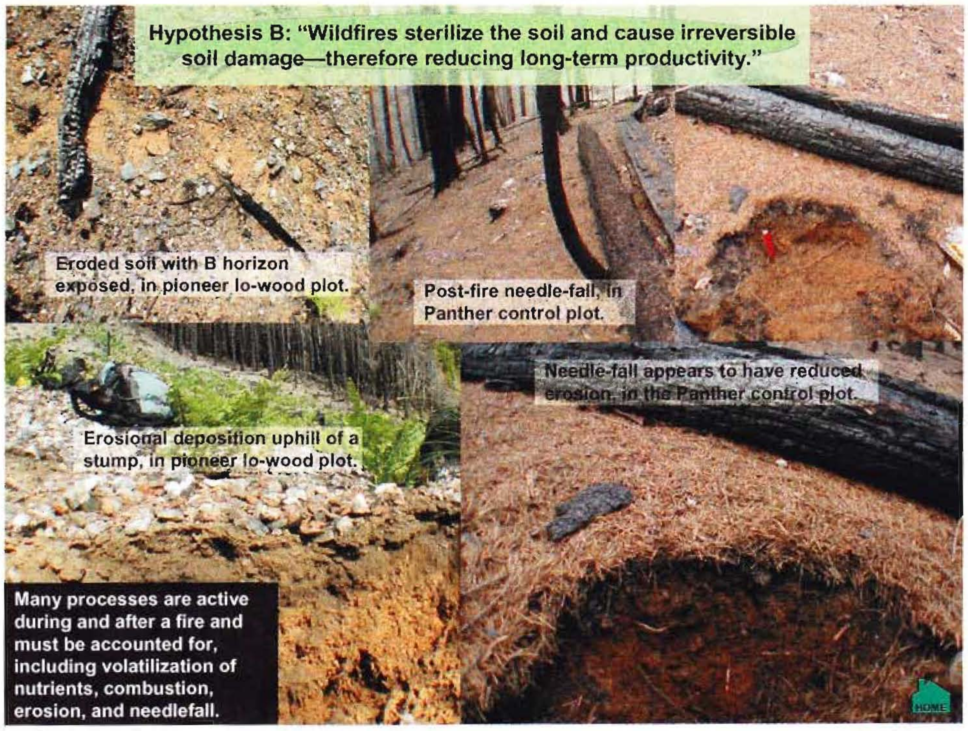

Douglas-fir, hi-wood
1993
2002
1998
2004


2002
These are back-to-back photos along the line that separated the Late succession from the Late-underburned treatments.
2002
Thinned but not underburned
Thinned and underburned

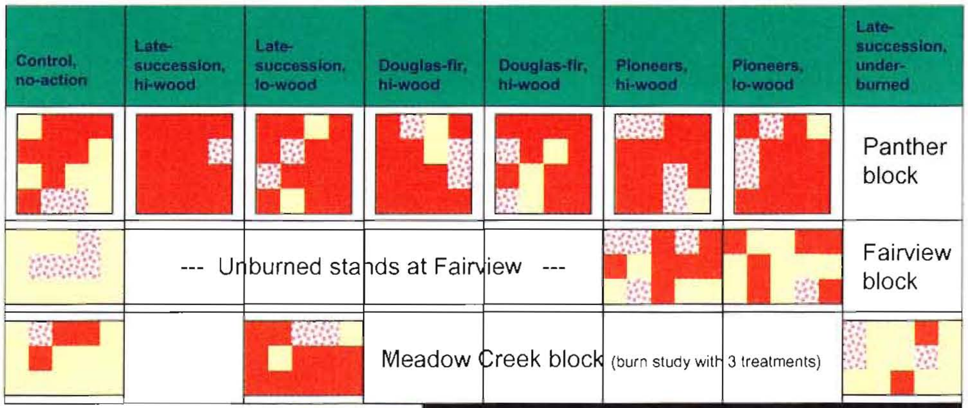

The potential role of hardwoods in reducing fire damage
One explanation for the observed lower mortality in Control stands is that the hardwoods (removed in thinned stands) may have reduced fire damage to Douglas-fir trees.
HOME
Initial results:
Fire damage to Douglas-fir trees is positively related to the presence of hardwoods such as tan oak and madrone.
Hardwoods appeared to have much less scorch (see photos from Control stands.

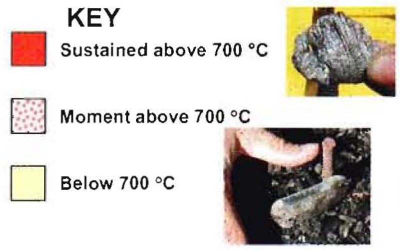


A. "Because thinning reduces fuels, it also reduces fire movement and severity."
What do we think we learned?
Thinning followed by underburning worked best, in this case.
Thinning alone (although shown to work in other wildfires) did not work well in our stands burned by the Biscuit fire.
Caveats: The Biscuit Fire burned through most LTEP plots on the same day. Because fire movement is determined by more than fuel, we cannot be certain that these results would occur with a different fire, climatic conditions, or even a different arrangement of stands. Our limited confidence comes from the similarity of fire effects on the two paired treatments in different locations.



Hypothesis B: "Wildfires sterilize the soil and cause irreversible soil damage—therefore reducing long-term productivity."
Eroded soil with B horizon exposed, in pioneer lo-wood plot.
Post-fire needle-fall, in Panther control plot.
Needle-fall appears to have reduced erosion, in the Panther control plot.
Erosional deposition uphill of a stump, in pioneer lo-wood plot.
Many processes are active during and after a fire and must be accounted for, including volatilization of nutrients, combustion, erosion, and needlefall.
HOME





The temperature of the Biscuit Fire

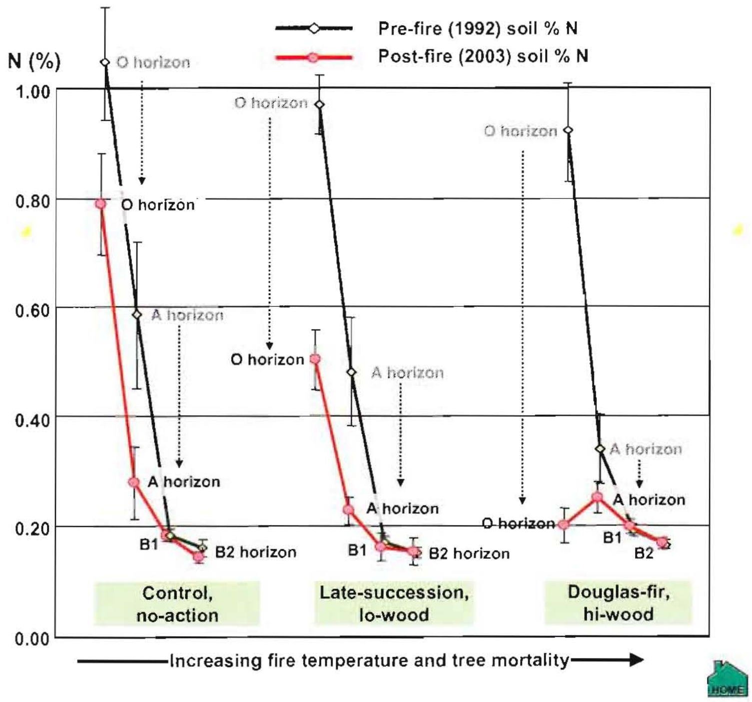
Fire temperatures across the 6-acre measurement plots of the LTEP experiments as measured by the extent that aluminum tags melted that were attached to rebar marking our 25-m grid system.

Initial result: Fire intensity—based on condition of Al tags on rebar marking the 25-m grid systems—was greatest in the Panther Lake plots, and least in the underburn plot and control plots. Note that the Fairview plots were burned (less hotly) in the backburn. These temperatures are enough to volatilize N, S, and possibly P and K. Further studies are needed to examine these potential losses.

Changes in concentration of nitrogen in soils across LTEP stands

Nitrogen (N) concentrations as measured in organic (O), top mineral (A), and lower mineral (B1 and B2) soil horizons. Green lines are before and red after the Biscuit Fire. Vertical brackets are 95% confidence intervals.

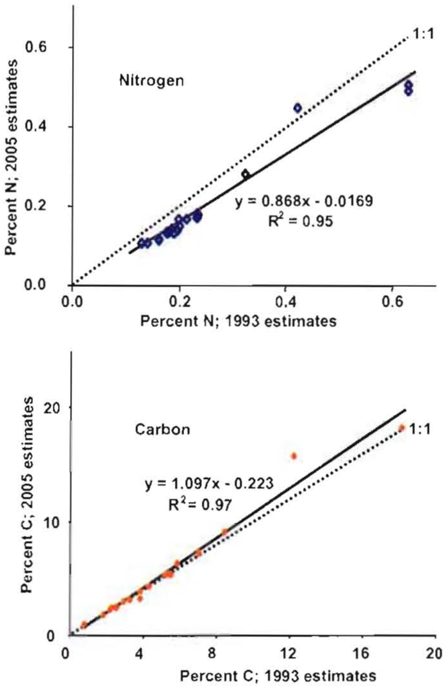
Initial result: Nitrogen concentrations of upper soil horizons diminished greatly on some burned LTEP stands.

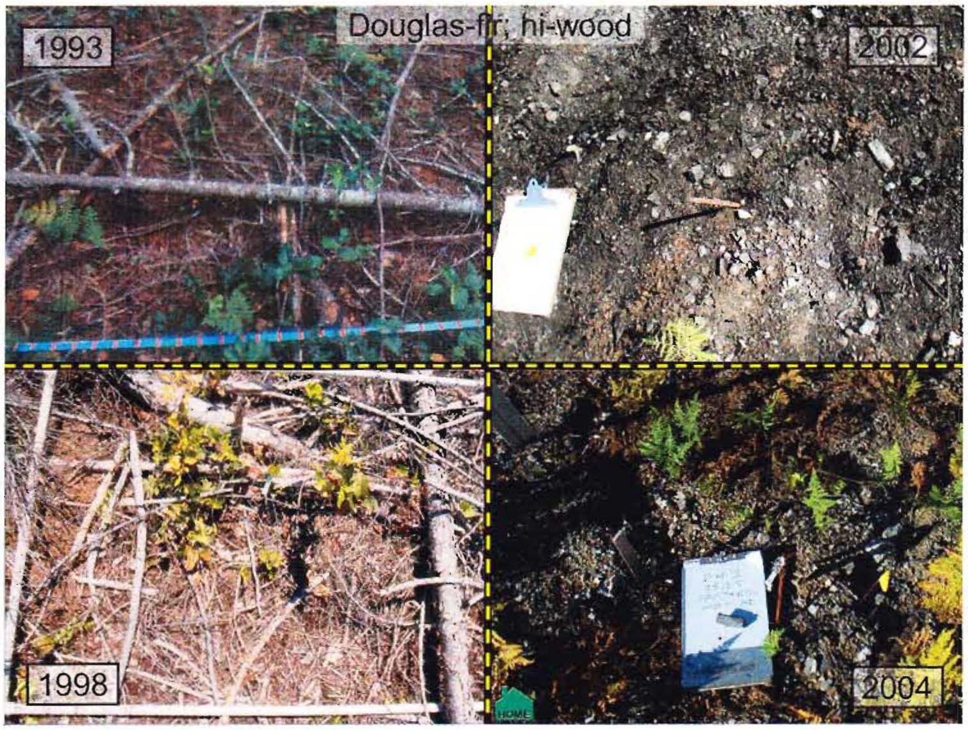


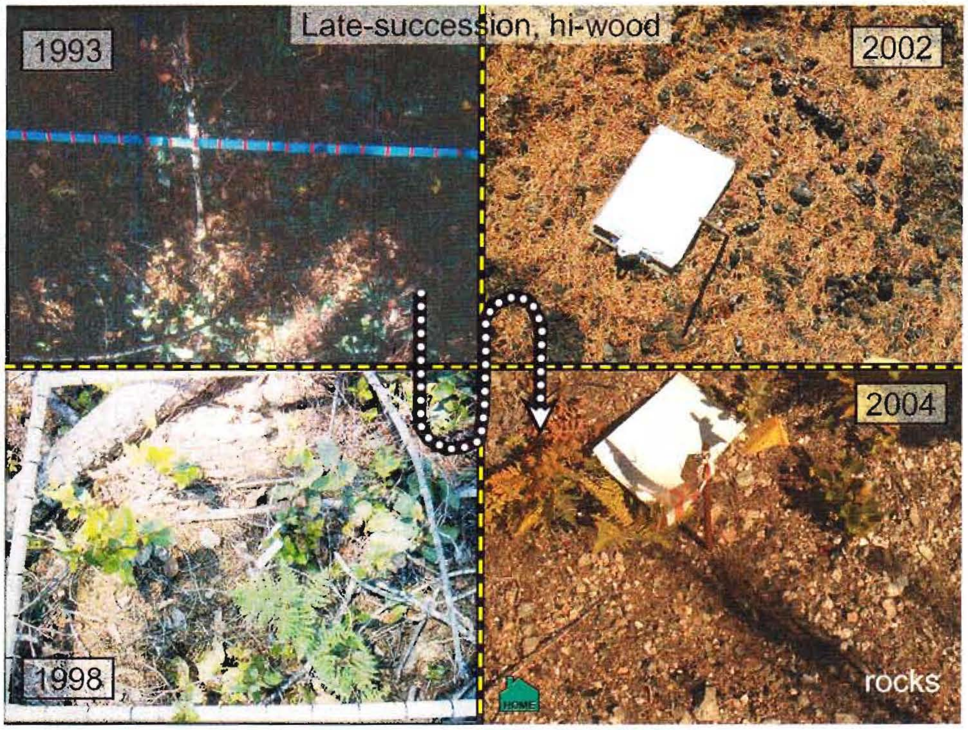
Instrument error—comparing analyses of pre-fire soil with 1993 and 2005 carbon-hydrogen-nitrogen (CHN) instruments.

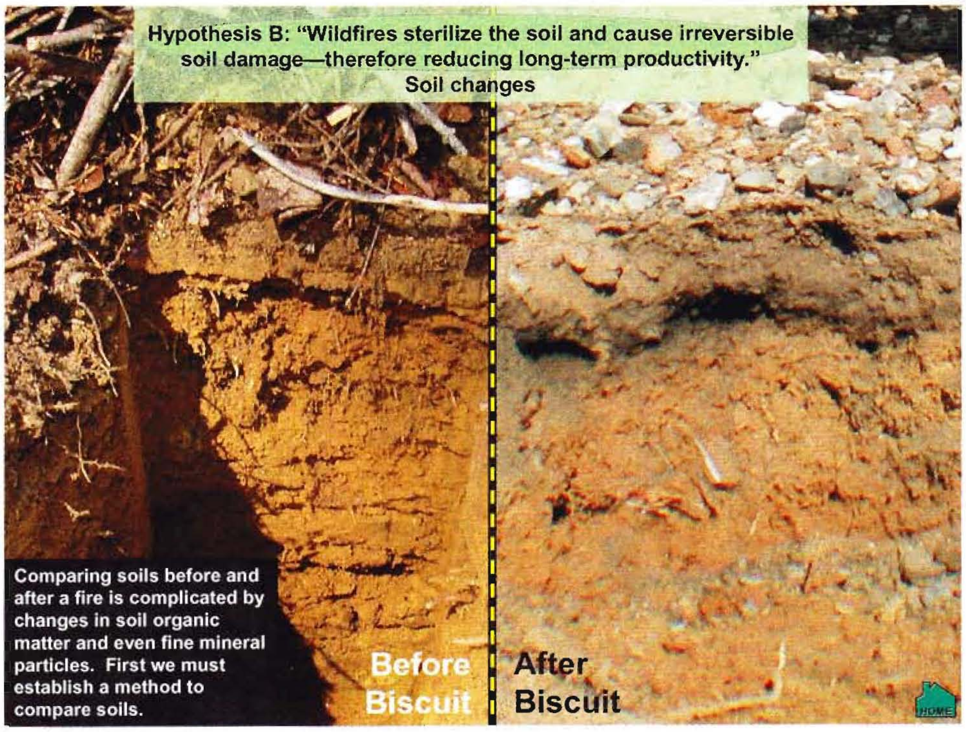
Initial results:

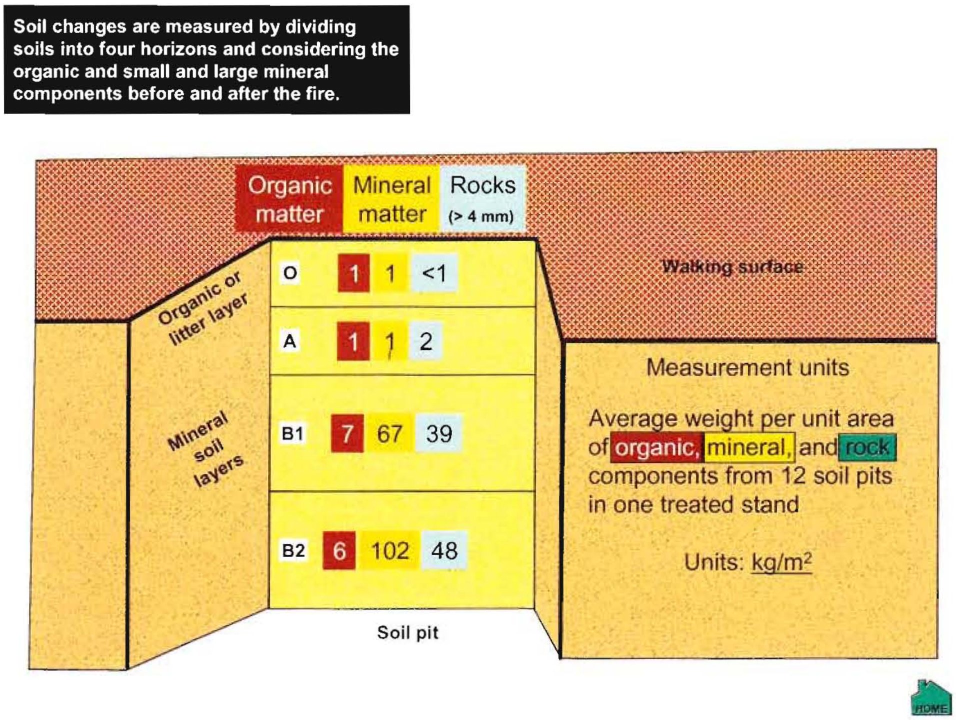
- Nitrogen concentrations in archived samples are estimated to be about 15% higher, when using modern instruments compared to instruments values from 1993.
- Instruments give nearly identical C estimates, suggesting that biological activity during storage is not a factor in different N estimates.

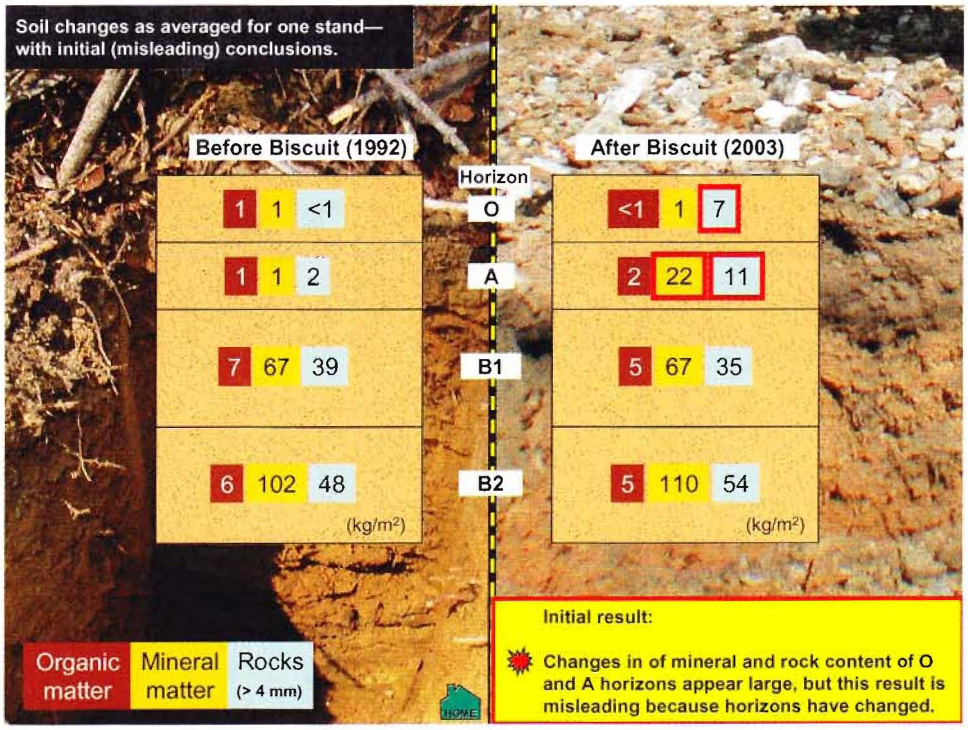




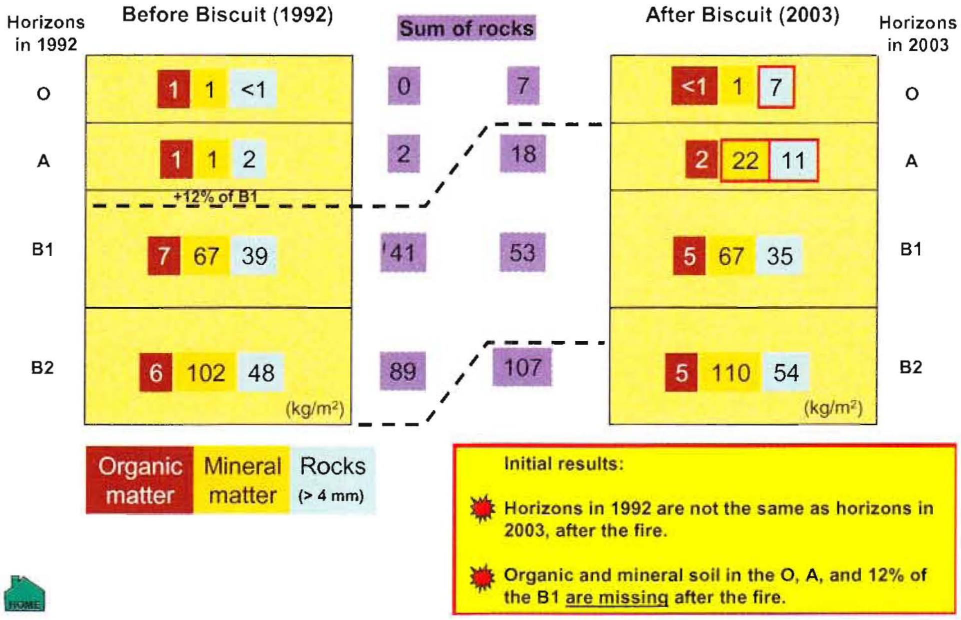

Late-succession, hi-wood
1993
2002
2004
1998
rocks


Hypothesis B: "Wildfires sterilize the soil and cause irreversible soil damage—therefore reducing long-term productivity."
Soil changes
Comparing soils before and after a fire is complicated by changes in soil organic matter and even fine mineral particles. First we must establish a method to compare soils.
Before Biscuit
After Biscuit

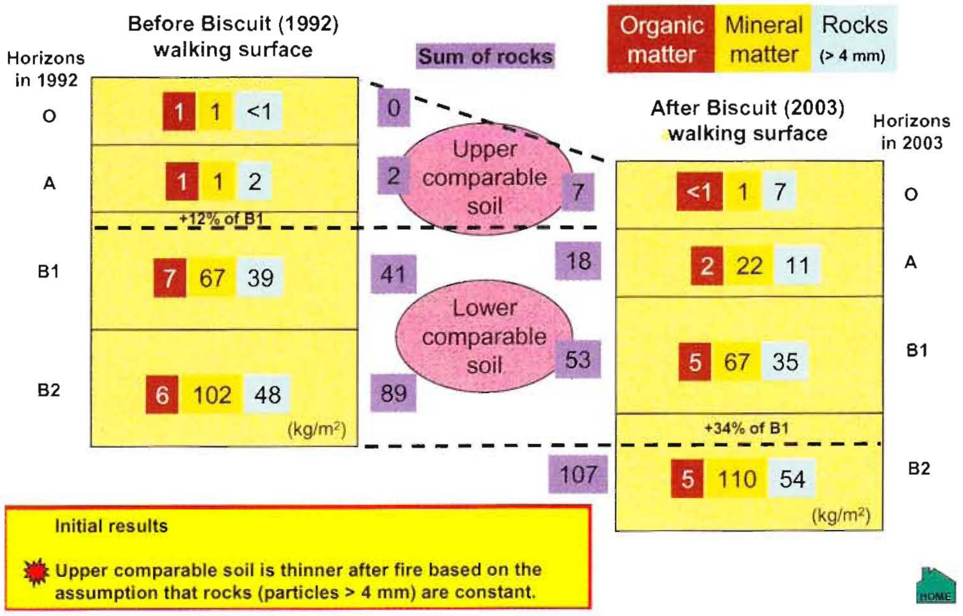

Soil changes are measured by dividing soils into four horizons and considering the organic and small and large mineral components before and after the fire.
Organic matter
Mineral matter
Rocks (> 4 mm)
Walking surface
Organic or litter layer
Mineral soil layers
O 1 1 <1
A 1 1 2
B1 7 67 39
B2 6 102 48
Soil pit
Measurement units
Average weight per unit area of organic, mineral, and rock components from 12 soil pits in one treated stand
Units: kg/m2
HOME


Soil changes as averaged for one stand—with initial (misleading) conclusions.
Before Biscuit (1992)
After Biscuit (2003)
Horizon
O 1 1 <1 | <1 1 7
A 1 1 2 | 2 22 11
B1 7 67 39 | 5 67 35
B2 6 102 48 | 5 110 54
(kg/m2)
(kg/m2)
Initial result:
Changes in of mineral and rock content of O and A horizons appear large, but this result is misleading because horizons have changed.
Organic matter
Mineral matter
Rocks (> 4 mm)
HOME

Soil changes as averaged for one stand—corrected for changes in rock content.



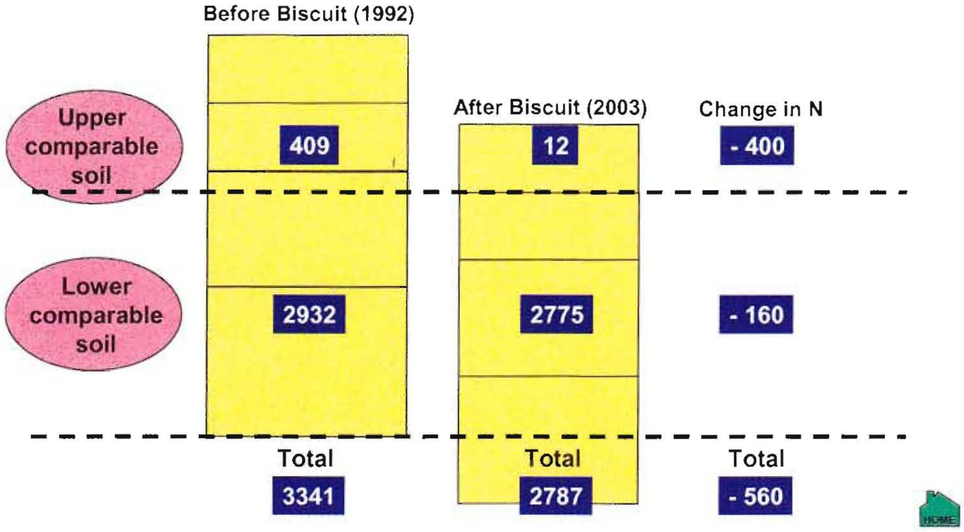
Soil changes as averaged for one stand—a new way to look at soil changes.

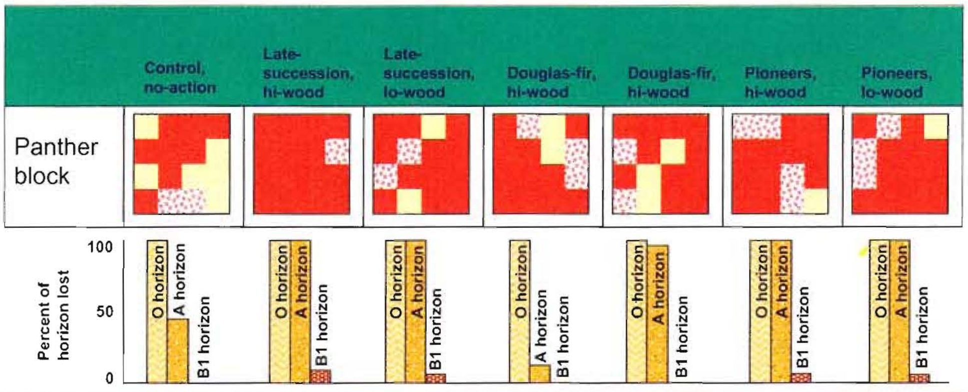


Soil changes as averaged for one stand—nitrogen content (kg N/ha) changes.

Initial results

- Major loss of nitrogen in some stands: over 400 kg/ha (another 400 estimated from burned vegetation suggests about 800 kg/ha total).
- Trees take up about 35 kg/ha every year; thus perhaps over 18 years of supply have been lost.



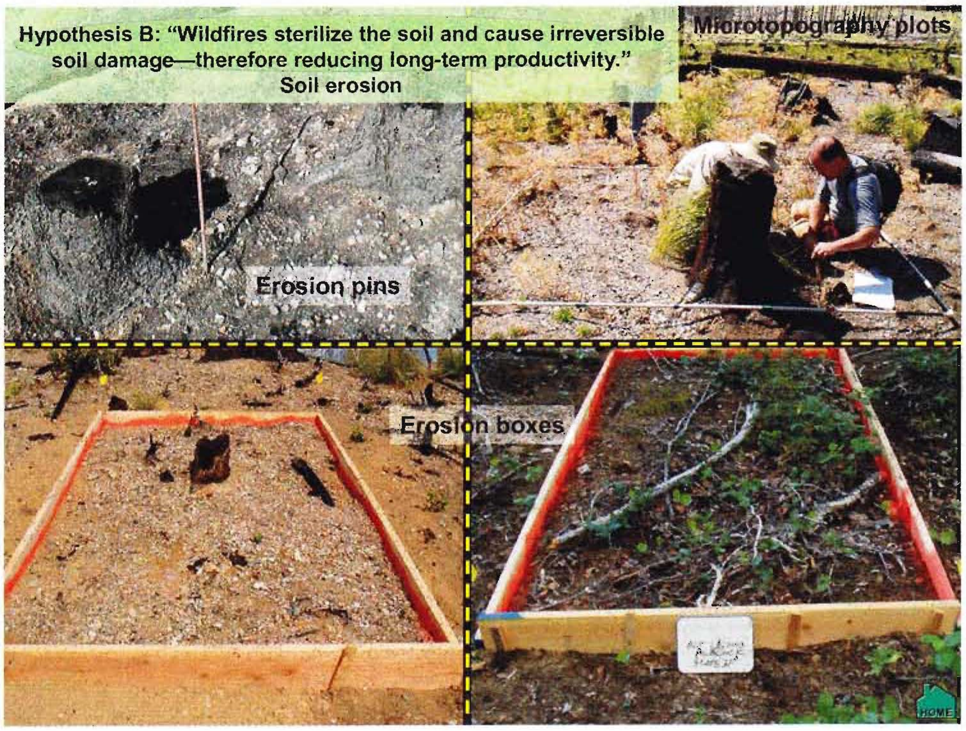


Soil losses across LTEP stands

The amount of soil lost was estimated by assuming that rocks (soil particles >4-mm diameter) would not be affected by water or wind erosion. Thus, when more rocks are found in upper horizons after the fire than before, the amount of associated smaller mineral and organic matter can be assumed to have been lost. Quantitative volumetric sampling across stands permits stand-scale interpretations.

Initial results:

- The organic (O) horizon was entirely lost from all stands burned at the Panther Lake block.
- The uppermost mineral horizon (A) was lost from 5 of 7 stands.
- Even some of the lower mineral soil (B1) was lost from 4 of 7 stands.
- Observed temperatures are weakly related to soil loss.

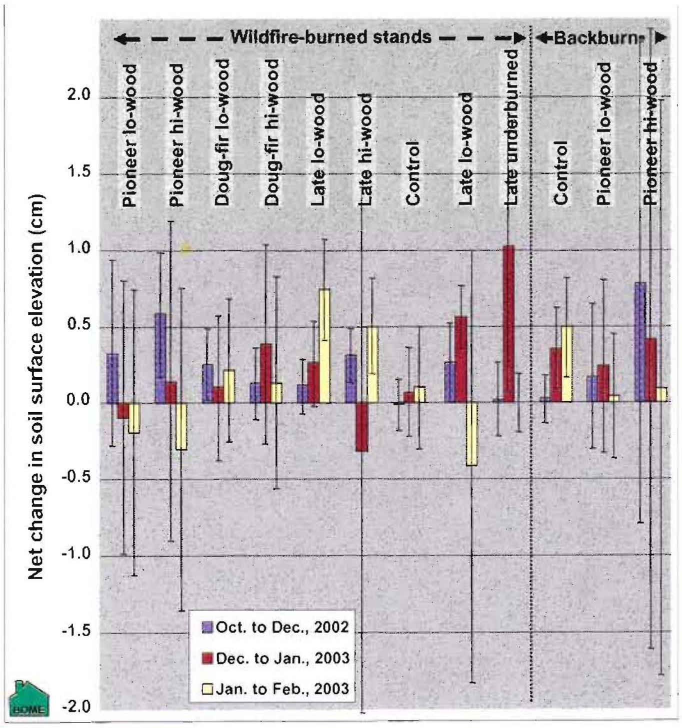


Erosion based on erosion-pin data across LTEP stands

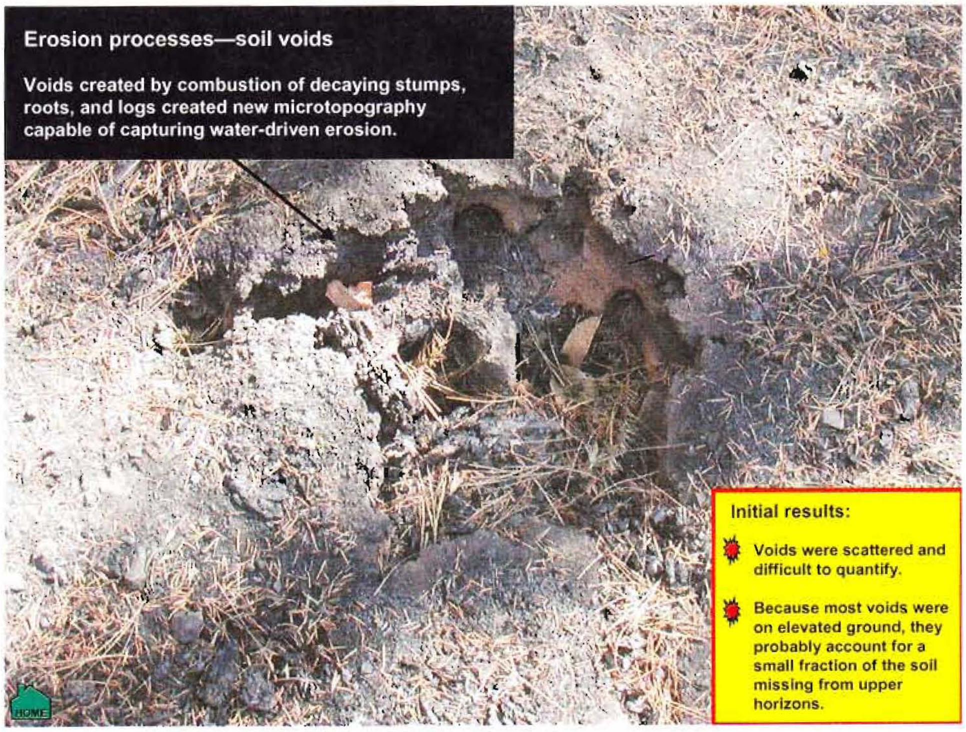
Erosion measured as changes in elevations of the soil relative to the top of grid-point rebar posts. Net gains are positive and losses are negative with 95% confidence intervals.

Initial results:

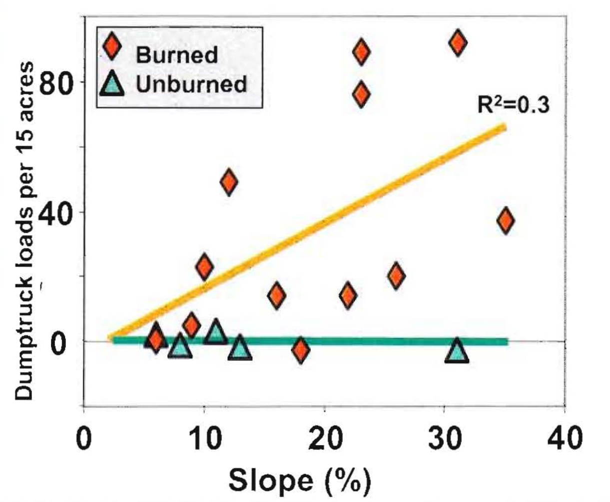
- Ground elevation increased by 1 to 8 mm on plots from October to December, 2002 following the fire (but only a few intervals do not include zero).
- After December 2002, elevation trends are negative in 3, mixed in 6, and positive in 3 stands.
- Volatility of gains and losses suggest local soil movement was widespread right after the fire.




Erosion processes—needle dams
Needle fall after the fire was quantified in soil sampling and observed in sequential photos.
HOME
Initial results:
Extensive needle dams were observed in control and late-successional treatments up to 2 years after the fire.
These dams all but disappeared in the 3rd year (photo)
HOME


Erosion processes—soil voids
Voids created by combustion of decaying stumps, roots, and logs created new microtopography capable of capturing water-driven erosion.
Initial results:
Voids were scattered and difficult to quantify.
Because most voids were on elevated ground, they probably account for a small fraction of the soil missing from upper horizons.
HOME

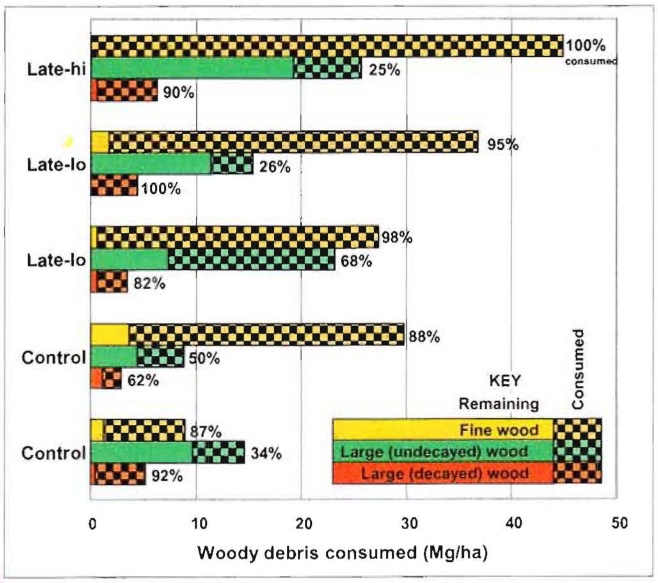
Erosion measured as changes in erosion boxes in 2nd year after fire



Initial results:

- Large water-driven soil movement was observed in erosion boxes on steeper, burned slopes.
- Little accumulation downslope at stand scale (see photo, at left, of the stream at the base of a 30-acre hotly burned area just above a road).

Hypothesis B: "Wildfires sterilize the soil and cause irreversible soil damage—therefore reducing long-term productivity." Loss of woody debris

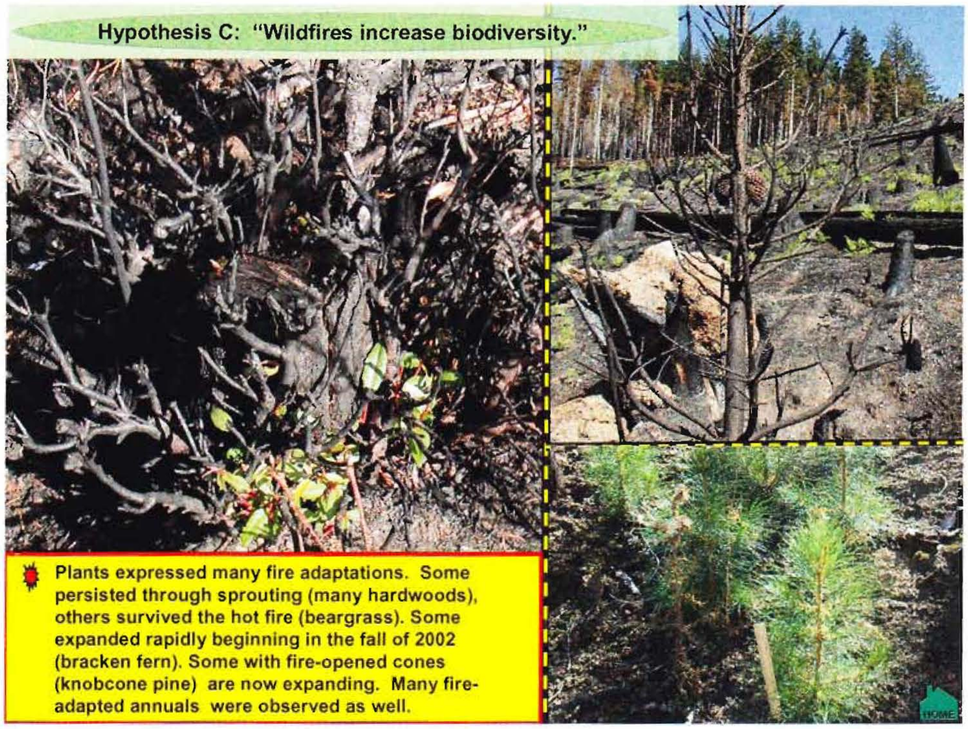


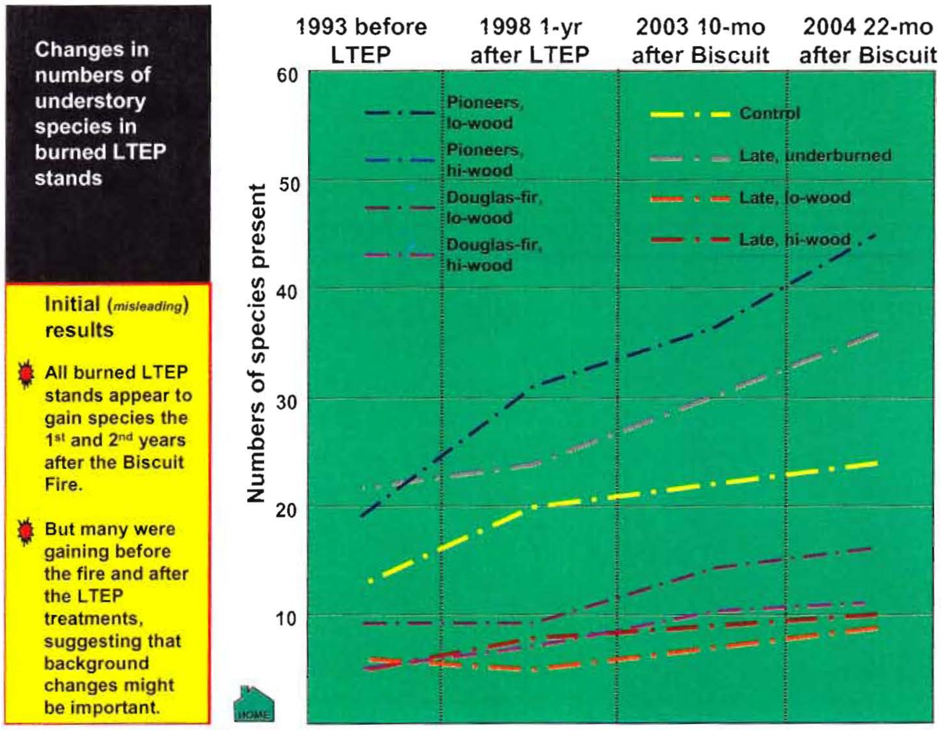
The role of fine and coarse woody debris in the Biscuit Fire across LTEP stands

Consumption of fine and large woody debris, based on measured change in amounts before and after the wildfire.

Initial results:

- Fine woody debris was a major fuel, as expected (8 to 46 Mg/ha was consumed), depending on LTEP treatment. Fine wood was also the most completed burned in the fire (87 to 100%).
- Most of the large, decaying wood also burned up (62 to 100%), but contributed the least fuel of all woody debris.
- Large, intact wood provided intermediate fuel amounts (6 to 16 Mg/ha) and was least burned as expected.

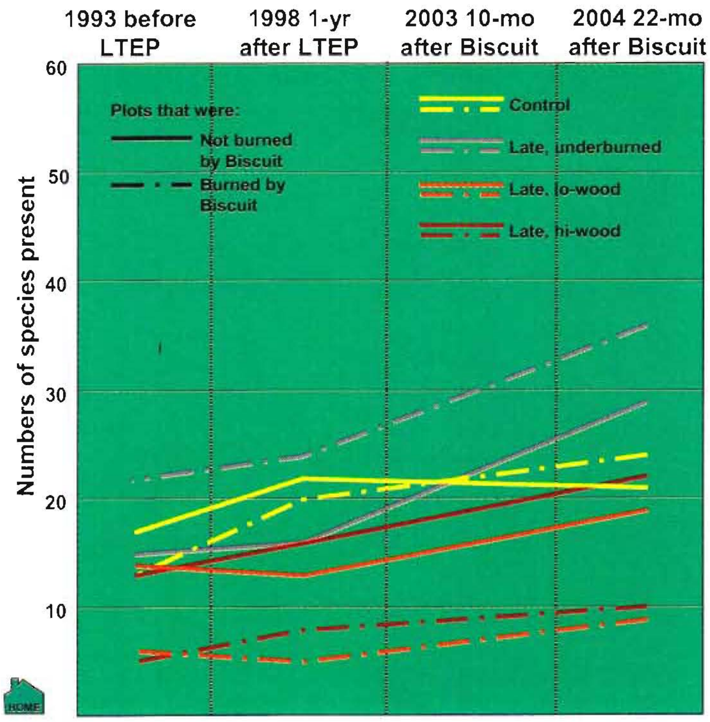

Hypothesis C: "Wildfires increase biodiversity."
Plants expressed many fire adaptations. Some persisted through sprouting (many hardwoods), others survived the hot fire (beargrass). Some expanded rapidly beginning in the fall of 2002 (bracken fern). Some with fire-opened cones (knobcone pine) are now expanding. Many fire-adapted annuals were observed as well.
HOME


Changes in numbers of understory species in burned LTEP stands
Initial (misleading) results
All burned LTEP stands appear to gain species the 1st and 2nd years after the Biscuit Fire.
But many were gaining before the fire and after the LTEP treatments, suggesting that background changes might be important.
HOME
1993 before LTEP
1998 1-yr after LTEP
2003 10-mo after Biscuit
2004 22-mo after Biscuit
Numbers of species present
60
50
40
30
20
10
Pioneers, lo-wood
Pioneers, hi-wood
Douglas-fir, lo-wood
Douglas-fir, hi-wood
Control
Late, underburned
Late, lo-wood
Late, hi-wood

Changes in numbers of understory species in Control and Late-succes-sional (thinned) LTEP stands

Initial results

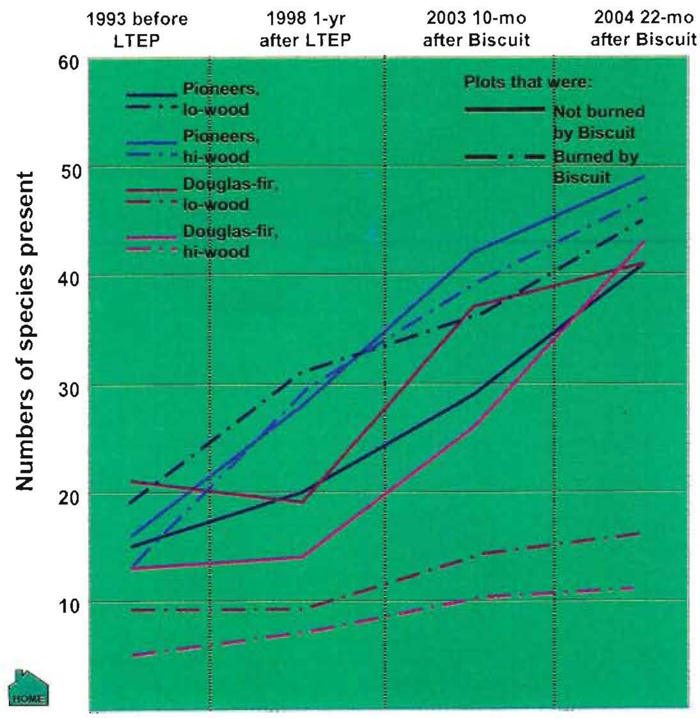
- In the Late and Underburned treatments, we see little effect of fire given background minor increases.
- In the Control treatments, the fire slightly increased species over a slow background increase.



Changes in numbers of understory species in early successional (Pioneer and Douglas-fir) LTEP stands

Initial results

- In the Pioneer treatments, we see little effect of fire given background sharp increases.
- In the Douglas-fir treatments, the fire decreased the background rate of increase.



Major conclusions:

Hypothesis A: "Because thinning reduces fuels, it also reduces fire movement and severity."

- Thinning alone did not reduce fire damage to mature trees in this case.

Hypothesis B: "Wildfires sterilize the soil and cause irreversible soil damage—therefore reducing long-term productivity."

- Some soils were greatly affected and perhaps some surfaces were temporarily sterilized.
- Changes is long-term productivity will be known only after tracking recovery (the vegetation is showing remarkable adaptation to fire and soil damage will likely be mitigated by some of these adaptations).

Hypothesis C: "Wildfires increase biodiversity."

- Relative to ongoing background (unburned) changes, wildfire increased understory species only slightly in Control treatments, decreased species in the Douglas-fir treatments, and had no effect on the other treatments—suggesting that local species are highly adapted to even intense wildfire.

HOME

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