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Department of
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Forest
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Final Report for JFSP01-3-1-05:
Demonstrating the Ecological Effects of Mechanical Thinning and Prescribed Fire on Mixed-
Conifer Forests

Background

A critical question in the Sierra Nevada is how to effectively use fuel treatments to restore forest ecosystems after nearly a century of fire suppression. With increases in stem densities and ladder fuels many forests require thinning, prescribed fire or both to restore forest conditions. In spite of their widespread use, the different effects of fire and thinning on fundamental ecological processes have never been examined in Sierra mixed-conifer forest. The Teakettle Ecosystem Experiment (<http://teakettle.ucdavis.edu>), begun in 1998, was designed to compare these effects in an old-growth experimental forest applying fire and thinning manipulations in a full factorial design. Using integrated sampling methods, coordinated studies followed vegetation, soil, microclimate, invertebrate and tree response conditions for 2-3 years before and for 3 years after treatments on 18 four ha replicated plots.

The designation of the Teakettle Experiment as a Demonstration Site by Joint Fire Science in 2001 allowed us to produce outreach material to communicate results with forest managers, private industry, researchers and interested members of the public. In 2001 we lead 3 field trips and produced a brief pamphlet summary of the experiment for visitors. However it was clear that due to the field site's remote location and access limitations (the site is only snow free from May to October when many foresters and fire management officers have other commitments), site visits would never reach a large audience. We therefore adapted the outreach to formats that would better meet the needs of the experiment's potential audience. We used the proposal's funds to produce 3 main products: a brief summary of the Teakettle Experiment for policy makers and administrators; an in-depth description of the experiment and pertinent results for forest managers; and a video of the experiment for foresters, students and the interested public. The first two products are 8 and 36 slide Powerpoint presentations which are also available as adobe pdf files for printing. These were developed in collaboration with The Information Center for the Environment (ICE) at U.C. Davis which has extensive outreach expertise. The third product has evolved from a more informal film (see enclosed DVD footage) to a more ambitious project. The film generated such interest from teachers, students, policy makers and Forest Service administrators that we will be seeking additional funds to make a state of the art 20-30 minute documentary. A professional script writer, Stephen Most, has been hired to produce a script (enclosed) which will provide the shooting schedule for filming at the Teakettle Experiment Forest next June. We have contacted several professional film crews (all use Beta cam SP format rather than the mini DVD format on the enclosed disks) and identified a potential director, camera man and lighting/sound grip to shoot the film should the project get



funded.

Products

- “The Teakettle Experiment: Brief Overview and Summary” an 8 slide Powerpoint Presentation [enclosed on disk]
- “The Teakettle Experiment: Brief Overview and Summary” an Adobe PDF document that can be printed and distribution [enclosed on disk and as handout]
- “The Teakettle Experiment: Fire and Thinning Effects on Mixed-Conifer Ecosystems” a 36 slide Powerpoint Presentation [enclosed on disk]
- “The Teakettle Experiment: Fire and Thinning Effects on Mixed-Conifer Ecosystems” an Adobe PDF document that can be printed and distribution [enclosed on disk and as handout]

A CD with all 4 of these products will be mailed out to each of the National Parks, National Forests and Bureau of Land Management offices in California. More copies are available and will be distributed to anyone requesting a copy. We hope the annual JFS conference will help get the word out to some of these groups.

- “The ecological effects of mechanical thinning and prescribed fire on mixed conifer forests” a talk using some of the Powerpoint slides has been given at:
The International Association of Vegetation Scientist meeting in July 2004
The Ecological Society of American Meeting in August 2004
The Southern Sierra Society of American Foresters Meeting in September 2004
- Field Trips visiting Teakettle have include more than 40 people including personnel from Sierra Pacific Industries, Southern California Edison, US Park Service, the Quincy Library Group, California Department of Forestry, the Sierra Club, California Audubon, and the Bureau of Land Management.

Future Products

We would like to see this film project through but do not have the funds to produce a professional quality film. We will be applying to the JFS 2005-2 AFP for a continuation of the project and the necessary funds to complete the film in the spring and summer of 2005. The enclosed script should give an idea of the film’s focus.

- Three DVD’s of film shot to date. This footage will provide some of the “b roll”, scenes related to what the narrator is describing
- “Fire and Forest Health: the Teakettle Experiment” script by Stephen Most

I hope this report will give you a good summary of the outreach materials and how much interest has been generated in this experiment’s results from these materials. It is my intent to continue getting this information out to managers and interested groups and to further that intent I hope we can secure funding to complete the film project. I have not presented the scientific results from the experiment here because those details will be communicated in a forthcoming special section on the Teakettle Experiment in the journal Forest Science.

Please let me know if I can provide any more information. Although the original timeline for this project may be over, I intend to continue providing outreach on the Teakettle experiment into the foreseeable future. Thank you for your support of this project.

Sincerely,



Malcolm North

TITLE: FIRE AND FOREST HEALTH
Teakettle Exp.

DATE WRITTEN: 10/21
SHOOT DATES:

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APPROVED:
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<u>Opening:</u> Footage of catastrophic fires: a recent wildfire maybe in southern Oregon, then the LA fire of 2003, showing a crown fire burning homes and other houses at risk.	NARRATOR VO #1: There have always been forest fires. But during the last century, the danger of fire to human beings and its impact on forests increased dramatically. Fires raging near urban areas took lives and damaged property. Crown fires raced through American forests with devastating, long-term effects.
DAVE McCANDLISS, Fire Management Officer for the Sierra National Forest, on camera.	DAVE McCANDLISS: Historically fires burned frequently in many western forests. They were integral to the development of the ecosystem, and they were essential for reducing the fuel load on the forest floor.
Forest Service fire prevention posters	Narrator VO #2: In the United States, which has millions of acres of public land, fire suppression was federal policy for nearly a century.
Smokey cartoon	Smokey: Remember, only you can prevent forest fires!
A Forest Service hotshot crew fights a fire on the ground.	Dave McCandliss (VO): Over the last hundred years, fire suppression has been effective. But it also produced a large accumulation of fuels, and this accumulation has changed the nature of fire. Many forests are so dense with fuels today that fire can devour these forests or large portions of them.
Dense vegetation within an old-growth mixed conifer forest. McCandliss walks through it.	Dave McCandliss: When a crown fire does occur in a fuel-laden forest, it can be much more severe and catastrophic than those fires that were part of the evolution of that forest. These hot catastrophic fires are often now the norm.
A crown fire. Eroded, charred, post-fire landscape	Narrator (VO) #3: Hot, fast-burning wildfires can denude the land, eliminating

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	vegetation, soil cover, and wildlife habitat, leaving behind a charred, eroded landscape.
HEATHER ERICKSON on camera	HEATHER ERICKSON: In a very hot fire, soils can get hydrophobic; they repel water. There's extreme erosion and stream siltation.
Water flowing rapidly down a blackened mountain slope. Footage of mass wasting coming down from the LA hills after the fire of 2003	Heather Erickson (VO): This can have disastrous effects downslope and downstream on the land and on wildlife. And where the burned forest is above urban areas, like Los Angeles after the wildfire of 2003, mudslides can endanger lives and destroy property on a large scale.
MALCOLM NORTH on camera	MALCOLM NORTH: A hot crown fire can have long-term impacts on the succession of ecological stages in the development of a forest. By changing the forest structure and eliminating wildlife habitat, fires alter its composition of species. Crown fires also impair the forest's capacity to produce wood and other products, and provide places for recreation.
Title page of the Healthy Forest Initiative	Narrator (VO) #4: Restoring America's forests to a state of health by removing the dangerous build-up of fuels is now the policy of the United States government. But what is a healthy forest? And by what means are forests best restored?
TITLE: FIRE AND FOREST HEALTH (Part One: <u>Introducing the Teakettle Experiment</u>)	
Aerial view of the Sierra National Forest.	Narrator VO #5: A multi-year Forest Service experiment is being conducted in the Sierra Nevada east of Fresno, California. This study illuminates the issue of forest health.
Malcolm North on camera	Malcolm North: What is forest health? As a scientist, I'm not comfortable with that term because forests aren't people who are healthy or sick. What we do know from looking at historical data in forests is that they have a range of conditions. These conditions are produced by climate and natural processes such as fire that shape them over a long period of time. That long-term, wide-ranging 'equilibrium' is what I

	think of as forest health. Current conditions in many fire-suppressed forests are clearly outside this historic range of conditions
Contour map graphic showing the Teakettle watershed emerging from the Yosemite/Sierra National Forest region	NARRATOR (VO) #6: This old-growth mixed-conifer forest offered Forest Service researchers a good basis for studying whether fire or thinning or a combination of the two can effectively restore a forest's historic range of conditions.
JIM INNES on camera at the Teakettle office. There's a map of the Teakettle, Experimental Forest behind him.	JIM INNES: The experiment was done in old-growth so that any changes in the ecosystem would result from the fire and thinning treatments rather than the forest's past management history.
The Teakettle canopy	Jim Innes (VO): This type of experiment required a relatively mature forest where pools of nutrients are fairly stable. Old growth has some variability, but this variability is part of the natural range of mixed conifer conditions.
Dave McCandliss walks through a thickly vegetated part of the Teakettle Experimental Forest	Dave McCandliss (VO): The Teakettle Creek watershed in the Sierra National Forest has had no large fires since the 1860s. Since the early 20th century all large fires here have been suppressed.
Dave McCandliss on camera	Dave McCandliss: Consequently, the Teakettle Experimental Forest, like others in California and throughout the country, has a dangerously dense fuel load. This is not how this forest would have developed naturally. Such a concentration of combustible materials put a forest at risk of catastrophic fire.
A truck carries a load of timber along a forest road. In the background is slash remaining from a cut stand. A logging operation cuts down trees	Jim Innes (VO): One method of reducing forest fuel loads is cutting trees. Sometimes thinning is used on its own in areas which would be risky to burn or because of costs, and sometimes it is followed by a prescribed fire.
Jim Innes on camera	Jim Innes: This experiment was designed to answer some crucial questions: If burning and thinning are used to restore a forest, how do their effects on the forest differ? Can thinning alone do the job? Is thinning needed to reduce fuels before lighting a prescribed fire? Is fire without

	thinning the best way to go?
	Narrator (VO) #7: The experiment that is being conducted at Teakettle can help forest managers determine the best way to reduce the risk of catastrophic fire without harming the functioning of forest ecosystems.
<u>(Part Two: Method & Content of the Teakettle Experiment)</u>	
Jim Innes with a site plan or map of the experimental forest	Jim Innes (VO): At Teakettle, Forest Service scientists divided the experimental area into eighteen similar plots. Each was four hectares or ten acres. These plots were set aside for different kinds of treatments.
Jim Innes on camera	Jim Innes: These were two different kinds of thinning
a shelterwood tree being logged	Jim Innes (VO): the cutting of canopy or shelterwood trees
a Caspo thinning operation	Jim Innes (VO): an understory thinning, which removed only smaller trees following guidelines for protecting California spotted owl habitat.
A map showing the eighteen experimental plots indicating the different treatments	Narrator (VO) #8: Different plots had different combinations of thinning without fire, thinning with fire, and fire without thinning. There are also control plots left unchanged by fire or by thinning.
Malcolm North on camera	Malcolm North: Beginning in 1998, for two years before the experimental treatments occurred, our team of scientists studied many aspects of the forest's functioning. We had to study the forest extensively before thinning and burning were applied to the experimental plots in order to tell the difference between the results of those treatments and natural variations.
A researcher takes measurements from a data logger	Narrator (VO) #9: Among the data that researchers gathered were measurements of the microclimate in each of the eighteen plots. The data loggers placed there record temperature, humidity, solar radiation, and wind speed.
Archival footage of project scientists at work—for example, Tom Rambo placing bryoria in a red fir, then spraying water on	Malcolm North (VO) To understand how fire and thinning would affect the forest we wanted to identify what the main

it; Heather Erickson pulling up soil to look at decaying matter within in.	mechanism or driver was that really influences how the ecosystem functions. Second, we wanted to uncover some of the key linkages within the forest so we could understand the ripple effects of our restoration treatments on the ecosystem.
Heather Erickson running her fingers through topsoil	Heather Erickson (VO): What goes on beneath the soil is crucial to the functioning of the entire forest.
Heather Erickson on camera	Heather Erickson: In studying the Teakettle forest it was important to measure soil composition, its depth, and its capacity for holding water. The amount of water the soil contains has a powerful effect on what can grow above it.
In an area with rocky outcrops and few trees, a researcher sends a probe into the soil to measure its depth.	Heather Erickson (VO): In this area, which has shallow soil, with bedrock close to the surface, there is a gap in the forest; only bare ground or shrubs are present.
Soil probe repeated in a densely forested area	Heather Erickson (VO): But this part of the forest has a deep pocket of soil, which holds a lot of water. Its also where the trees are clustered, particularly the largest, tallest trees. This pattern of gaps alternating with closed canopy forest and the very size of the trees varies according to the amount of water that's available as a result of the depth to the bedrock.
Malcolm North in a riparian area	Malcolm North: Water—how much there is and where it's located—seems to drive much of this forest. This is probably true for many western forests where frequent fires were a part of the historical natural processes because they were dry ecosystems. In the absence of fire, many trees fill in the forest understory, competing for scarce water.
Dead trees in the San Bernadino Mountains	That increases the moisture stress within every aspect of the ecosystem. This moisture stress can severely stress trees. Bark beetles can sense this stress and in southern California there have been large beetle outbreaks which have killed trees over large areas producing a large fuel load for the inevitable wildfire.
MARC MEYER on camera near a stream.	MARC MEYER: Wildlife is greatly

He walks to the edge of a riparian area.	influenced by the availability of water. Riparian corridors, the area around streams, are particularly rich. They are heavily used by several small mammals we studied. As you walk away from a creek bed with its lush vegetation, there's almost a line where the riparian area stops.
MATT HURTEAU cuts a "cookie" from an old growth stump and measures its inner growth rings.	Narrator (VO) # 10: Water can become the limiting resource for plants and many of the forest's functions. It influences when trees become established and how well they grow. This UC Davis ecologist analyzed tree rings to correlate tree establishment with El Niño years when there was an unusual amount of rainfall and snowmelt.
Matt Hurteau on camera	MATT HURTEAU: We can tell from the number of tree rings when a tree was established. And the width of a ring indicates the amount of growth in a given year. Many of the trees in this forest became established in wet El Nino years, particularly if that wet year followed a fire. This tree started in 1754, two years after a fire and in a very wet El Niño year. These years when it grew a lot are also know to have been wet years.
Rainfall in the forest	Malcolm North (VO): Not only does water influence when trees become established and how well they grow, it can be the limiting resource for plants and many of the forest's functions.
Malcolm North on camera	Malcolm North: In addition to identifying water as the main driver of ecosystem processes, we wanted to track important linkages between different parts of the ecosystem in order to understand how the forest would respond to fire and thinning.
Tom Rambo climbs a tree then appears within the forest canopy. A pan of the forest from the canopy.	Malcolm North (VO): Not surprisingly, one major linkage we found connected the bottom of the forest, in its soil, to its top, in the overstory canopy. This connection is between the canopy, its influence on microclimate and wildlife habitat, and even to food that animals find underground.
A cartoon shows the flow of energy, water, and relationships between species within	Narrator (VO) # 11: By turning sunlight into carbohydrates, the canopy fuels the life

the old growth ecosystem	of the forest. It creates a microclimate that stores and conserves water. It offers habitat for raptors, owls, and squirrels. And the squirrels are essential for the lifecycle of fungi that provide them and the trees vital nutrients.
Marc Meyer holds a flying squirrel. He releases it and it lurches up a tree. Then the squirrel glides to another tree.	Marc Meyer (VO): The flying squirrel is a good example of the connections and importance of the overstory canopy to how this forest functions.
Marc Meyer on camera	Marc Meyer: Flying squirrels nest in tree tops, often in cavities. They need large trees or snags to den in. When the ground is covered in snow, the squirrels rely on food found only in the tree top.
TOM RAMBO with lichen on camera	TOM RAMBO: I'm especially interested in the lichens that serve flying squirrels as their winter food, when they can't dig under the snow for truffles. Lichens are ninety percent of their diet from January through May.
CU of bryoria that Rambo holds in his hand.	Tom Rambo (VO): This kind of lichen is called bryoria. It grows on red fir and is found mostly near water. Not only is this food, flying squirrels use it for their nests. When you can eat your bedding on a winter day, that's pretty handy.
Close up of a truffle in the soil Footage of squirrels gliding	Marc Meyer: When the ground is snow free, truffles are what the flying squirrels will come down out of the canopy for.
Meyer takes a fecal sample from a captive squirrel. An associate spreads the sample on a slide and looks at it through a microscope.	Marc Meyer (VO): The squirrel eats the truffles, passes the spores through its gut, and helps disperse the fungi, ensuring that it is widely spread in the forest soil.
Camera tracks from a conifer needle, down the tree bole, out along the ground, to Heather Erickson digging.	Heather Erickson: These white hairs in the soil are mycorrhizae. This fungal growth extends all through the soil. It forms a common connection between different tree and shrub species. When it fruits, it creates a truffle—a form of fungal growth that supplies water and nutrients needed by these trees. In fact the trees couldn't survive without the fungi. The fungi in turn gets energy from carbohydrates made by those needles 60 meters overhead.
Graphic shows the squirrel-truffle-water-	Marc Meyer: The connections between the

tree connection.	forest canopy, the squirrels, and the truffles are key links in the forest food chain. The flying squirrel is the main food source for the spotted owl, which is also nocturnal, and raptors prey on both squirrels and spotted owls.
Malcolm North on camera	Malcolm North: Any forest restoration, whether by thinning or fire, needs to leave enough trees and logs to maintain the connections between the fungi, the animals, the trees, and the water. Otherwise the linkages that bind this ecosystem will substantially change.
Footage of logging and of fires being set	Narrator (VO) # 12: To understand how fire and thinning affect forest health, the eighteen experimental plots in the Teakettle forest were treated in 2000 and 2001. Researchers have studied and compared the results of the treatments in the years since then.
Surveying instruments map the location of large structures in the experimental forest	Jim Innes (VO): One of the things that we're doing is mapping the location of trees and snags and shrubs, all of the large structures in the forest. We want to know how things have changed spatially due to the treatments. For example, what is a good range of spacing between trees to get pine regeneration?
Jim Innes on camera at a CASPO thinning area	Jim Innes: Thinning can reduce the danger of catastrophic fire, and it restores the appearance of an open, healthy forest. This plot had a Caspo thinning; that is, thinning the understory only and retaining most of the overstory canopy and all the large trees.
at a shelterwood thinning plot	Jim Innes (VO): If thinning takes larger trees, it substantially opens up the forest and reduces the overstory canopy. This plot in the experiment had what we call shelterwood thinning.
a burned plot	Jim Innes (VO): This is a place that was burned only.
a burned and thinned plot	Jim Innes (VO): This plot was burned and thinned.
overgrown old growth	Jim Innes (VO): And this plot was left alone. The key question is, which treatment or combination of treatments reduces the

	fuel load without undermining the functioning of the forest ecosystem?
Dave McCandliss on camera in a burn plot	Dave McCandliss: Although historically summer lightning and Indian-set fires usually burned in late Summer or early Fall, today we have some limits on when we can burn. First we often cannot burn during the Summer because of air quality restrictions. Also during the Summer we may not be able to safely burn an area without the risk of losing control of the fire. This often means setting fires in the Spring when fuels are still moist or in the Fall after some rain has fallen.
Ground fire in mixed conifer old growth	Dave McCandliss (VO): Prescribed fire does not burn the same way that fires do when temperatures are higher and humidity lower. But those are necessary limitations on this experiment. That's how prescribed fire is often used.
	Narrator (VO) #13: How did fire and thinning affect Teakettle? Can judicious cutting play a role in restoring the forest and reducing fuels without harming the intricate cycles of water, sun, plant growth and animal life that maintain forest health?
<u>(Part Three: Conclusions from the Teakettle Experiment)</u>	
Malcolm North on camera	Malcolm North: In analyzing the results of the experiment we've found out many things. First was that prescribed fire alone, in our experiment, did not have much effect on the forest or reduce fuels. This was because the late season burn under moist, cool conditions did not consume many fuels. It did not cover much of the plot or kill many of the small trees that produce moisture stress and provide ladder fuels. In other situations fire alone might be effective, but when applied off-season in our study, it did not restore the appearance or the functions of the historic forest.
Jim Innes on camera in a CASPO-thin-only plot	Jim Innes: Moderate thinning alone such as in this CASPO plot reduced the small trees and restored some of the appearance of the historic forest. It also reduced moisture

	<p>stress by removing these smaller trees. However this increase in water did not restore the ecosystem functions. For example, there are almost no plants now in the forest understory because the thick layer of logging slash has stalled herb and shrubs from becoming established.</p>
<p>Jim Innes scooping up a deep layer of litter in a thin-only plot</p>	<p>Jim Innes (VO): Rather than removing this flammable stuff, thinning alone adds to the coarse woody debris and needle litter that has accumulated from one hundred years of fire suppression. On close inspection thinning alone did not restore either the appearance or the healthy function of the forest.</p>
<p>A light burn going through a forest, leaving CASPO intact</p>	<p>Narrator (VO) #14: A combination of understory thinning and fire was most effective at restoring the forest. The slash produced by the cut gave the fire enough fuel to keep it moving through the forest under typical Fall burn conditions, allowing the burn to have a real impact on the ecosystem.</p>
	<p>Malcolm North (VO): We found that understory thinning followed by fire was best for restoring the forest appearance and its functions. The thinning removed the ladder fuels, reducing the chance of the fire moving into the overstory, and it increased the spread and heat of the ground fire.</p>
<p>Jim Innes on camera</p>	<p>Jim Innes: Thinning the overstory by removing the larger trees severely impacted the ecosystem linkages.</p>
<p>Marc Meyer in a shelterwood plot</p>	<p>Marc Meyer (VO): When heavy thinning is used, as occurred here, most of the canopy environment is removed. There are almost no truffles in these shelterwood-thinned plots. When large parts of the canopy are removed, there aren't enough green leaves to provide the carbohydrates fueling this canopy to underground truffle linkage.</p>
<p>Marc Meyer on camera</p>	<p>Marc Meyer: The forest canopy also provides essential habitat for arboreal animals including flying squirrels and spotted owls. So taking out chunks of the overstory canopy by logging large trees can</p>

	reduce the canopy environment just as a catastrophic crown fire can. Large structures, whether live trees or snags, provide vital habitat and maintain linkages that are important for post-disturbance recovery.
(Close)	
A scientist examines seedlings in a post-burn plot	Narrator VO #15: Restoring forests after a century of fire suppression will take time and further experimentation.
Malcolm North on camera	Malcolm North: Not every forest is like the mixed-conifer forest in the Teakettle Creek watershed. There is a wide range of forest types within the United States, and forest managers have to consider different ways to restore forest health in lands they are responsible for. In our experiment at Teakettle, ground fire supplemented with fuel from an understory thinning was most effective at restoring the ecosystem.
A light burn on a Caspo-thinned plot	Dave McCandliss: Fire is what these forests evolved with; it's what they're missing; it's what they most need to start them toward a restored condition. Thinning can help the fire get its work done, particularly if prescribed fire is used off-season, but it is a supportive tool, not an end in itself.
Beauty shots of fire and thin-treated old growth in the Teakettle Experimental Forest	Malcolm North (VO): This study in California's Sierra Nevada shows that fire in combination with judicious cutting can play an important role in protecting the nation from catastrophic fire while renewing the ecological vitality of our forests.